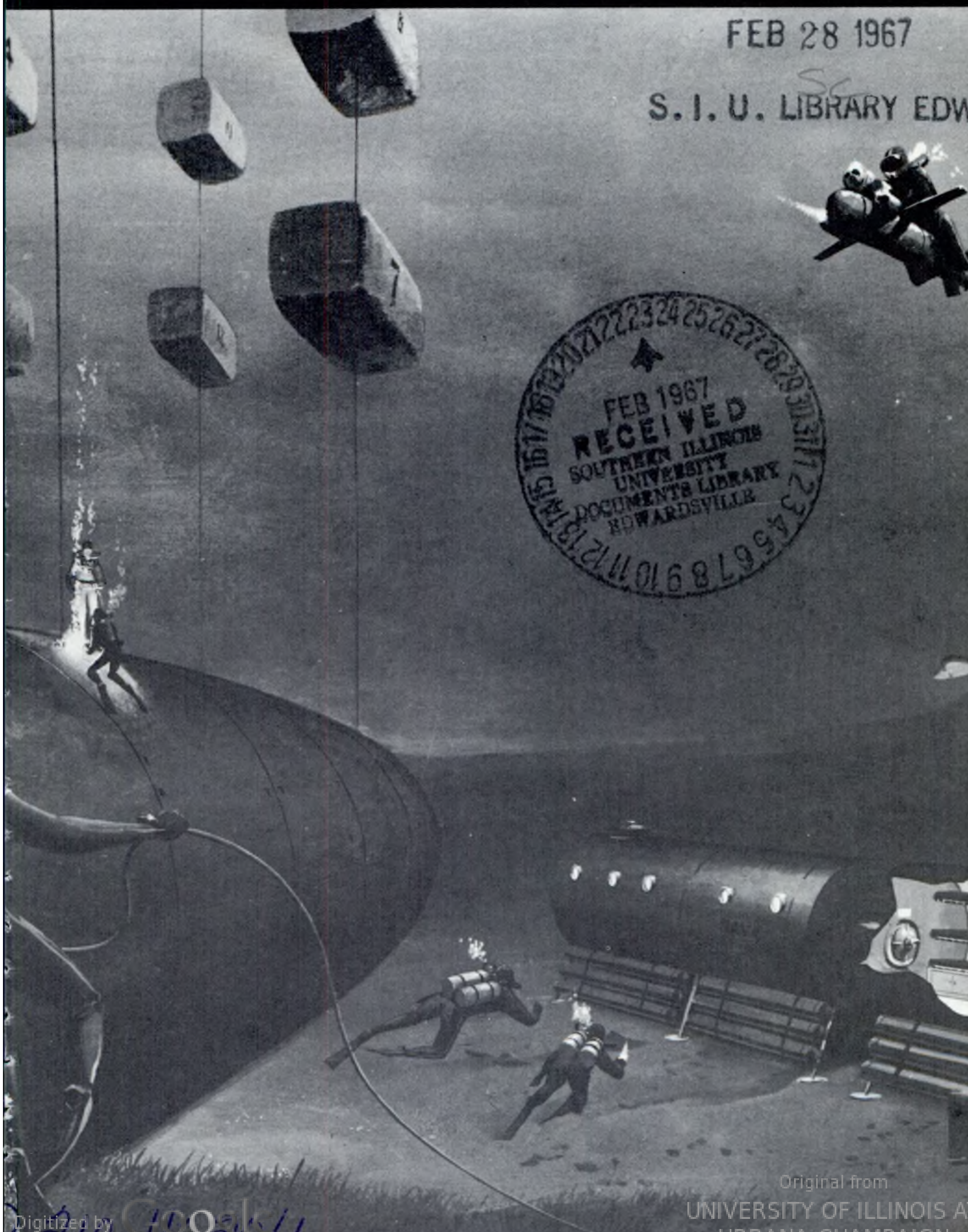
NAVAL RESEARCH REVIEWS

JANUARY 1967

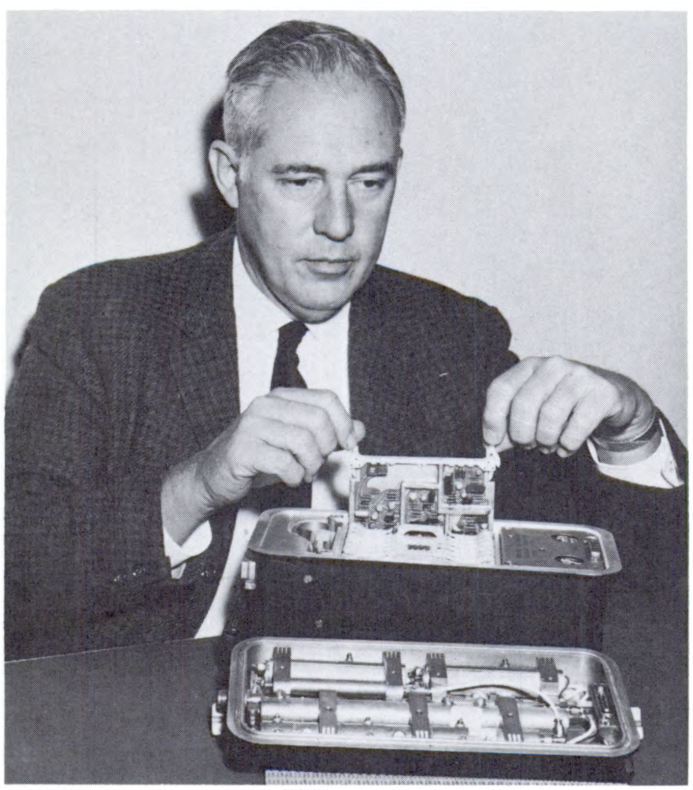


New IFF Transponder for Military Aircraft

A lightweight IFF (identification, friend or foe) transponder capable of performing at altitudes as great as 70,000 feet and temperatures as high as 95°C without requiring external cooling has been developed by the Naval Research Laboratory and has been selected by the Department of Defense for universal use in military aircraft of all services. The design of the transponder is such that the cost of production for this wide use will be many millions of dollars less than that of other transponders.

Through a coded signal, by means of which one aircraft interrogates another, the transponder provides military identification and air-traffic control as well as the altitude transmission functions required to fly the civil airways. Through the unique design of the device and the application of solid-state electronics, small size (approximately 350 cubic inches) and light weight (less than 15 pounds including the mount) have been achieved. The hermetically sealed case is die cast, and the modules are mounted directly on the case, thus reducing cost through the elimination of a chassis. The mechanical rigidity of the transponder permits it to be bolted, without shock mounts, directly to the frame of a high-speed aircraft.

According to Mr. Laddie Rhodes, of NRL, who conceived and directed the development of the new transponder, a key feature is ease of serviceability. Each major function is contained in a module (printed card) that can be replaced or interchanged without adjustment, and each function is provided with test points to allow rapid fault detection. If extensive repair is required, a technician can remove a malfunctioning unit, determine the trouble, make an adjustment, and return the transponder to the aircraft within 30 minutes. The average time taken to service transponders now in use is two to three hours. Furthermore, it is expected that the minimum mean time elapsing between failures will be 500 hours, which is a far longer time than that provided by transponders now in use.



Laddie Rhodes, of the Naval Research Laboratory, demonstrates the ease with which his transponder can be repaired by replacement of a defective module.

Highlights from "Effective Use of the Sea"

In June 1966, the President released the report of his Science Advisory Committee concerning man's understanding of the oceans and their use. This report, entitled "Effective Use of the Sea," presents the results and findings of more than a year's review of the national needs and programs relating to the ocean. It was developed by a panel of outstanding representatives from the academic, industrial, and governmental communities. The recommendations and conclusions contained in the report are currently being considered by the National Council on Marine Resources and Engineering Development, under the chairmanship of Vice President Hubert H. Humphrey.

As the largest single agency in the government involved in ocean science and technology, the Navy has a great interest in the findings and recommendations contained in this report. While it is not intended to constitute an endorsement of any of the recommendations and conclusions, the following highlights are presented as a summary of those portions of the report of major interest to the Navy.

Ocean Science and Technology and National Security

Introduction

The most urgent aspect of Federal involvement in ocean science and technology for the next 5 to 10 years relates to national security in the narrow, strictly military sense. The U.S. Navy, which has responsibility for essentially all our defense efforts involving the ocean environment, will have increasing need for specialized oceanographic data for specific devices being developed or improved and will continue to require better understanding of characteristics of the ocean environment in which it operates.

In particular the Navy will need to improve the capabilities of its undersea strategic forces and ASW forces, as well as to increase its ability to perform undersea search and recovery. Improvement of the Navy's capabilities in these areas depends heavily on our national ability to discover and exploit new knowledge in ocean science and on our success in developing new and relevant ocean technology. Although everyone is aware in a general sense that ocean knowledge has military implications, the underlying reasons may not be widely understood. The military importance of oceanography entails an understanding of the nature of our national security programs, which themselves are not always completely comprehended.

Whereas the Navy's involvement in oceanography because of security and its often specialized interest will of necessity be distinct from that of other Government and private programs, the Navy must maintain working relations with all elements of the scientific and technological communities concerned. This relationship has been excellent in the past, correctly reflecting the Navy's deep interest in oceanographic research, and it should be strengthened in the future.

The Navy's Oceanographic Program

The Navy's oceanographic program excluding the one-time ship-construction appropriation of a nuclear-powered deep-ocean engineering vehicle has expanded from $120 million in fiscal year 1965 to $141 million in fiscal year 1966 and to $205 million for fiscal year 1967. Although the program has been subdivided in many different ways, it can for the purposes of this report be divided into:

(a) Basic research and education;
(b) Research and development for undersea weapons and sensors;
(c) Mapping and charting;
(d) Undersea technology;
(e) Rescue, search, and recovery of undersea objects;
(f) Test and evaluation facilities;
(g) Oceanographic data and information services.

Basic research and education are so vital to both the Navy and the national interest in the marine environment that they will be discussed singly in the next subsection. Research and development for undersea weapons and sensors are the Navy's purview, and any discussion must take into consideration the Navy's requirements, which is beyond the scope of this Panel's assignment. The Panel does *recommend*:

1. Unclassified R&D information be made available in timely fashion.
2. Classified R&D information in the area of sensor development be made more available to Federal and industrial communities having application for the data than has been the case.

The judgment of the Panel is that current Navy classification policies often weigh short range and narrow security considerations too heavily as compared to the longer range security which must be gained by more rapid and effective development of the scientific and technological base from which its systems are derived. Our recommendation therefore is that the Navy review its classification policies with a view to furthering more rapid progress by increasing the diffusion of deep sea technology. While information that will compromise military systems must be classified, advantages of wide diffusion and input diversity from scientific and industrial communities generally outweigh any risk involved.

Mapping and charting, sometimes referred to as hydrographic surveys, are responsibilities of the Defense Intelligence Agency. Ocean mapping and charting by the Navy are executed as part of the total national oceanographic program. Military requirements dictate a greater degree of accuracy in charting the ocean bottom than is required by other Federal agencies. Therefore, no quantitative recommendations can be made with respect to the Navy's survey program requirements. However, criticism applicable to the survey program of Environmental Science Services Administration is equally valid with respect to the Navy's Hydrographic Survey Program. The Panel concurs on the recent action to establish an R&D program in Navy mapping and charting and *recommends*:

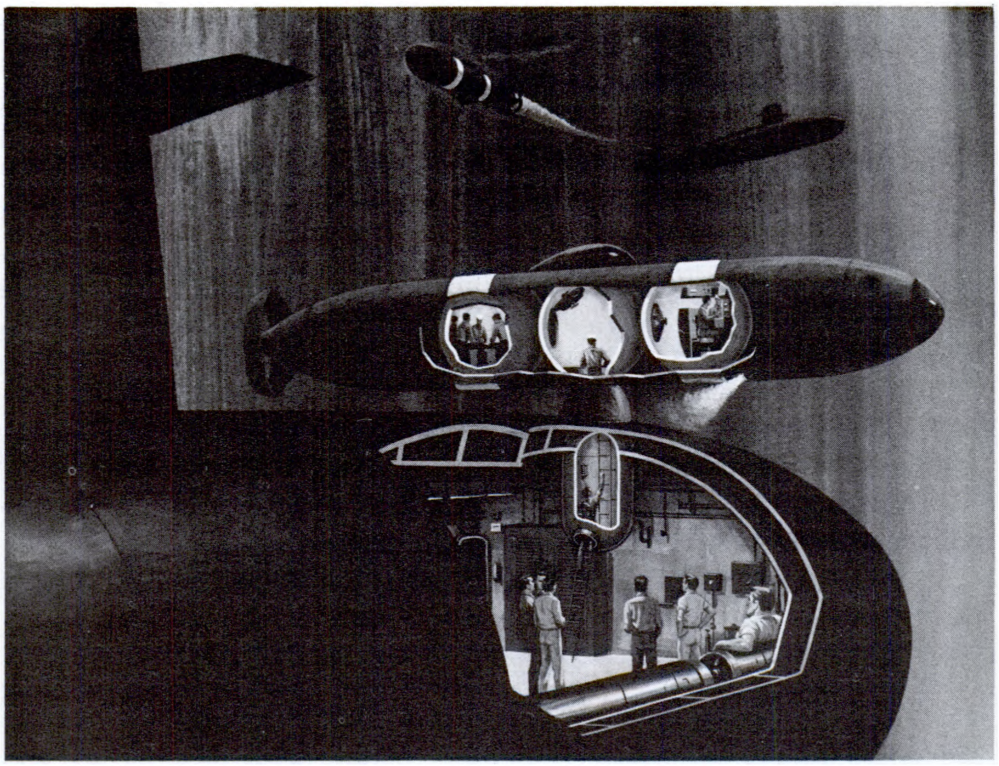
1. A minimum expenditure of $2 million per year in light of significant Navy expenditures in mapping and charting.
2. Continuation of commercial ship leasing for added survey requirements.

Undersea technology is that general area of ocean engineering not associated directly with specific defense systems. The ability to construct towers on the ocean floor, general undersea navigational concepts, and deep undersea materials technology form part of the Navy's undersea technology program. The Sea Bed (vol. 4) report recommended a substantial Navy program of several hundred million dollars' expenditure over the next several years in this area. The Panel *recommends* a significant increase over the present $2 million a year in Navy expenditures.

Shortly after the loss of the Thresher the Navy convened a board to evaluate and ascertain the Navy's ocean capabilities specifically with regard to submarine rescue. After a year-long study this group (Deep Submergence Systems Review Group) recommended establishment of a 5-year program having four basic areas, costing about $332 million. These four categories were specified for the Navy's concentrated effort:

1. Submarine location, escape and rescue;
2. Deep-ocean, small-object location and recovery;
3. Increased salvage capability;
4. Extended capabilities of man as a free swimmer to perform useful work in the ocean environment to his physiological limits.

As a result of these recommendations the Navy formed a special group called the Deep Submergence Systems Project which was to implement these capabilities and enable the Navy to have worldwide operational capabilities by 1969. This group, initially placed within the Navy's special project office, was recently made a separate CNM-designated project in order to focus the Navy's effort on exploration of oceanic depth. An additional task for this new group was management



Artist's concept of submarine rescue vehicle. This small rescue vehicle, capable of reaching disabled submarines, is being developed for the Deep Submergence Systems Project. Approximately 50 feet long, 8 feet in diameter, and weighing 30 tons, the vehicle will help give the Navy a 24-hour response time to submarine distress calls.

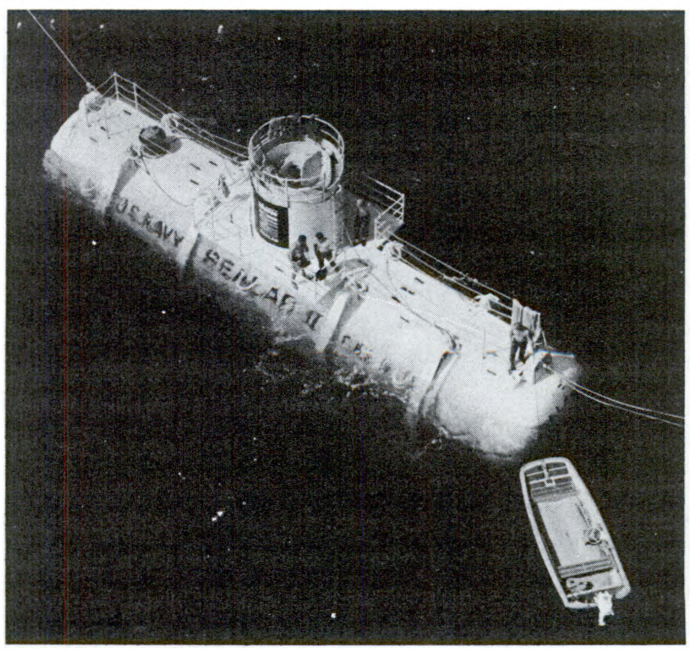
of the nuclear powered oceanographic vehicle (NR-1). The accomplishment of the four specific tasks initially given this group has been delayed in part because of funding problems. This year's budgeting for the prototype rescue vessel is approximately $3-1/2 million short of the amount required; this difference is attributable to the low estimated cost at the onset of the program. This vehicle, now stripped of all significant search-and-recovery capability, will give us limited capability by the end of 1968 to rescue men from disabled submarines at their collapse depth. A full complement of six vehicles in 1970 will provide worldwide rescue capability. There exists today no demonstrated, operational capability to rescue personnel from submarines beyond a depth of 600 feet; this leaves a depth gap with no capability to rescue and no capability to rescue from under ice.

Search-and-recovery capability regarding small objects has suffered the most severe cutback. Initial recommendations to the Navy provided a capability to locate and recover small objects over 98 percent of the ocean floor (20,000 feet) by 1970. A worldwide operational capability in this field will require highly sophisticated, deep-diving search-and-recovery vehicles, supporting research and development and instrumentation. The experience off Spain in the recovery of the nuclear weapon illustrates the problems in the fields of acoustic detection and imaging, underwater navigation and marking devices and endurance and maneuvering capabilities in the vehicles. It was fully 3 weeks after the loss of the nuclear weapon before any deep-ocean equipment was on the scene and an adequate surface-navigation network established. This portion of the Navy's program is now limited to one R&D prototype search-test vehicle with limited depth capability. In the area of large-object salvage the initial goal, salvaging an attacked submarine from its collapse depth, has been restricted by lack of funds to a 1970 operational capability of 600 feet, the depth of the continental shelves. Backup studies will enable implementation of desired capabilities, should adequate funding be made available.

In the area of extending man's capabilities as a free swimmer at desired depths, the Navy is performing only the minimum necessary, specific physiological research and development through controlled experiments in shore-based pressure facilities. This work is supported by a series of experiments (Sea Lab 1 and 2 being completed and Sea Lab 3 scheduled for February 1967*). These experiments are expected to continue until there is a demonstrated capability as deep as 1,000 feet.

In summary the four specific areas of effort recommended by the Deep Submergence Systems Review Group to the Secretary of the Navy regarding implementation and operational capabilities continue to be hampered by funding limitations. A worldwide rescue capability will be available in 1970. There is no planned capability for locating

Sea Lab II



*SeaLab III now scheduled for October 1967.

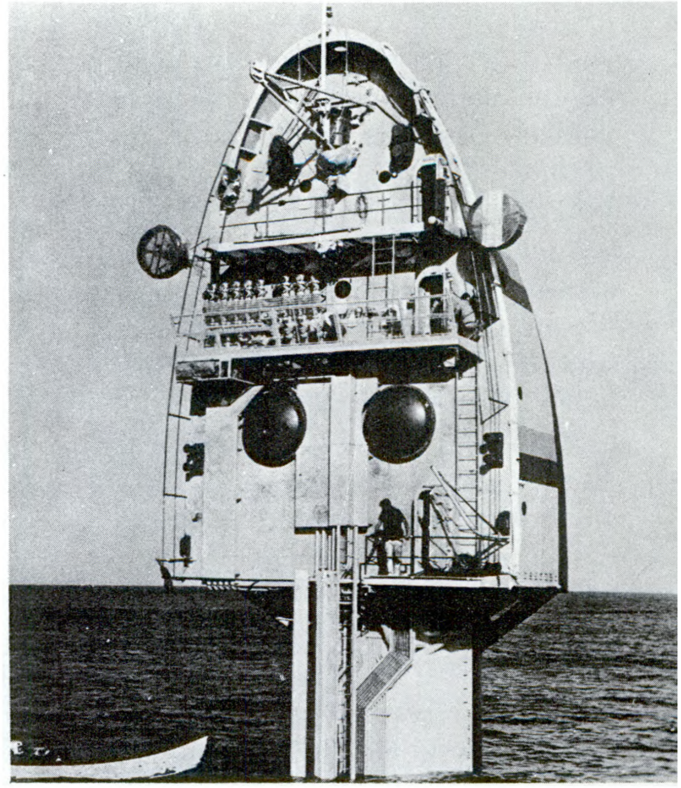
and recovering small objects from ocean depths beyond 6,000 feet (the mean depth of the ocean is 12,000 feet). The effort to extend free-swimmer capability into depths is proceeding on schedule but lacks adequate physiological and biomedical research. The Navy's salvage capabilities for intact submarines will be limited to the Continental Shelf.

The Navy's Role in Education and Research

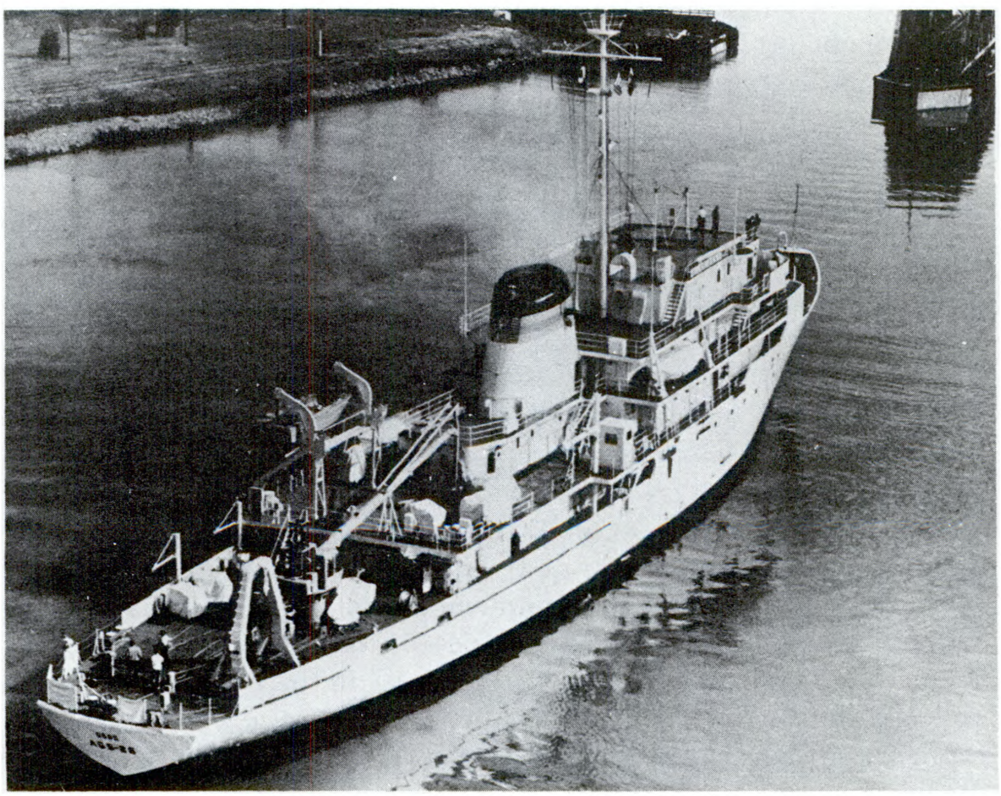
Although the Navy's role in ocean science is separable and clearly mission-oriented, the Panel feels very strongly that it should continue to be closely linked with academic education and research. In the past this connection has been mutually profitable. Academic oceanography would hardly exist if the Navy, chiefly through the Office of Naval Research, had not provided leadership and imaginative support during the past 20 years. This is a debt universally and freely acknowledged by research oceanographers. On the Navy's side support of broad research has provided substantial information about oceans necessary to carry out its present mission. In addition many research tools developed for basic oceanography have served as prototypes for operationally useful equipment. Examples include explosive echo-ranging, the bathythermograph, deep-sea-moored buoys, deep submersibles, underwater photography, bottom profiling by precision depth-sounders and discovery of deep-scattering layers. Variable-depth sonar and short-pulse target identification were byproducts of oceanographic research.

Moreover, oceanographers are highly responsive to Navy problems having little connection with research. Many instances can be cited of the Navy and the scientific community working hand in hand. Most recent of these is, of course, the concerted, successful effort to locate and recover the unarmed nuclear weapon off the Spanish coast. Response of the oceanographic community was instantaneous, and this group played a leading role in the weapon's recovery. In this instance, as in the tragic loss of Thresher, oceanographic institutions and civilian scientists put aside personal plans and volunteered to assist the Navy in its recovery mission. This civilian-Navy teamwork has proved highly successful and harmonious. Conversely, Navy personnel by virtue of their support of oceanographic laboratories are sufficiently aware of laboratory capabilities to facilitate immediate, effective action when an emergency arises.

Navy support of marine geophysical work in this country during the past decade has led to development of techniques for obtaining long-range sound transmission in oceans and acquisition of knowledge regarding parameters that affect it. When the Navy encounters difficulties with its sonar operations, competent people are available to rectify them. Similar instances in other fields of oceanography illustrate the



ONR's manned oceanographic buoy, FLIP (FLoating Instrument Platform), provides a stable platform for making oceanographic measurements. The unique vessel flips from the horizontal to vertical position and back by flooding and blowing ballast tanks.



The USNS SILAS BENT, first of a new class of research ships, is the latest addition to the Naval Oceanographic Office's fleet of research and survey vessels.

interaction between civilian scientists and the Navy. Further, as the Navy's detection and weapon systems become more sophisticated this interaction can be expected to increase.

Finally, and vitally important, the Navy has been a major consumer of the output of academic oceanography in both manpower and science. Without increased numbers of scientists and engineers knowledgeable about oceans the Navy cannot carry out many of the programs reviewed above. Likewise, without the generalizations produced by academic research the Navy cannot efficiently utilize information collected to support these programs.

For these reasons the Panel strongly *recommends* that the Navy continue its support of academic research and education related to oceans. As was pointed out previously, the Navy's budget for oceanography has almost doubled in the fiscal years 1965-67 period. The Navy's contribution to academic oceanography in the area of basic research during the period has remained constant. Under these circumstances the Navy may not be able to effectively utilize oceanography in the future. It is important that the Navy maintain a proportionality between its support of academic research and education and its total oceanographic program. This would imply a marked increase in support of academic oceanography if the proportionality prior to 1965 is to be maintained as the whole Navy program expands. We suggest, in addition, that the ONR might profitably reexamine the particular importance of ocean science and technology to the Navy's basic mission.

Interaction of Navy Programs with Civilian Technology

The Panel's projections concerning directions and rate of technological development, upon which so much of the Nation's ocean program depends, assume that the Navy will successfully pursue its current projects on Deep Submergence Systems and Man in the Sea. In the event the Navy fails to accomplish its objectives in these areas the Panel's estimates of progress, time, and cost will have to be revised. In such case it would be in the Nation's interest to assign programs with similar goals to civilian agencies.

The recent successful location and recovery of the unarmed nuclear weapon off Spain demonstrated the mutual benefits of close Navy-industry cooperation. It is recommended that the Navy make a continuing, special effort to utilize the people, facilities, and know-how of the private sector in achieving its objectives in the Deep Submergence and Man in the Sea Projects. Only in this way can the Nation hope to capitalize quickly and profitably on its ocean technology capability. In the event complete information exchange would involve classified data, the Panel *recommends* that arrangements be made to provide properly qualified industrial groups with access to this classified information.

By 1975 the Panel foresees the possibility of conducting complex, highly technical operations on the ocean bottom which are well beyond the limits of present technology. The Panel *recommends* that a proper Federal role related to ocean-technology development would be provision of a test range equipped with standardized stations in which component systems, concepts, and materials can be critically tested. Such a test range might consist of stations on the water's edge in the surf zone, at depths of 200, 600, 2,400, and 6,000 feet and perhaps in the abyssal deep. This facility would engender government-industry cooperation and technology developments with the desirable result of shortening the time required for specific developments and acceptance testing. The Navy in meeting its needs will undoubtedly require such a range. The Panel *recommends* that the Navy undertake a study which could lead to development of this range. Once implemented it should be made available to industrial and university groups, users being expected to pay a prorated share of the total operating cost and depreciation, as is the case in other national facilities.

Conclusions

An already extensive Navy dependence on oceanography R&D was predicted to increase rapidly in the future. Not only are oceans becoming more important as arenas for strategic and tactical military operations, but operations themselves are pressing into less familiar or understood portions of the marine environment. The twofold growth of the Navy's oceanographic program over the fiscal year 1965-67 period testifies to the degree of recognition given by the Navy and Congress to increasing military need for knowledge of the marine environment and for carrying out service operations within it. This trend apparently will not be deemphasized in the future; if anything, the overall Navy oceanography program may accelerate.

The priorities which determine the bulk of the Navy's oceanographic efforts are primarily military, and certain of these considerations are paramount, involving specialized requirements for both research and surveys, as well as engineering developments. We therefore *recommend* that the program remain solely under Navy direction rather than consolidated with perhaps somewhat similar programs of other agencies such as ESSA or a new civilian agency of ocean development such as the one proposed in this report.

Support figures indicate that basic research has remained relatively constant while the overall Navy oceanography program has approximately doubled. It is not entirely clear to us that the great increase in ocean-engineering effort associated with such new programs as the Deep Submergence Systems Project should proceed indefinitely without a corresponding increase in the Navy's basic-research support. A proportionality between research, particularly basic research, and the total R&D effort in the given fields should probably be maintained if brute-force engineering solutions are not to be inadvertently substituted for what ought to be more discriminating deployment of operational requirements made possible by greater environmental knowledge. Such knowledge generally requires considerable lead time for development and a long-term investment attitude toward research programs that produce it. It is in this connection that we wish to emphasize the importance of strengthening the traditional Navy tie with the oceanographic research and educational community, which appears to be jeopardized at present by stronger bonds with industry. Prompt and effective assistance from the ocean-science community to such urgent needs as the Thresher search and the recent successful weapon-recovery operation off Spain are, we feel, dramatic and by no means isolated examples of the beneficial, responsive nature of this tie. Both direct evidence from budgets and indirect evidence from excellent research proposals for basic studies which have been refused suggest the need for increased Navy support of the basic oceanographic sciences and technologies.

Opportunities in Oceanographic Research

Physical Processes

Benthic Boundary. At the bottom of the deep ocean there is a transition from fluid, to fluid with suspended particles, to solid with interstitial fluid, to solid. The detailed nature of this boundary is unknown, as well as whether its characteristics result primarily from physical or biological processes. An understanding of this boundary is essential in order to solve such problems as long-range sound transmission of powerful sonars (SQS-26), occupation at the bottom in permanent or semipermanent structures and search for objects at or near the bottom. The study of the benthic boundary is now possible because of the development of recording devices and probes which measure temperature, velocity, and pressure fluctuations at great depths.

The Abyssal Ocean. The deep distribution of oceanic variables (temperature, salinity, current, *etc.*), and planktonic and sedimentary particles appears to be determined by upwelling and turbulent fluxes. The most urgent need is for observational studies of the turbulent mixing processes. A thorough, well-planned effort to study the turbulent microstructure of the main thermocline would provide insight on the general circulation of the oceans, global weather and climatic fluctuations as well. It is intolerable that direct measurements of turbulent fluxes at depth are not being attempted. In our judgment this is within present-day technological capability but might require substantial engineering. A few pioneering studies made with sensors mounted on submarines and lowered by wire from surface vessels have shown fascinating microstructure. These studies provide a good basis for future development. Submarines are essential to the study of water under ice sheets. This cold water, of high salinity and density, eventually becomes the water at the greatest depths. The development of the bottom water remains largely unknown.

Buoy Programs. During the past few years several draft plans have been submitted to international bodies for oceanwide observational programs employing dozens of ships extending over several years—purportedly to study variability of oceanic circulation. To us they have seemed ill-designed from the point of view of sampling, because we believe it would be better to study smaller scales and higher frequencies first, even though these do not provide busywork for fleets of oceanographic vessels. In fact instrumented buoys seem better adapted to variability studies, although ships will, of course, be necessary to service them.

To date, use of moored buoys has been largely limited to efforts of individuals who, lacking the resources, logistic support, and necessary organization, have been unable to maintain dense enough arrays for a long enough time to gather statistically significant data. The signals are complex, and a sophisticated measuring program is required to read them. The problem would be difficult enough if all oceanic fluctuations were a broad spectrum of linearly superimposed internal waves, but, as mentioned above, there is undoubtedly a significantly nonlinear domain. Oceanographers need to evolve some fairly elaborate measuring arrays, with limited regions heavily instrumented. They are in the position of radio astronomers who need a radio telescope of a novel design, a facility quite beyond the capability of a single individual to design, build, and operate. The oceanographic community has been too concerned with conventional research and fund-raising and has devoted insufficient attention to exciting new scientific projects such as a viable buoy program.

Air-Sea Boundary. In order to predict large-scale atmospheric behavior for periods longer than a day or two, vertical fluxes of heat, momentum, and water vapor must be specified at the surface, both on land and in sea. Research and development along several independent lines are needed.

The spectral structure of atmospheric turbulence is being determined, and direct measurements of vertical fluxes are being made with rapidly responding sensors mounted on fixed platforms, aircraft, or submarines. Temperature and wind velocity sensors exist in experimental form. Interesting work is under way at a few institutions, but adequate humidity sensors have yet to be developed. This lack represents an important constraint on air-sea interaction research. Mean profiles measured from fixed platforms and buoys are also being used at a few institutions to estimate vertical fluxes.

However, in order to relate vertical flux measured at a point by either of the above methods to the "synoptic" scale commensurate with the weather prediction problem, measurements using integral methods over extended areas are needed. These require a carefully planned and coordinated program of research utilizing fixed platforms, buoys, aircraft, and possibly submarines. To date such programs have not been initiated.

Methods of isotopic and surface chemistry have recently been applied to the air-sea boundary, and these offer some interesting opportunities which should be exploited.

A substantial effort has been directed to the study of surface waves, particularly with regard to nonlinear actions and generation by wind. Studies have been dominantly theoretical; the need is for adequate field and laboratory measurements. Recent measurements of wave growth seriously differ from the accepted theory of wave generation. A substantial improvement could be achieved by means of a larger array of bottom-mounted pressure sensors (wave telescopes) which monitor the surface-trapped energy with reasonable resolution.

Coastal Boundary. The focus of the intersection of the surface and bottom boundary is the coastal zone. The hydrodynamics of breaking waves, tides, and tsunamis on the sloping shelf is not clearly understood. The mechanism of interaction between moving fluid and sediment underneath is not at all understood. It is well known that coastal structures do not perform in a way that is expected in other engineering fields. There are many examples of marinas where the annual dredging cost equals the construction cost, or harbors where sheltering breakwaters have led to increased seiching or wave action within the harbor. This points to the subject's difficulty, the need for fundamental research, and better application of known rules to actual practice.

Summary. It appears to us that it is now appropriate to end an era in which the main emphasis within physical oceanography has been on exploration. The MOHOLE and JOIDES programs to core far below the sea floor at carefully selected sites are more reasonable for the present level of oceanography. Likewise, the new, developing technology of bottom-mounted and buoy-supported instruments coupled with theoretical advances derived from efforts in geophysical fluid dynamics should lead to substantial, new, observational programs. These programs, as outlined above, can provide information about the environment essential for living sensibly within the oceans and using them. The focus should be on the nature of the benthic boundary, the weather and climate of deep oceans, and the interaction of oceans with the atmosphere and the coast.

Biological Processes

The Panel believes that marine biology must be regarded in broad terms. Specifically, marine biology embraces four major areas of research:

1. Animal and plant populations and their interaction with each other and the ocean.
2. The unique characteristics of diverse marine organisms that enable them to survive in the ocean.
3. Utilization of marine organisms as unique experimental material for investigation of biomedical problems.
4. The processes and factors involved in food production from the sea.

Some of the most scientifically interesting and socially significant problems confronting mankind exist in this arena.

Biomedical Applications. Our present understanding of many biomedical problems is based largely upon research initially conducted on lower organisms. The insights so afforded are valid because many biological processes of most kinds of organisms are fundamentally alike. Understanding of mammalian genetics stems in part from research on insects and micro-organisms; our understanding of human biochemistry derives from studies of lower animals and plants; and many of our present insights into the phenomena of fertilization and embryonic development are derived primarily from investigations of marine organisms.

One of the most challenging areas of contemporary biological research concerns growth and development. We still know little about how a human egg, one cell, is transformed into an adult composed of billions of cells in a thousand varieties, all precisely organized to produce a normally functioning individual. When normal development goes awry, various abnormalities or birth defects result. Much of our knowledge of fertilization and development has been obtained from studying marine organisms, some of which develop from egg to adult in 1 day and during this time are open to continuous observation and experimental manipulation. Study of the development of diverse marine organisms remains the best opportunity for enhancing our understanding of developmental biology.

In summary, the situation with respect to marine biology parallels that of physical oceanography. There are many clearly identifiable problems. Although there remains a need for special ocean surveys, we no longer need to give special emphasis to them. The broad outlines of the subject are clear. What is needed is a much greater emphasis on the problem areas reviewed above.

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Federal Organization and Program

Program Budget and Breakdown

TABLE 1
National Oceanographic Program Budget
Fiscal Year 1965-67
[In millions]

Agency	Actual, Fiscal Year 1965	Estimated, Fiscal Year 1966	President's Budget, Fiscal Year 1967
Defense	98.0	80.5	113.5
Commerce	20.1	13.1	16.4
Interior	20.2	19.5	19.4
National Science Foundation	44.0	43.2	43.0
Atomic Energy Commission	6.0	11.6	13.5
Health, Education, and Welfare	5.2	6.3	9.7
Treasury	2.0	2.1	2.3
Smithsonian Institution	.9	1.5	1.6
State	.4	.5	.5
Total	196.8	178.3	219.9

TABLE 2
ICO Breakdown of the National Oceanographic Budget Fiscal Year 1965-67
[In millions]

	Actual, Fiscal Year 1965	Estimated, Fiscal Year 1966	President's Budget, Fiscal Year 1967
Research[1]	70.5	81.4	84.3
Surveys	26.3	29.5	38.4
Ocean engineering	62.0	40.7	66.0
Ship construction	20.7	12.5	16.2
Instrumentation	10.3	9.4	8.4
Facilities	6.0	3.5	5.2
Data center	1.0	1.2	1.4
Total	196.8	178.2	219.9

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

Federal Role in a National Ocean Program

The Panel does not feel that it is the Federal Government's responsibility to plan or carry out the entire national ocean program. State governments, municipalities, private industry, and individuals motivated by local interests, profit, zest for adventure or curiosity should and must be counted on to devise and execute much of the desired program. There are, however, four Federal functions necessary to assure that the results are in balance and compatible with the national interest:

1. Enunciate national policies with regard to furthering U.S. marine interests.
2. Foster exploration, development and use of oceans and their resources through the establishment of appropriate financial, legal, regulatory, enforcement, and advisory institutions and measures.
3. Describe, predict, and develop capabilities for modifying the environment.
4. Initiate, support, and encourage programs of education, training, and research and provide technical services and facilities for relevant activities in science and technology.

Today, about 20 Federal agencies are concerned with ocean affairs. Each plays some role in one or more of the above functions, and all four are carried out to some degree at the Federal level.

It is obvious from a review of present agencies' activities, however, that only the last two functions are to any degree well developed and coordinated across agency lines. The first two functions, articulating national ocean policy and fostering exploration and use of the seas, are greatly in need of systematic development and implementation by a more centralized authority; and all four would benefit from it.

Department of Defense

Navy activities in oceanography are divided between those directed toward solving specific Navy problems and those involving a broad support of oceanography through Office of Naval Research contracts with universities, nonprofit institutions, and industrial laboratories. The Navy not only is a major supporter of basic research, but is also the principal contributor to survey programs through the U.S. Naval Oceanographic Office and to the development of ocean engineering, primarily through the Deep Submergence Systems Project. This project is funded at $32.8 million for fiscal year 1967. The Navy thus plays a dominant role in the country's oceanographic programs, with very heavy emphasis on the development of undersea technology. The

Panel has recommended continuation of Navy responsibility in this area.

ARPA maintains a small program (about $100,000) of seismicity study in the ocean and hydroacoustic seismic wave propagation, in support of their program for detecting underground nuclear explosions.

Organization for the Future

If one examines present agency activities against the four governmental functions, the Government is doing very well in meeting its responsibilities in supporting programs of research and education. NSF and ONR have developed strong support for academic activities in oceanography, although these need to be broadened beyond oceanographic institutions. On the whole the Panel believes that both NSF and ONR have discharged their duties well. Beyond the provision of ships, laboratories, and the National Oceanographic Data Center, the Federal Government has done little to provide technical services and facilities. We see an increased need for such facilities, and we expect the Navy to play a much more important role in the future than it has in the past.

Some progress in describing the environment has been made, but our abilities to predict are still minimal. Responsibilities for description and prediction are scattered throughout the agencies. The Navy supports a large survey program, as does ESSA, while smaller survey programs are found within Bureau of Commercial Fisheries, Geological Survey, and Coast Guard. The Navy, Coast Guard, and ESSA are all involved in the prediction problem, but the techniques remain primitive and do not reflect substantial advances in theoretical oceanography.

With the creation of a new agency oceanographic activities of the Nation would be supported in five ways:

1. By the NSF in its traditional role in support of fundamental studies through grants and fellowships with special emphasis on aspects that contribute to manpower education for ocean science and technology.
2. By the new agency in carrying out its responsibility for management of the environment and ocean resources and for providing description and prediction services through a balanced program of direct participation and support of industry and universities.
3. By the Navy in carrying out its mission of national security through its laboratories and industry and through ONR support of civilian institutions, as well as by its supporting role in the development of undersea technology and provision of national test facilities.
4. By agencies such as AEC and HEW in carrying out their missions.
5. By the Smithsonian Institution in fulfilling its unique obligation to systematic biology.

Priorities

Ocean Science and Technology

The Panel assigns highest priority to those efforts in oceanography that deal with national security. The problems clearly indicate a need for developing the capability of operating anywhere in the oceans, either by manned or unmanned vehicles, at any time. We are a long way from achieving this capability. The Navy should continue to be the lead agency for that part which pertains to national security.

The Navy in its Deep Submergence Systems Project is making an intensive effort at achieving part of this capability. We give this program a high priority, and we feel it should be expanded, including extramural consultation and participation. The requirements for achieving the capability include:

1. Development of large working volumes at atmospheric pressure.
2. Development of tools, manipulators, and semi-remote-control power tools and support structures.
3. Development of small underwater systems having power plants in the 10- to 100-kw range, which will require a greater emphasis on fuel-cell power systems than the Navy has so far supported.
4. Knowledge about the long-term effects of high pressures on man.

In terms of national security we feel high priority should be given to studies of the benthic boundary, since weapon systems of the future may be deployed on the ocean floor, and to basic studies of weather in the oceans at all scales. These studies are needed for construction and operation of undersea structures and are critical to the ASW problem.

We *recommend* that the Navy continue and expand its support of basic research through ONR. It has made highly successful contributions through research and education in the past, and we expect it to continue to do so in the future.

Summary of Major Findings Affecting the Navy

Oceans and National Security

Increased Federal participation in ocean activities is required for national security. The developing strategic situation, which may require a much improved undersea deterrent force, coupled with the need for defenses against missile-launching submarines, implies that the Navy must develop the capability to operate anywhere within the oceans at any time. The Navy has underway a Deep Submergence Systems Project. This effort as presently constituted is insufficient if the Navy is to meet its goals in a reasonable time period. The Panel therefore *recommends* expansion of activities which will permit operation at any location and time within the oceans. It is *recommended* that a continuing, special effort be made by the Navy to utilize personnel, facilities and know-how of the private sector in achieving its objectives in the Deep Submergence Systems and Man in the Sea Projects. Navy technological results in these programs should be made available to industry upon acquisition.

The Navy presently has primary responsibility for development of capability for using man at depths in the oceans. The general level of research in the Man in the Sea Project is inadequate. Insufficient attention has been given to biomedical problems of survival in the wet, cold, dark, high-pressure environment, and our efforts in this field lag well behind those of other countries. If the goals of the Man in the Sea Project are to be achieved, adequate opportunities must be provided for basic studies by a variety of institutions. In particular we *recommend* establishment of a major shore facility fully equipped for the range of basic studies required by Man in the Sea. This facility should be associated with a university or medical research center. Navy efforts may need to be complemented through instrumented, movable, submersible laboratories for basic studies on man living beneath the sea's surface for extended periods. These laboratories should be available to a wide community of scholars outside the Navy who are interested in biomedical problems of man in the deep sea.

The Panel recognizes that development of adequate programs in undersea technology and Man in the Sea may be hampered by traditional views within the Navy to the effect that the Navy is primarily an *operating* force at or near the *surface*. If the Navy does not adequately pursue programs recommended in this report, program responsibilities for Man in the Sea and undersea technology should be shifted to a civilian agency.

The *Thresher* experience in 1963 and the recent lost nuclear weapon incident off the Spanish coast clearly illustrate the continuing importance of search-and-recovery capabilities. We *recommend* that ocean search-and-recovery missions related in any way to national security be the Navy's responsibility. However, the technology developed through such programs should be made available to industry on a current basis.

The Navy should have broad responsibilities in furthering ocean science and technology in addition to its problem-oriented research. Most of the technology developed for undersea operations within the Government will result from the Navy's efforts. An important need is development of a test range equipped with standardized stations at which components, systems, concepts, and materials can be critically tested. Such a range will be an expensive undertaking, though of great value to private industry and university research. We therefore *recommend* that a supporting role of the Navy should be provision of test facilities that are open to scientific and technological communities. Users would be expected to pay a prorated share of operating costs and depreciation, as is the case in other national facilities.

The Navy has maintained good relations with the academic oceanographic community, and, in turn, the community has frequently responded to the Navy's needs in rapid and effective manner. The successful bomb recovery operations off the Spanish coast are a recent, dramatic but typical example of this cooperation. Long-term support of academic oceanography through the ONR has been fruitful in the past, and we *recommend* that the Navy continue these programs. The total Navy commitment to ocean science and technology has almost doubled in fiscal year 1965-67, yet Navy support of basic research has remained constant. This situation cannot continue if the Navy is to make adequate use of new developments in ocean science and technology; therefore, the Panel *recommends* that Navy support of basic research in the oceans increase at a rate consonant with the total Navy program in ocean science and technology.

Research in Oceanography

The Panel finds that much research effort in marine biology and physical oceanography during the last 10 years has concerned surveys of the ocean, measuring "classical" quantities. Such surveys were important 50 and even 20 years ago in defining problems; however, the subject has advanced to the stage that well-defined problems are *known* to exist. The Panel *recommends* that emphasis be shifted from *surveys to solutions* of these problems. A problem of great importance in physical oceanography both because of intrinsic scientific interest and possible contributions to security and commerce within the oceans is that of oceanic weather, weather being defined as fluctuations of temperature, pressure and current over a wide range of time and length scales. Major progress in this area can result from implementation of any of several buoy programs proposed heretofore. The Panel therefore *recommends* initiation of a step-by-step buoy program from detailed studies of limited regions to larger scale studies. A step-by-step program is necessary because buoy technology is not well developed.

Ships for Oceanographic Research

A substantial portion of the personnel in numerous oceanographic institutions is concerned with administration and operation of ships.

Ship time is more readily available to members of an institution than to scientists at universities and other organizations not directly connected with such an institution.

Within the institutions ship operations are no longer as flexible or as responsive to scientific objectives as they were 5 or 10 years ago. Operating costs of many ships are met by a conglomeration of grants and contracts. Because of administrative difficulties, we *recommend* comprehensive block-funding for oceanographic vessels. The funding should imply a commitment for the operating cost of the ship for its expected life. Operating moneys should be funded separately from the oceanographic project for which the ship is used.

Block-funding will facilitate more effective planning and scheduling of oceanographic ships. It does not, however, solve the problem of access to ships by qualified scientists regardless of institutional affiliations. Therefore, we *recommend* that oceanographic ships be grouped generally into regional fleets of reasonable size. Perhaps three or four such fleets would serve the Nation's needs. Fleets should be assigned to independent regional organizations representing user groups from oceanographic laboratories and universities. Every effort should be made to include in user groups those institutions which at present do not have formal activity in ocean science and technology.

Organization of Oceanography Within the Federal Government

The Panel *recommends* that the Nation's oceanographic activities be supported in five ways:

1. By the NSF in its traditional role of supporting fundamental studies through grants and fellowships, with special emphasis on aspects that contribute to manpower education for ocean science and technology.
2. By the new agency in carrying out its responsibility for management of environment and ocean resources and for providing description and prediction services through a balanced program of direct participation and support of industry and universities.
3. By the Navy in discharging its mission of national security through its laboratories and industry and through ONR support of civilian institutions, as well as by its supporting role in the development of undersea technology and provision of national test facilities.
4. By agencies such as AEC and HEW in carrying out their missions.
5. By the Smithsonian Institution in fulfilling its major obligation to systematic biology.

Cost of Recommendations

The defense component of the oceanographic program will probably increase more than nondefense expenditures if these recommendations are implemented. The Navy needs large, expensive facilities for its program. Furthermore, we have charged it with construction and operation of facilities for other agencies, industry, and private research, and with continuing support of education and research. Under the circumstances a doubling of the present program by fiscal year 1971 would not be unexpected.

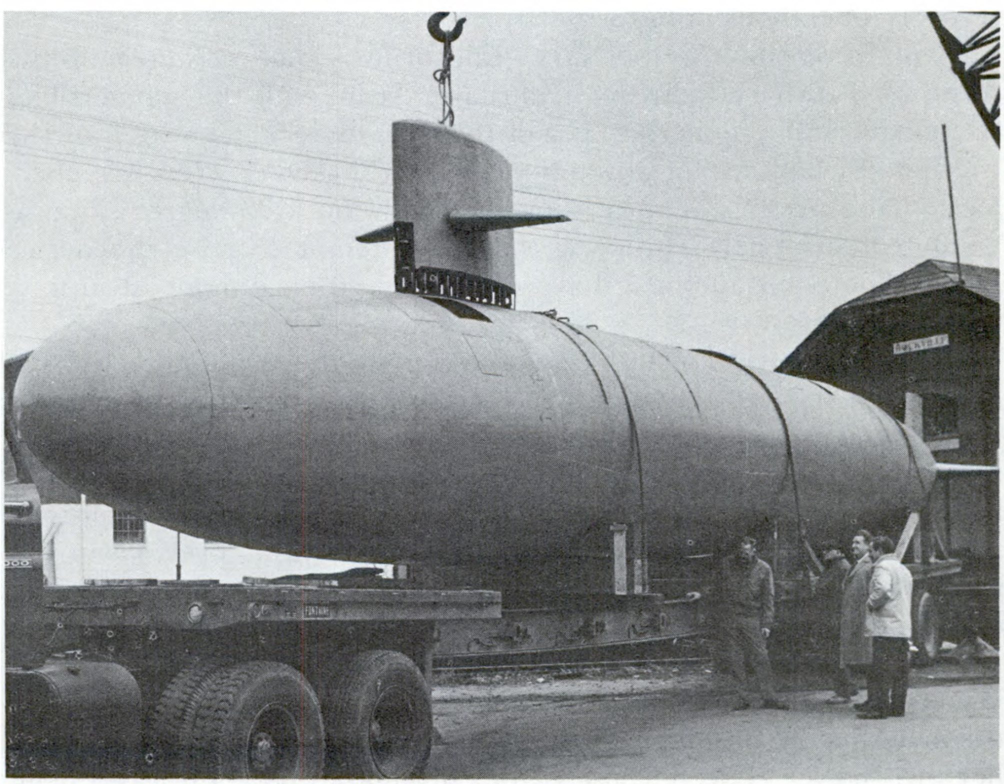
Unique Submarine Model Arrives at DTMB

A SS(N)637 Class 1/4 scale model of a nuclear submarine was delivered to the Navy's David Taylor Model Basin, Carderock, Maryland, on 6 December.

The model, which was built by Canadian Vickers for the Navy, will be used for studies in flow, vibration, and underwater acoustics. Planned programs will make use of the model for at least five years. Results from the model tests should contribute greatly to the advancement in submarine design.

This model, which is one of the largest structural scale models of a complete submarine in the world, involves the most sophisticated model design ever manufactured. It was built to this scale as the ultimate member of a series of models of increasing detail.

The model will be housed at the Model Basin for the winter months for installation of instrumentation and vibration-in-air testing. In the spring it will be transported to the Underwater Explosions Research Division of the Model Basin at Norfolk, Virginia, for deep pressure tests. From there it will be transported to the Model Basin Field Station, Bayview, Idaho, where studies will be performed in Lake Pend Oreille.



1966 - A Good Year for Alvin

CDR Rhodes Boykin, Jr.
Senior Submarine Warfare Officer
Office of Naval Research

Nineteen sixty-six was a banner year for Alvin, the Navy's busy little oceanographic research submarine. This unique experimental research tool served the Navy well, performing her tasks in sites ranging from Eastern United States shores to the coast of Spain.

Alvin is operated by the Woods Hole Oceanographic Institution for the Office of Naval Research for the purpose of carrying out a broad program of oceanographic research and performing special Navy missions at depths up to 6000 feet. The vessel, which was built by the Applied Sciences Division of Litton Industries, is 22 feet long, has a top speed of three knots, a cruising speed of 1.5 knots, and a range of 15-20 miles. The pressure sphere, which is 7 feet in diameter, accommodates two pilots and one observer and instrumentation and life-support equipment sufficient to sustain the crew for 24 hours or more.

Alvin had just completed her shakedown trials and was in the process of a final overhaul when a B-52 bomber and a KC-135 tanker (conducting routine refueling operations) collided in mid-air over the coast of Spain in January 1966. The resulting loss of an H-bomb in Spanish coastal waters initiated one of the greatest underwater search and recovery operations in history.

Alvin, in response to the Navy's call for assistance, was flown to the scene on February 2. In mid-February, Alvin, with the submersibles Aluminaut and Cubmarine, began the slow underwater search of the precipitous bottom terrain. On March 15, Alvin's crew members located the missing bomb resting perilously on a 70-degree slope in 2500 feet of water. However, the first attempt to raise the device failed. The bomb tumbled down the slope and once more Alvin took up the search.

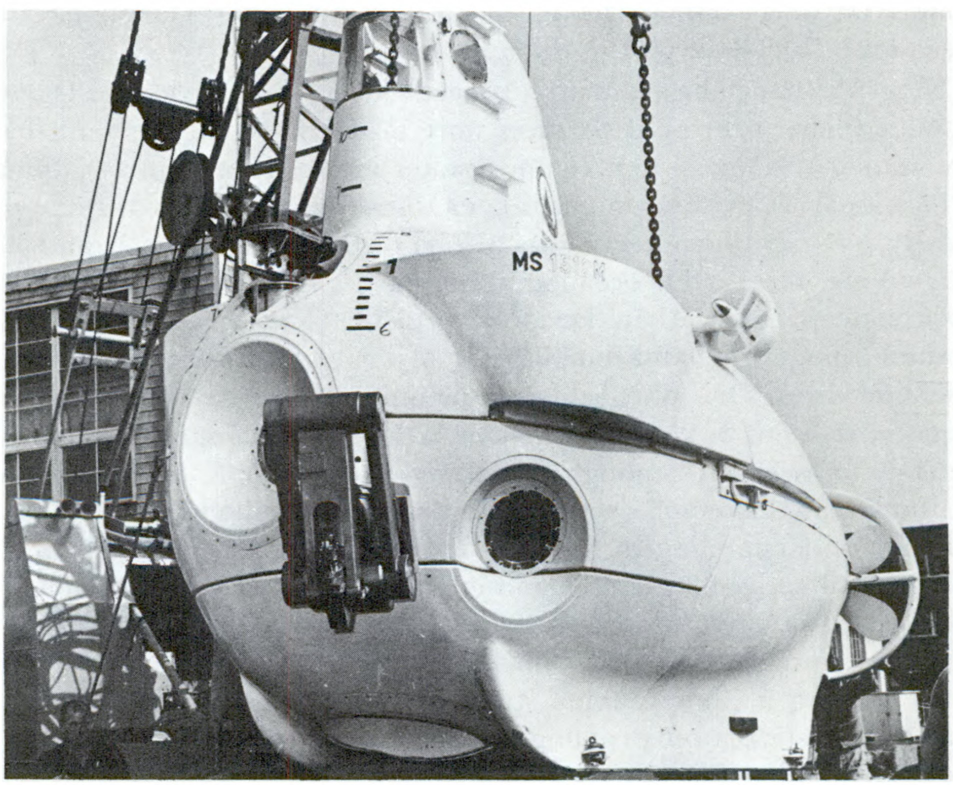
On April 2, Alvin's pilots located the weapon the second time. During the second recovery attempt, which was successful, Alvin stood by on the bottom monitoring the operation, ready to try again if the bomb should fall. During the entire mission, Alvin made 34 dives totaling 228 hours to depths as great as 3000 feet. The longest dive, which took place on March 15, lasted 11 hours. When it was all over, Alvin was transported by ship to Woods Hole to be refitted for summer and fall operations.

Alvin arrived in Bermuda on July 1 after a successful trip from Woods Hole aboard her support catamaran. This ocean journey marked the first time the support catamaran had steamed a long distance under her own power. The purpose of the Bermuda operation was a deep ocean engineering inspection of the Artemis array, a long-standing commitment to the Navy. In spite of the bad weather encountered during most of the operations, Alvin was able to complete the assignment successfully. Seven dives were made, six of which were to depths of 6000 feet. This was the deepest known underwater inspection and photographic mission ever undertaken, and it was accomplished in a very hostile environment. Cliffs, gullies, and strong currents encountered at these great depths made the task exceedingly difficult.

During the Bermuda mission, a purely scientific dive was made to a depth of 5850 feet. Dr. Robert Hessler, a biologist from Woods Hole, was aboard as observer. Alvin was rigged with two plankton sampling nets, which could be opened and closed by the mechanical arm. These nets were used to collect samples very near the bottom, a task difficult to accomplish with a surface towed net. The samples obtained are now being analyzed.

After an uneventful trip to the Tongue of the Ocean, Bahamas, Alvin began in late July to honor another Navy commitment. This time her assignment was a deep ocean inspection and photographic mission of the Navy's Atlantic Undersea Test and Evaluation Center off Andros Island.

This deep-water ship and weapons test range, which was conceived at the Naval Underwater Weapons Research and Engineering Station



Alvin, the Navy's oceanographic research submarine.

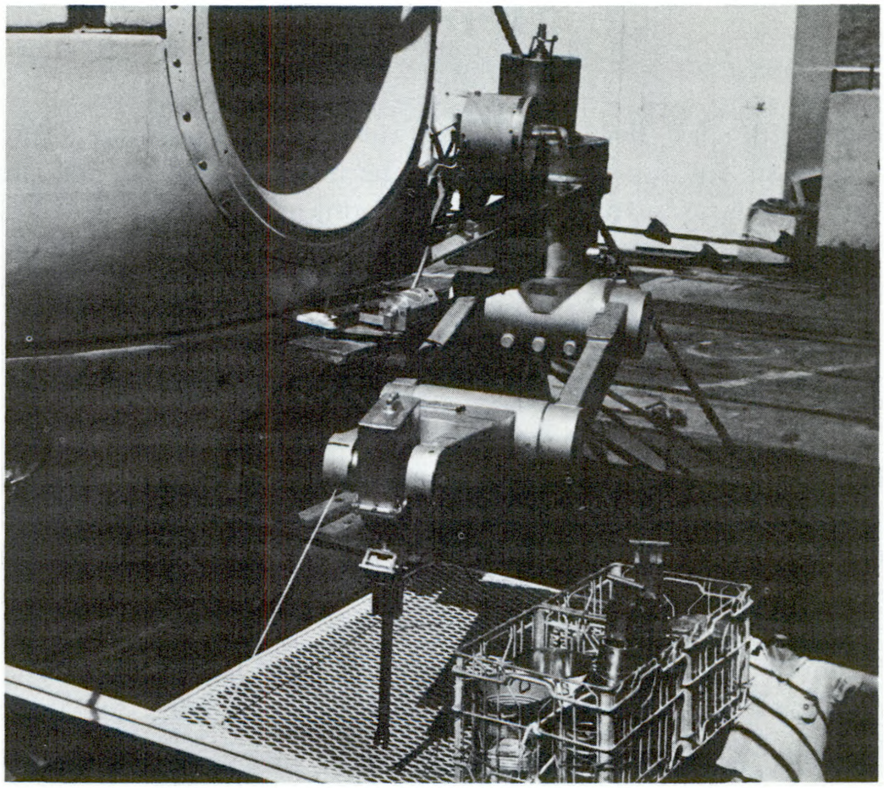
(NUWS), Newport, Rhode Island, and dedicated last April, provides indispensible data for the Navy's antisubmarine warfare program. The tracking equipment positioned at the bottom includes 59 hydrophones that are attached to cables leading back to computer and tracking facilities on land. Torpedoes fired at various depths and speeds over the hydrophone field generate signals which can be analyzed to determine the accuracy of weapon performance. Because the accuracy of each analysis is wholly dependent on the reliability of the hydrophones, it is essential that hydrophone positions, components and operation be as perfect as possible. Before Alvin was made available to NUWS, the station had no way to inspect the equipment.

Eight dives up to depths of 6000 feet were needed to complete the mission. Each dive lasted about five hours. Although natural light was completely gone at these depths, NUWS engineers were able to trace the cables leading to the hydrophones with the lights and camera mounted on Alvin's hull. In the process, they followed the strands over canyons and up steep cliffs, including one which rose 800 feet from its base. After inspecting the cable runs, the hydrophones, and a large vertical acoustic array, the engineers reported that the AUTEC range was well designed and properly emplanted. Also, they reported that the equipment was in good condition and that very little fouling had occurred. In addition to NUWS personnel, observers from the Navy's David Taylor Model Basin and International Telephone and Telegraph, Inc. took part in the operation.

Next Alvin and the catamaran proceeded to New Providence Island, B.W.I., where a series of six dives were made. Three of them, in shallow water, were made to take underwater movies for use in a National Educational Television program later this year. The other three were strictly for scientific observation. In one of these, made on August 23, Allyn Vine, the WHOI oceanographer who is Alvin's namesake, made his first deep dive in Alvin. He took her to 5850 feet to observe currents, bottom topography, and temperature at this depth. On the other two scientific dives, Dr. John Schlee, a member of the Geological Survey Agency, resident in Woods Hole, joined the crew to observe the bottom geology to ascertain, among other things, the structure of the Tongue of the Ocean. Core and rock samples were obtained and dated to gain a better understanding of how the Tongue of the Ocean was formed.

The final series of scientific and engineering dives in the Tongue of the Ocean was sponsored by the Naval Oceanographic Office. Fifteen dives were made, beginning on August 25, with objectives ranging from making a photographic study of bottom visibility to collecting data on acoustic bottom profiling and loss measurements.

On September 26, Alvin completed her tasks in the Bahamas and departed under tow by the catamaran for Woods Hole, arriving October



View showing mechanical arm mounted on Alvin.

2. Although a week in October had been set aside for scientific dives in Hydrographers and Oceanographers Canyons, bad weather prevented all but one dive. On October 20, Alvin was taken to Otis Air Force Base near Woods Hole for overhaul.

In summary, ONR can point with pride to Alvin's accomplishments in 1966. A recapitulation reveals a total of 75 dives during the eight-month operating cycle, an average dive duration of 5.7 hours, an average dive depth of 3200 feet, and a total of 21 dives in excess of 5000 feet. Upon completion of her overhaul, Alvin will be used in a broad-based oceanographic program in 1967 beginning in the Caribbean in the winter and ending late next fall in New England waters.

In recognition of the outstanding contribution by Alvin during the Palomares H-Bomb Search and Recovery Operations, the following WHOI personnel were awarded the Navy Civilian Meritorious Service Medal by the Honorable Robert Frosch, Assistant Secretary of the Navy for Research and Development:

Dr. Earl E. Hays - Chairman, Applied Oceanography Department

Mr. William O. Rainnie - Chief Pilot - Alvin

Mr. Valentine P. Wilson - Pilot - Alvin

Mr. Marvin J. McCamis - Pilot - Alvin

Mr. William M. Marquet - Electronics Engineer - Alvin

The Monster Buoy

During the past decade oceanographers have continuously found requirements for buoys which could be anchored in the deep sea to collect oceanographic data over long periods of time. In 1959, the Office of Naval Research, recognizing these requirements, decided to sponsor a carefully engineered development program of a general purpose buoy. ONR is continuing to manage the program as part of the Navy Oceanographic Program under the direction of the Oceanographer of the Navy.

To insure that the buoy would meet the needs of research programs and that it would represent the latest advance in oceanographic buoy development, a guidance committee, composed of research and engineering scientists from the oceanographic community, was established. The Convair Division of General Dynamics was the development contractor.

The buoy (appropriately labeled the Monster Buoy) which emerged from the extensive tests and programs conducted has the following general characteristics:

1. The buoy hull is discus shaped, forty feet in diameter and seven feet thick, with the bottom three feet of the hull tapered inward at an angle of about sixty degrees. Mounted on the hull is a forty-foot high mast which acts as a snorkel for the engine generators and as part of the discone radio antenna.

2. The power supply for the buoy is a propane fueled engine generator battery combination. The present system consists of two engine generators, a 20-cell battery, four 200-gallon propane bottles, and necessary plumbing and wiring. Each system (less fuel bottles) is located in a single equipment compartment. Each engine generator is enclosed in its individual box or module. For routine operation the systems are separate, with each handling part of the total load. The system uses a nickel cadmium battery.

3. The radio transmitter, for telemetering, operates on command from a shore station. It has three to four frequencies available between 3 and 30 megacycles. This provides sufficient flexibility for reliable transmission at all times.

4. The data system can handle 100 scientific channels. These can be sampled once an hour and the data stored in two memories. The short-term memory will be used to telemeter data to shore, and will report all data collected during the past 24 hours each time it is queried. This will occur every six hours. The long-term memory will report all data collected during the one year of unattended operation.

The Monster Buoy, developed for the Office of Naval Research by Convair, is one of the most significant advances in oceanography in the last decade.

5. The data is telemetered in binary bits as a pulse code modulated signal (PCM) on a frequency modulated carrier (FM). The radio will be single side band (SSB) with 100 watts average power.

At the present time, two prototype buoys (Bravo and Alpha) have been constructed. Buoy Bravo has undergone an extensive series of tests in the Gulf Stream and off the coast of Bermuda where it was moored at a depth of 20,000 feet. It will soon be moved to the Convair plant in San Diego, California. Buoy Alpha has recently been completed and is being readied to participate in the next phase of the program.

Three basic tasks are involved in this next phase. The first is the installation of identical Ocean Data Acquisition Systems in both buoys. The next step is a long-range telemetry test using Buoy Alpha and its shore-located Mobile Data Center. Third, system studies to insure proper integration of all developments into the overall operational capability of the buoys will be undertaken.

Buoy Bravo is to be completely refurbished. The hull and mast will be cleaned and repainted. Sensors will be installed on permanent mountings. Engine generators located in individual modules will be installed. The Ocean Data Acquisition System will then be completely operational and ready to be deployed.

In preparation for the telemetry testing program, Buoy Alpha will be outfitted with a variety of sensors which will make oceanographic and meteorological measurements. Included will be sensors to measure wave height, slope, and profile; current velocity and direction; surface water temperature and salinity; subsurface water temperature, salinity, and pressure; precipitation; radiation; relative humidity; wind direction and velocity; and barometric pressure. The buoy will then be moored in 500 fathoms of water off La Jolla, California.

The range of coverage for radio telemetry between Buoy Alpha and the shore-based Mobile Data Center is approximately 2500 nautical miles. To test the system, the MDC will move northward along the West Coast pausing to interrogate the buoy at regular intervals. A variety of commands are possible. This flexibility is due to the capability of selecting any one of five completely independent sensor-scanning programs stored in the buoy's magnetic core memory.

System studies will be continued on the various parts of the overall buoy system. These studies will include data acquisition studies, energy conversion system studies, mooring system studies, and sensor studies. They must be undertaken in order to assure that a possible breakthrough in any art applicable to buoy technology is made known and investigated.

When the long-range telemetry tests are completed, Buoy Alpha will be returned to San Diego for complete refurbishing. It will then be ready to join Buoy Bravo in deployment and operation in scientific experimental programs. The Office of Naval Research will have provided oceanographers with a convenient system for obtaining information never before available.

An Acre of Buoys

The Naval Oceanographic Office recently established "an acre of buoys" approximately half way between Cape Hatteras and Bermuda to measure and interpret the dynamic characteristics of the ocean in a small area. It was planned to take measurements at intervals varying from 15 minutes to one hour over a period of from six weeks to six months by means of sensing arrays moored at depths as great as 17,000 feet.

The arrays are of two basic types. One is the Scripps Catamaran array, which measures water temperature at depths as great as 1000 feet, and which records temperature, wind speed and direction, compass heading of the catamaran, and line tension at one hour intervals. The second type, called the "NAVOCEANO array," is a combination tautline-slackline moor that measures currents at five-foot intervals between depths of 50 and 6550 feet, temperature and pressure from 330 feet to 6550 feet, and wind speed and direction.

Skyhook Churchill 1966

CDR Donald A. Sumner
Physics Branch
Office of Naval Research

On August 14, 1966, a milestone in scientific ballooning was passed when the Office of Naval Research 1966 Skyhook balloon program, conducted at Fort Churchill, Manitoba, Canada, was completed. Between June 10 and August 14, thirty-two consecutive successful flights were made. The balloons used in 28 of these flights were at least three million cubic feet in volume, and 18 flights were made by balloons with a capacity of 10.6 million cubic feet. Each balloon carried a scientific payload weighing from 66 to 631 pounds which probed the cosmic-ray flux. Other measurements were made at stratospheric altitudes as high as 144,000 feet on flights that lasted as long as 22 hours.

"Skyhook Churchill '66" was the eighth of a series of scientific balloon flights that began in 1959. The series was a logical extension of the ONR Skyhook balloon program that began on September 25, 1947, when a University of Minnesota emulsion package was carried to an altitude of 100,000 feet. In 1959, Dr. James A. Earl of the University of Minnesota (now of the University of Maryland), supported by ONR, conducted the first scientific investigations by balloon at Fort Churchill. The host for this first venture was the Director of Canada's Defense Research Northern Laboratory. Assistance was provided by members of the Canadian Army and the U.S. Army Arctic Test Center, who were stationed at a military base at Fort Churchill.

The Fort Churchill support facilities, now designated the "Churchill Research Range," have been placed entirely under civilian control. The Research Range is operated jointly by the Canadian National Research Council and the U.S. National Aeronautics and Space Administration under the general supervision of Dr. J. H. Brandy of the Research Council. Each year since 1959, the number of balloon flights, the support provided by the Research Range, the quality and scope of the Range facilities, and the variety and number of scientific groups represented have increased. All of these factors played a role in the success of this year's program.

During the 1966 season, eight institutions participated in the Fort Churchill balloon flights. These institutions were the California Institute of Technology, the University of Chicago, the NASA Langley Research Station, the Goddard Space Flight Center, the University of Minnesota, the University of Maryland, the University of Rochester, and the Jet Propulsion Laboratory. Under the sponsorship of ONR and NASA, investigators from these institutions conducted a multitude of cosmic-ray experiments, took simultaneous measurements of the vertical distribution of dust and ozone, obtained radiation measurements at high altitudes in support of the supersonic-transport program, and tested instrumentation for future satellite investigations.

Many changes have taken place in the makeup of the Skyhook program at Fort Churchill since the program began in 1959. The first program utilized eight contractor personnel, six balloons, one aircraft, and was conducted for a period of one month. The latest program involved 13 Raven Industries balloon operations personnel, more than 40 balloons, four aircraft, and lasted for more than two months. The operations personnel included two launch crews, which permitted multiple launchings in a minimum of time. Thus, they could take advantage of every period of suitable meteorological conditions.

Headquarters for the recovery operation was 520 miles west of Churchill at Uranium City on Lake Athabaska, Saskatchewan. From there, the recovery pilots operated a float-equipped Cessna 206, a Cessna 185, and a Bell G3 helicopter in the best traditions of the bush pilot. Aircraft tracking of as many as four airborne systems and logistics support between the launch and recovery areas were furnished by the crew of a C-47 (DC-3) aircraft operating from Fort Churchill. This aircraft also verified the tracking capability of the three-station direction-finding network established for the 1966 program.

Two innovations contributed materially to the success of this year's program. The first was the installation of a 12-inch very high frequency (VHF) antenna on the tracking beacon. This antenna provided clear, sharp signals for direction finding from aircraft and ground stations during all types of weather. The 300-foot medium high frequency (MHF) antenna used in previous years posed an obstacle to balloon launchings because the balloons or their payloads could easily be tangled in it upon leaving the ground. The second innovation was the use of "Stratofilm" polyethylene balloons, which were built by Winzen Research, Inc. Not one of these balloons burst or leaked during the 1966 operations.

The success of the 1966 scientific balloon operations at Fort Churchill was the result of the highly motivated efforts of many people representing many institutions. The plans for 1967 are now being formulated. If the successes of 1966 are an indication of the future, another milestone will be reached.

The thirteenth annual Radar Symposium will be held in Seattle, Washington, June 13-15, 1967. Since 1955, the University of Michigan has conducted this annual symposium under tri-service sponsorship. The host sponsor for 1967 is the Air Force through the Air Force Avionics Laboratory, Wright-Patterson Air Force Base, Ohio.

On the Naval Research Reserve

New Autogyro Interests Naval Reserve

Members of Naval Research Reserve Company 1-1, Boston, Massachusetts are closely following the progress of a diverse group of Navy and Marine Corps personnel in the development of an entirely new type of autogyro aircraft.

The autogyro, which will have the unusual capability of automatically folding and stowing its overhead rotor so that it can travel along the ground at high speeds like an automobile, is being developed by the Aeronautical Research and Engineering Corporation in Boston. The founder and president of the company is a 24-year-old Marine Reservist named George Fryer, who is applying for membership in NRRC 1-1. One of the company's directors is GEN W. E. Sweetser, Jr., USMC (retired), who has 28 years' experience as a Marine aviator. The executive vice-president is Roger Swanson, a former member of the old Naval Air Corps.

Among those watching developments are CDR D. M. Aulick, USN, Executive Officer and Research Reserve Assistant of the Office of Naval Research, Boston; and CDR P. W. St. George, USNR, a business executive and electronics engineer who is Commanding Officer of NRRC 1-1. Both CDR Aulick and CDR St. George have been studying the military potentials of the autogyro.

This new aircraft, called the "Autocopter," will be able to land or take off in any small clearing. It will have a flying range of 425 miles at an air speed of 125 m.p.h. and a service ceiling of 14,400 feet. On the ground, the autogyro, which will seat four, will have a speed of 65 m.p.h. It will be small enough—2,500 pounds and 17.5 feet long—to park in any garage or meter space.

Unlike a helicopter, an autogyro is stable and cannot stall or spin. In flight, the rotor is free-spining, with power supplied by a pusher propeller. The Autocopter's rotor, however, can also be powered by hydraulics, which will give the aircraft a hovering potential. In ground travel, the rear wheels are also powered by hydraulics.

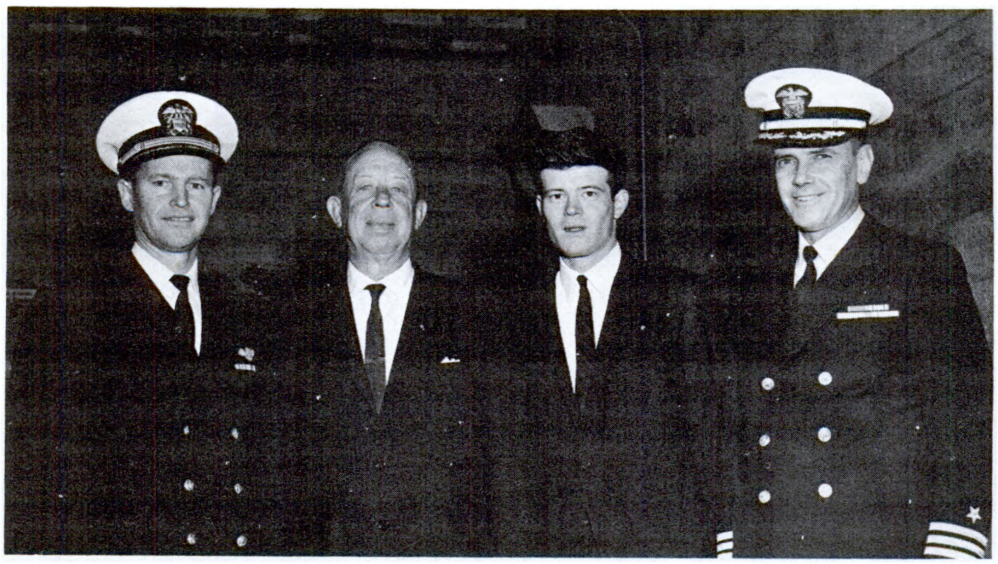
The Autocopter, which will have a buoyant, salt-water-resistant fiberglas fuselage, can be easily converted for water travel. A small modification in the basic design would permit replacing the four wheels with pontoons. Also, the Autocopter can be equipped with special fiberglas armor plating for protection against small arms fire.

The completed Autocopter can be shipped anywhere in three basic components—power plant, fuselage and frame—and assembled. Four pins will attach the engine. It will be relatively simple to operate, according to Mr. Fryer, who said that naval officers with no previous flight training can be taught to fly an autogyro in eight hours or less.

CDR St. George, the CO of NRRC 1-1, became interested in the Autocopter during his recruiting efforts to find individuals in research and engineering who meet the Navy's requirements for its Research Reserve Companies. NRRC 1-1, which was founded in 1949, is the second largest in the country, having 74 members. Most of the members are officers who have served on active duty. Seventeen of the membership, which includes a high proportion of professional men, engineers and scientists, have advanced degrees and seven have doctorates. The company meets twice a month at the Massachusetts Institute of Technology.

The Autocopter project began two and one half years ago. Initial flight tests are expected to take place this winter.

Submitted by:
CDR P. W. St. George
CO, NRRC 1-1



After inspecting the Autocopter are (left to right) CDR D. M. Aulick, USN; GEN W. E. Sweetser, Jr., USMC (ret); George Fryer; and CDR P. W. St. George, USNR.

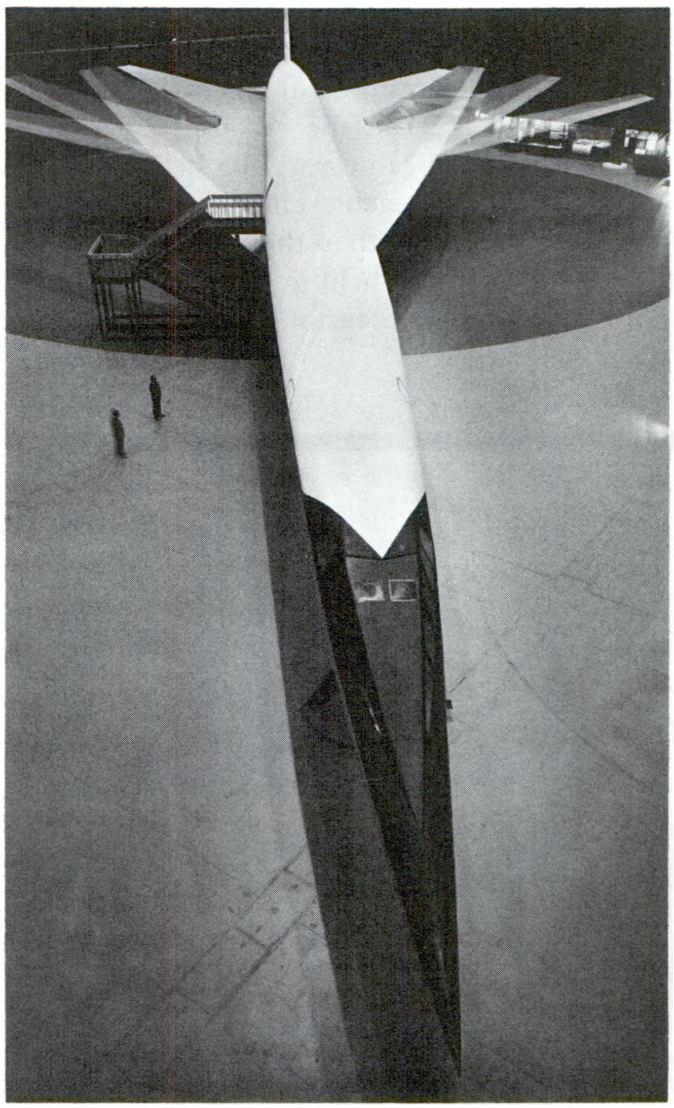
Visits to Washington Industries

With the rapid expansion of the Pacific Northwest, the major focus in that area has been upon industry. To add interest and variety to the Naval Reserve program, and to better acquaint Research Reservists with their local industry, Naval Reserve Research Company 13-1, Seattle, Washington, has planned tours through a number of local plants to supplement many fine talks presented by representatives of the related industries.

Under the able guidance of the Commanding Officer of NRRC 13-1, LCDR Philip H. Stern, USNR, and the Program Officer, LCDR Willard Bevans, USNR, the company recently toured the mockup of Boeing's supersonic transport airplane which was selected to become the first such airliner built in the United States. Guests on the tour were CAPT Elbert S. Churchill, USNR, Commanding Officer, and LT M. R. Lacey, USNR, Executive Officer, of the Naval Reserve Training Center, Seattle.

Another recent tour was made to the Department of Fisheries facilities in Seattle. This visit was timely and interesting because of the controversy over the presence of a Russian fishing fleet off the Northwest coast.

As the tours have aroused considerable enthusiasm, more of them are being planned for the near future.



Mockup of Boeing's supersonic transport airplane.

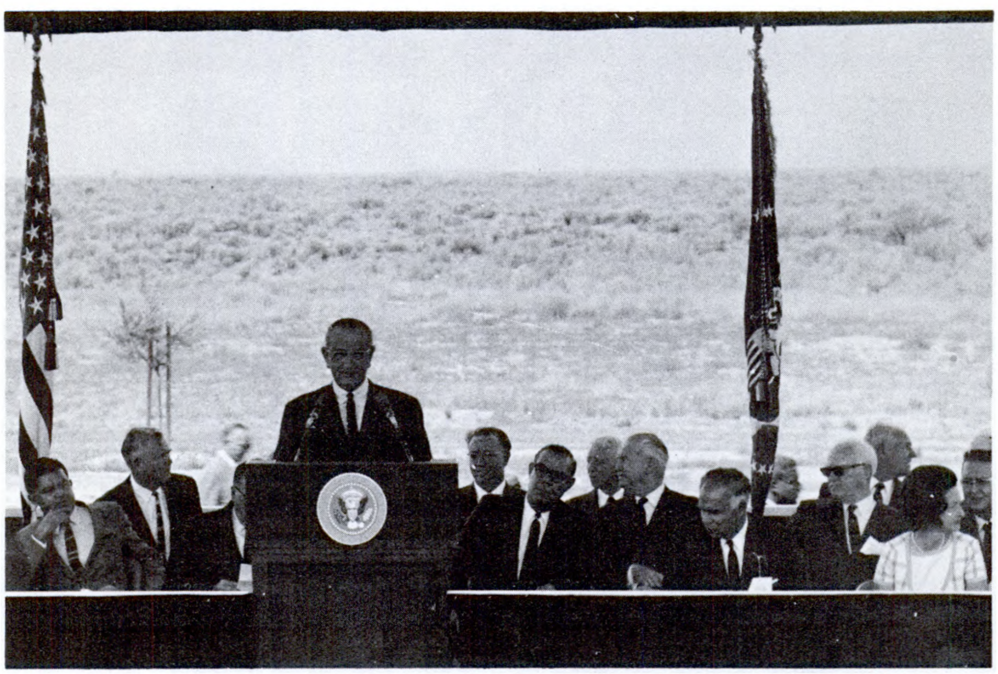
NRRC 13-6 Assists for President's Visit

The 13th Naval District Band, under the direction of Chief James L. Fox, participated in services held August 26, 1966, when the historic Experimental Breeder Reactor No. 1 (EBR-1) at the National Reactor Testing Station near Idaho Falls, Idaho, was accorded permanent recognition as one of the nation's registered historic landmarks. The ceremony was attended by President and Mrs. Lyndon B. Johnson, several Senators and Representatives, and all of the Atomic Energy Commissioners except one.

The arrangements for the 13th Naval District Band to participate were made by the Naval Research Reserve Company 13-6 of Idaho Falls, at the request of the Idaho AEC Operations Office. LTJG H. S. Cook, aide to the Commandant, 13th Naval District, finalized plans for participation and accompanied the band to Idaho Falls.

EBR-1 was first brought to power on December 20, 1951. Its nuclear heat was fed to a turbogenerator and electricity was produced. This historic accomplishment marked the world's first production of electricity from nuclear fission. However, the accomplishment was only incidental to EBR-1's greatest achievement: proving that fast breeder reactors can produce more fuel than they consume.

Highlighting the ceremonies, held in the heart of the sagebrush-covered, 894-square-mile National Reactor Testing Station, was the address



President Johnson speaks at ceremonies held at Idaho Falls by the President of the United States. The President was introduced by Mr. William L. Ginkel, Manager of the Idaho Operations Office. President Johnson told an attending audience of 12,000 persons that "one-fifth of the nation's electrical capacity will be nuclear generated by 1980," and extolled the Idaho Atomic Reactor which started it all.

The President said, "Orders have presently been placed by public and private utility companies for power reactors with a combined capacity of more than 15,000,000 kilowatts—more than enough electric power for the homes of all the people of Idaho and several western states. This is energy to propel the machines of progress, to light our factories, to provide new sources of fresh water, and to help solve the mysteries of outer space as it brightens our life on this planet."

New Seminar to be Held at Argonne National Laboratory

The Office of Naval Research and the Naval Reserve Research Company 9-23, Forest Park, Illinois, in conjunction with the Argonne National Laboratory, will present a two-week active duty for training seminar at Argonne, Illinois, from April 24 through May 5, 1967.

The host company, NRRC 9-23, is commanded by LCDR H. Krass, USNR. Seminar Chairman is CDR R. Puricelli, USNR, of the Argonne staff.

The seminar will include descriptions of nuclear research in the Life and Physical Sciences at Argonne National Laboratory. The tentative program calls for presentations by Laboratory staff members in the following areas: biology and medicine, including research programs with applications to the U.S. space effort; chemistry, with special attention to the creation of noble gas compounds; high energy physics research; reactor engineering, including discussions of reactor safety and of nuclear applications in space; metallurgy; mathematics; electronics; and chemical engineering.

The seminar schedule also calls for tours of several Argonne facilities, and visits to the Abbott Laboratories, the Great Lakes Naval Training Center, the Chicago Filtration Plant, and the Naval Ordnance Plant.

A highlight of the training seminar will be a banquet at which Dr. Albert V. Crewe, Director of Argonne, will speak on "Science and Crime."

The Naval Propellant Plant, in Indian Head, Maryland, is now officially known as the Naval Ordnance Station. The change was made to reflect the station's interrelationship with the Naval Ordnance Systems Command and other ordnance stations.

NRL Scientists "Observe" Meteor Shower

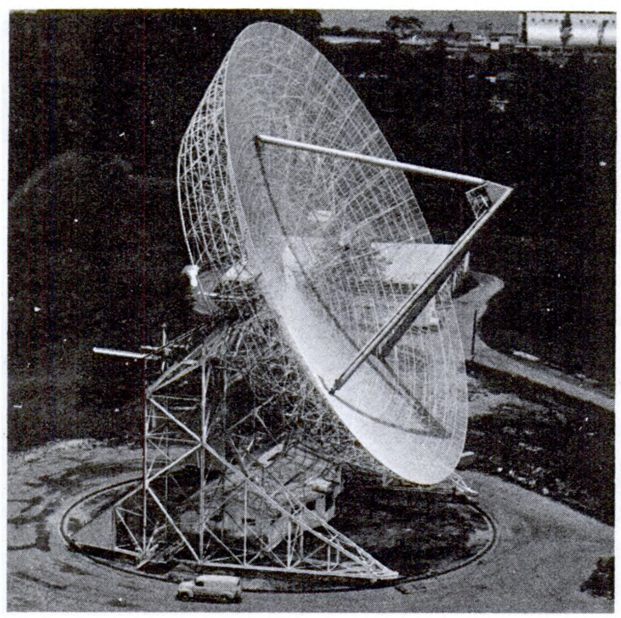
While most observers of November's spectacular Leonid meteor shower were scanning the horizon with their eyes or optical instruments, Naval Research Laboratory scientists sat in an instrument-filled room high above Chesapeake Bay peering intently at a radar screen.

They also were "observing" the shower—by means of spikes on the radar screen. Each spike represented passage of a meteor as recorded by the Laboratory's 150-foot diameter radar antenna at its Chesapeake Bay Division.

NRL scientists reported that their experience with the antenna during the Leonid shower proves it can provide useful data on such phenomena. They pointed out that radar adds a new dimension to the long-continuing study of meteor showers by optical observations. Radar can "see" more meteors and smaller meteors than can be observed by the human eye.

The radar observations made in November were especially important because the peak of the shower occurred at 7:10 a.m., an hour when the eastern part of the United States was in sunlight. It is impossible to view meteors against a background of sunlight.

Laboratory scientists are particularly interested in the effect of meteor showers on the ionosphere, a region beginning about 60 miles above the earth's surface. The 150-foot radar antenna has been used as a research tool for determining the electron content of the ionosphere and its temporal variations and to study phenomena which causes radar echoes from field-aligned ionization. It is also used to determine radar-echo characteristics of missiles, satellites, and other space targets.



NRL's 150-foot radar antenna at its Chesapeake Bay Division.

President Lyndon B. Johnson paid special tribute to Dr. Robert M. Page (right) during a retirement party December 20, 1966, for the Naval Research Laboratory scientist who left his post as Director of Research on December 30. In a letter presented by Captain Thomas B. Owen, Laboratory Director, the President noted that Dr. Page's "distinguished career as a scientist and an administrator is an example for many dedicated young people who have chosen the public service as a career." During his 40 years at the Laboratory, Dr. Page received more than 50 patents including substantially all basic radar patents. He has been Director of Research at the Laboratory since 1957.

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Random Noise

Dr. Richard C. Carlston, of the Office of Naval Research Metallurgy Branch, has been elected a Fellow of the Washington Academy of Sciences. He was nominated in recognition of his discoveries in the electrochemistry of anion exchange processes, particularly the so-called "lithium chloride effect," and of his contributions to a deeper understanding of the crystal chemistry of transition metal oxides and the factors which contribute to structural phase stability.

Dr. Richard Trumbull, former Director of the ONR Psychological Sciences Division, has been assigned to the position of Research Director, effective January 2. Dr. Sidney G. Reed, Jr., former Research Director, has been named Physical Sciences Advisor.

Dr. Frank W. Patton, of the Naval Research Laboratory's Optical Physics Division, has been invited to become a visiting lecturer at Dartmouth College, Hanover, New Hampshire, for the winter term of 1967. Dr. Patton will teach Thermodynamics and Statistical Mechanisms—a course taken mostly by seniors. In addition, he will be working with college professors on the magnetic properties of color centers in alkali-halides and related materials.

Dr. Guy Sellers Harris, 66, former Associate Technical Director for Research at the U.S. Navy Underwater Sound Laboratory, New London, Connecticut, died on Sunday, November 27. During 1962-63, Dr. Harris served as Chairman of the Navy Department's Underwater Sound Advisory Group, which advises the Chief of Naval Research and the Chief of Naval Operations on all matters pertaining to the scientific discipline of underwater sound as it is applied and used by the U.S. Navy.

Note: "Random Noise" is a new feature of NAVAL RESEARCH REVIEWS. *It will contain news of the Naval research community, announcements, and other items of interest.*

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Editor: BEATRICE M. EIESLAND

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Artist's conception of a future undersea habitat and divers working with the Navy's planned Large Object Salvage System. The system, when developed, will have a capability of raising 1000 tons deadweight using surface based stabilized crane system and a series of buoyant pontoons. See article beginning on page 1.