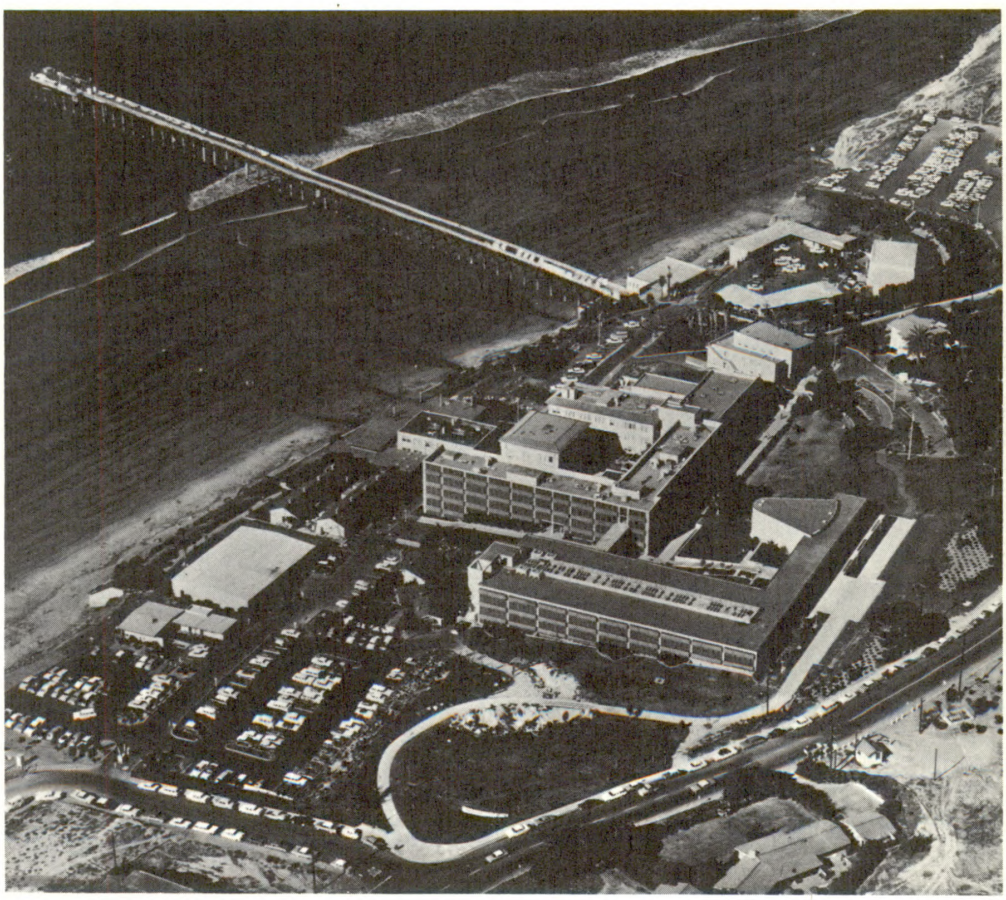
NAVAL RESEARCH

REVIEWS

DECEMBER 1965

OCEANOGRAPHIC INSTITUTIONS

On following pages, NAVAL RESEARCH REVIEWS *presents the first of a series of articles that will highlight major oceanographic institutions that receive support in large measure from the Office of Naval Research. Other articles of the series will appear during 1966.*



The Scripps Institution of Oceanography, La Jolla, California.

The Scripps Institution of Oceanography

Marsten C. Sargent
Scientific Liaison Officer for
The Office of Naval Research
Scripps Institution of Oceanography

History

The beginnings of the Scripps Institution of Oceanography can be traced to 1892 when the University of California first sponsored studies of marine biology on the coast of southern California. In 1912, title and management of a site in La Jolla were taken over officially by the University, and the Institution acquired the name of Scripps, in honor of Mr. E. W. Scripps and Miss E. B. Scripps who had contributed most or the support to that date. In the first decades, in spite of isolation and the lack of craft with a cruising radius greater than a few dozens of miles, some major discoveries were made. G. F. McEwen, E. G. Moberg, and E. C. Michael recognized that along the coast of California cool water rises to the surface from depths of a few hundred feet, especially in spring and summer. They related this upwelling to the prevailing seasonal winds and showed that it causes the summer fogs and low temperatures on the coast and also the tremendous productivity of the coastal waters, which was evidenced by the great sardine fishery of those days. Since their discoveries, it has become known that this phenomenon occurs predictably on other coasts of the world and supports other major fisheries, such as that for Peruvian anchovy.

In 1936, Harald U. Sverdrup, a distinguished physical oceanographer from Norway, on becoming director of Scripps, started arousing interest in the deep sea. From another generation of the Scripps family, he acquired a 95-foot auxiliary schooner, with which he and the staff ventured as far as 1200 miles by sea from La Jolla. During the few years before 1941, he and his associates, notably R. R. Revelle, R. H. Fleming, M. W. Johnson, and F. P. Shepard, obtained data, prepared charts, and published reports on the major features of the ocean currents, the origins of the water types, the topography of the bottom, and the kinds and distribution of the commonest pelagic invertebrates in the coastal strip several hundred miles wide from Cape Mendocino to Cape San Lucas, including the Gulf of California. During these years, the U. S. Fish and Wildlife Service first assigned people from its Palo Alto laboratory to participate in Scripps cruises, and the California Department of Fish and Game cooperated in data collection.

Upon the outbreak of World War II, the University of California established a Division of War Research under the National Defense Research Council. A number of Scripps scientists devoted their full time to the San Diego facility, which worked closely with the U. S. Navy Sound School and the Radio and Sound Laboratory (now the Navy Electronics Laboratory), thus becoming the first important link between Scripps and the Navy. During this period, M. W. Johnson discovered that the source of a static-like noise that was frequently troublesome to sonar operators was snapping shrimp, whose typical habitats and hours of activity could be predicted on a worldwide basis. Sverdrup and other researchers at La Jolla, under contracts with the Hydrographic Office and the Bureau of Ships, developed methods of predicting waves, swell, and surf that were used in the invasion of North Africa and thereafter throughout the war. They also taught marine meteorology to classes of officers of the Armed Services, from which sprang a number of oceanographers who are now well known. In spite of the pressure of the time, Sverdrup, Johnson, and Fleming, in the early months of the war, finished *The Oceans,* by far the most comprehensive volume on this subject published before the present decade.

In 1946, the newly established Office of Naval Research began supporting some of the work funded previously by the other Navy agencies. In the years that followed, it has become the largest single source of funds for the Scripps Institution. With this and other support (chiefly from the State of California, the National Science Foundation, and the Atomic Energy Commission), Scripps has expanded its investigations to the whole Pacific Ocean. It has also made four cruises into the Indian Ocean, of which two continued around the world.

Present Organization

Scripps is now an institution for research and graduate instruction in the University of California, San Diego. The University's San Diego campus, which began to take shape before 1960, will, according to plan, in about 25 years, consist of 12 undergraduate colleges and several graduate schools. At present, it includes one college, a graduate school of science, and a skeleton staff for other units. The Scripps Institution, with a total payroll of more than 800, has an academic staff of 35 faculty members and 90 research scientists in three divisions: Oceanography, Marine Biology, and Earth Sciences. In 1965, seven doctors degrees and four masters degrees were awarded. Within the Scripps organization, several research groups that emphasize diverse problems are administratively separate, such as the Marine Physical Laboratory, the Visibility Laboratory, and the Marine Life Research

Group. University units that are not part of Scripps but that work closely with it and are quartered on its campus are the Institute of Geophysics and Planetary Physics and the Institute of Marine Resources. Adjacent to the Scripps Institution in La Jolla is the Fishery Oceanography Laboratory of the Bureau of Commercial Fisheries, which also houses the headquarters and laboratory of the Inter-American Tropical Tuna Commission. Scripps and the Bureau of Commercial Fisheries maintain a radio station on the campus with worldwide coverage. More than half of the Scripps staff works in the La Jolla laboratories, but a considerable fraction is about 15 miles away on Point Loma in facilities in or close to the buildings of the Navy Electronics Laboratory, with which the Institution has close working relations. Within a few months, the Institution will complete an operating base for its fleet on a six acre site on the Point.

As the principal tools of its trade, Scripps has six ships and will soon have a seventh. They are the following:

Name	*Length*	*Tons*	*Type*
AGASSIZ	180 ft	800 gross	ex–FS
ARGO	210	1400 gross	ex–ARS
HORIZON	143	570 gross	ex–ATF
OCONOSTOTA	100	254 displacement	ex–YTF
ELLEN B. SCRIPPS	95	115 displacement	new
THOMAS WASHINGTON	210	1100 gross	new AGOR 10
ALPHA HELIX	130	290 gross	(under construction)

The fleet also includes FLIP (see page 7) and several small craft that range in length from 28 to 65 feet.

Scientific Work

The variety and complexity of the scientific work at a large oceanographic institution defies any brief account other than a mere catalog. Scientists at Scripps are actively studying surface and subsurface currents; surface waves, internal waves, swell, tsunamis, and tides; circulation and the exchange of dissolved substances; the physiography of the bottom, the origin, transport, and distribution on the bottom and in long cores of minerals and fossils; the structure of the material in the upper few hundred meters of the bottom by seismic reflection and the deep structure of the earth by seismic refraction, magnetometry, and gravimetry; shore processes; the behavior of sound, light, and electromagnetic energy in the sea; biological oceanography, including the identity, distribution, morphology, life histories, population dynamics, physiology, and quantitative ecology of plankton, fish, and bacteria.

It is not possible to mention everybody who has made important contributions, and of course it is beyond anyone's capacity to credit all the facets of a major idea to their myriad originators. The following may not even be the most important contributions made by Scripps in the last two decades, but they are representative in variety and quality.

Surface Waves

The study of surface waves, which was first stimulated at Scripps by Navy needs, continues unabated under W. H. Munk and others. Measurements by C. S. Cox and R. L. Snyder of the growth of wind waves with increasing fetch or downwind distance from shore have yielded to empirical formulation but have compelled an overhauling of more basic theoretical treatments which is not yet complete. A method has been developed for calculating the distribution of wave slopes from aerial photographs of the sun's glitter pattern on the sea. W. H. Munk, F. E. Snodgrass, and associates have been able to date and locate storms in the Antarctic and Indian Oceans using the changes with time of the power spectrum of swell arriving on the southern California coast from the southwest. The shift in time of the most prominent frequency in the observed swells, due to dispersion, gives the time since the train originated, and the velocity yields the distance. The direction is obtained from the times of arrival of individual waves at several points in an array (*e.g.,* a triangle).

Waves from submarine earthquakes (tsunamis or "tidal waves") have periods of 2-1/2 minutes or longer from crest to crest. As with swell, it is possible to determine the point of origin of tsunamis (although the accuracy is not equal to that obtainable from seismographic observations). G. R. Miller and W. G. Van Dorn have estimated the total displacement of the sea bottom or the equivalent energy input necessary to generate observed tsunamis. When trains of long waves are recorded simultaneously in deep water offshore and in shallow water close to the coast, the coherence and phase difference between the stations vary with frequency. The conclusion of Munk and associates is that the shallow water acts as a wave guide for long waves in frequency bands determined by the geometry of the location.

A program is underway to calculate (and measure by way of check) the tides in the deep ocean directly from the fundamental equations of mechanics and astronomical data.

The studies of waves at Scripps combined with the work done at other institutions has led not only to methods of predicting waves and surf on beaches but also, through extensive work by the Navy Oceanographic Office, to advising ships at sea on the best routes for minimizing encounter with adverse wave conditions. The new work on tides was undertaken in part with the hope that by distinguishing clearly the

periodic effects of the sun and moon from the irregular effects of wind, atmospheric pressure, and local geometry, better predictions can be made of destructive storm tides and of tides at locations where historical data are inadequate for the harmonic analyses now in use.

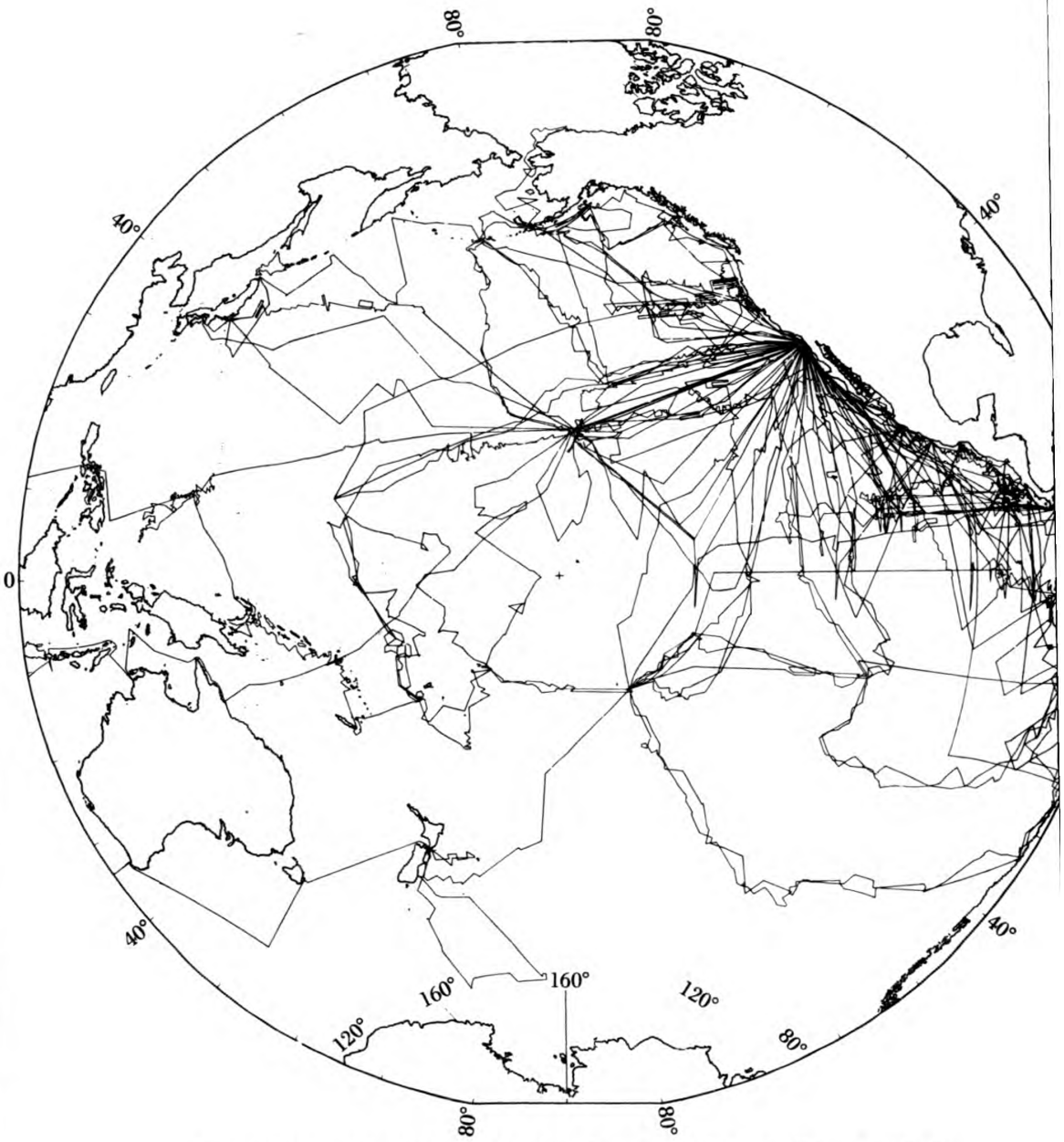
Currents

The surface currents of the North Pacific, which were known in a rough way to the masters of the Manila galleons 300 years before Scripps was founded and known in part to Polynesian navigators even earlier, have gradually been assuming a clearer pattern in recent decades. The pattern has taken shape most noticeably since 1950, when Scripps began making long cruises in the Pacific. Observations made by cooperating agencies, notably the Navy and the Bureau of Commercial Fisheries, have contributed also to the emergence of the pattern. An important advance in recent years has been the identification and measurement of large permanent subsurface currents. The first of these was described originally by the late Townsend Cromwell, whose name it now bears. On the equator at modest depths (*e.g.*, 30 to 300 meters at 140°W), the Cromwell Current flows eastward at velocities that sometimes exceed three knots. Above it the long-known South Equatorial Current flows westward at speeds that sometimes exceed one knot. The Cromwell Current is known over a length of 3500 miles and carries as much water as the Florida Current. This discovery has been extended by Knauss especially, but also by workers at other institutions, so that several well-developed subsurface currents are now known. Although respectable theory had indicated the existence of subsurface currents in other localities, a determined search for them was not made until the Cromwell Current was found. The discovery has stimulated a great deal of new theoretical work.

New understanding of surface circulation comes from the discovery of a South Equatorial Countercurrent in the Pacific by J. L. Reid, who also has found evidence of a similar east-flowing current in the Atlantic, and from a series of explorations of the currents along the west coast of South America by W. S. Wooster with the cooperation of oceanographers in Peru and Chile. The knowledge gained to date (together with technological advances) makes it possible to plan for the near future an extended series of synoptic observations by instrumented buoys. The buoys would be moored at critical points to chart the dimensions of the major currents and their daily and seasonal changes throughout the northeastern Pacific.

Internal Waves

In a medium having a vertical density gradient, particles at all depths can move in closed orbits like those in surface waves. Such movements,



Hemispheric chart showing tracks of most of the expeditions made by the Scripps Institution in the Pacific Ocean before 1964.

or internal waves, are most commonly observed by measuring the changes of temperature at a point in a water column having a vertical temperature gradient. With suitable precautions, such changes can be used as measures of vertical water movement. Cox and others at Scripps have contributed significantly to our understanding of these complex phenomena. Recently, they have shown that in stratified water, tidal energy flows into the internal wave system as the tidal currents move over a sea floor of varying depth. As much as one-third of the tidal energy in an ocean may be dissipated in this way. Ability to predict these movements along with the turbulent movements of water in the

sea can lead, among other things, to a better understanding of the propagation of sonar signals, especially over long ranges.

FLIP

A stable floating platform on the surface of the sea has long been wished for by scientists as well as by the seasick. The first successful craft of this kind was built under the direction of members of the staff of the Marine Physical Laboratory at Scripps, especially F. N. Spiess, P. Rudnick, and F. H. Fisher. Omitting many essential design features, one can describe the structure as a cylinder 355 feet long that is 20 feet in diameter for nearly half its length. It can be towed in a horizontal position to a point of interest and upended by admitting sea water to a series of ballast tanks, and afterwards it can be returned to the towing position. When vertical it draws 300 feet, and its bow, which contains a laboratory, living space, and machinery, projects 55 feet above the water. The position and orientation of instruments mounted anywhere on this rigid structure are related exactly to the position and orientation of the emergent portion.

FLIP was launched in 1962 and fitted out in October of that year. As of September 1965 it had made 26 expeditions, gone through 77 flipping cycles, and spent 230 days at sea, including a period of 28 days at a point 1000 miles west of Cape Mendocino, where, in waves more than 25 feet high, it rose and fell no more than 9 centimeters and rolled no more than one degree. FLIP has been used for measuring internal waves, swells in the open sea, anisotropic sound refraction in the sea bottom, and especially for studies of directional underwater sound propagation—the mission for which it was designed and for which it is almost uniquely suited.

DIMUS

Steering large acoustic arrays by signal processing rather than by mechanical rotation has become an art of steadily increasing importance to the Navy as arrays have gotten larger and more efficient use of the information received by the sensors has been demanded. V. C. Anderson of the Marine Physical Laboratory of the Scripps Institution, who for a long time has been interested in the directional characteristics of ambient noise in the sea, developed a system dubbed DIMUS for "digital multibeam steering." The most basic contribution amounted to representing the signal from each hydrophone during a specified time by a single binary digit which can be processed by well-developed techniques. In DIMUS the inputs are passed through clipping amplifiers which quantize them into either of two amplitude states representing solely positive or negative polarity. The inputs from all hydrophones are sampled simultaneously at very short intervals, and each

input is introduced into a shift register. In order to form a beam directed at an angle θ, the appropriate stages on all shift registers are sampled simultaneously to produce time delays complementing the times of arrival of the signal from angle θ at individual hydrophones in the array. The DIMUS principle is being incorporated into a number of Navy equipments now under development or construction.

Physiography of the Sea Floor

The continuously recording echo sounder and precise time measurement make it possible to resolve the depth of water within a few fathoms and to resolve bottom features with a diameter of a few hundred fathoms. With careful planning of courses so that the records show critical sections, the oceanographer is now able to see relatively small features, which give him clues to the processes which shape the bottom. This is especially true when the bathymetry is compared with seismic refraction and reflection data, with magnetic and gravimetric measurements, and with the mineral and fossil contents of bottom samples. All of these subjects are being studied at Scripps. H. W. Menard has been especially active in assembling bathymetric data and drawing conclusions about the character of the bottom features of the Pacific and the processes molding them. For example, he relates two types of features that were considered formerly to be distinct in nature and origin. The greatest topographic feature of the sea floor (and of the globe) is a nearly continuous mid-ocean elevation that can be traced from the North Atlantic to the North Pacific by way of the Indian Ocean. It is characteristically broad, has gentle slopes, and in the Pacific is the site of a narrow band of earthquakes and active or recent vulcanism. In the central and North Pacific, however, there is a connected series of ridges that are narrow and steep and that bear islands and deep guyots, which indicate long quiescence and slow subsidence. Menard suggests that the latter is a more mature stage in the development of the great mid-ocean ridge system. With other investigators, he has charted five fracture zones, or narrow bands of mountainous bottom, separating bottom areas of different average depths. These zones, which follow great circles approximately perpendicular to the west coast of North America, are over 2000 miles long and 600 miles apart. Aside from its scientific interest, this kind of discovery shows the practical possibility of inferring the physiography and other properties of the ocean bottom in areas in which few observations have been made. The Molokai Fracture Zone (one of the five) has been described only recently, but its existence and position were predicted ten years ago on the basis of very scanty evidence.

Near Shore Sediment Transport

The continual shifting of beach material and offshore bars has always presented serious problems to engineering developments of the shore and shallow waters on open coasts. Frequently, the construction of a jetty to protect a harbor entrance has been followed by an accumulation of sand that seriously constricted the entrance. D. L. Inman has been a leading figure in studies of the mechanisms of the movement of sand. At first, these studies were supported by the Beach Erosion Board (now the Coastal Engineering Laboratory), but for the last decade they have been supported principally by the Office of Naval Research. A much simplified description of the basic mechanism is that the rapid orbital movement of water particles in waves and the turbulence of the surf cause the sand to be picked up; and the steady, slow water movement of general currents causes the momentarily suspended sand to be transported a short distance along the bottom (or up or down the beach) before it is redeposited. This interaction of waves, which supply the energy to lift the sediment, and currents, which are responsible for the net transport of sediment, is a transport mechanism potentially operative wherever waves move sediment. It is likely the most important mechanism for sediment transport over the continental shelves of the world.

Inman and other investigators have shown that when waves strike a straight shore at an angle, a net shoreward transport of water is compensated by the development at regular intervals along the beach of rip currents, which are narrow but swift currents running directly away from shore for a few hundred feet. The sand, accordingly, moves shoreward slowly over a broad front and then is scoured and moved rapidly seaward in a narrow zone. Inman has studied the relationship between the changes in the profile of a beach during a cycle of spring and neap tides in a location where strong afternoon sea breezes occur regularly. The steepness of the beach changes regularly depending on whether the energetic wind waves beat on it at a high water level or a low one. Using SCUBA, Inman and his associates have measured precisely changes in the bottom level outside of the surf zone and related them to changes in the amount of sand on the beach. With increasing utilization of the shore and shelf in prospect, studies of this kind are becoming critically important.

Fisheries Studies

In the late forties, the California sardine fishery, which for a quarter century had been one of the world's great fisheries, entered a serious decline. The Legislature and Congress were moved to support a considerable expansion of studies that Scripps, the California Department

797-145 O-65—2

of Fish and Game, and the U.S. Bureau of Commercial Fisheries had long cooperated in with little formality. These agencies then organized the work under the title "California Cooperative Oceanic Fisheries Investigations."

For more than 15 years CalCOFI have kept under surveillance (often at intervals of less than a month) the strip of water 300 miles wide from the Columbia River to Cape San Lucas. The currents, temperature, biologically important chemical substances, plankton, and all fish populations of present or potential commercial importance have been under study. At this time no satisfactory succinct answers can be given to the questions, "What happened to the sardine?" and "When will the sardine return?" However, it is now known that a sustained fishery much larger than the sardine fishery in its best year is possible in California. The barely fished anchovy are more numerous than the sardine and, judging by the distribution of fish scales in sediment cores, very likely always are. Other large unexploited populations of valuable fish (hake, jack mackerel, squid) have been discovered. The barriers to exploitation are chiefly legal and social. For example, public opinion and law have not yet recognized that the most popular American way to eat fish is to feed it to chickens and steers and eat the resulting eggs and meat. Consequently, regulations forbid the reduction of anchovies to fish meal even though millions of tons of the latter are imported. Another facet is that California fishermen are accustomed to fishing for small volumes of valuable fish, such as tuna, instead of large volumes of cheap fish. When these barriers are overcome, science will have led the way to a large addition in natural resources.

It should be added that most Navy activities on the West Coast and in the coastal waters have made use of data on physical oceanography collected by CalCOFI.

Consultant Services

An activity of the Scripps Institution staff (and other scientists) not specifically required by contracts and seldom even mentioned to swell the list of accomplishments in annual reports is service to the Navy as consultants, advisors, members of standing committees, participants in *ad hoc* conferences, and members of boards, visiting committees, or similar bodies to review research or other programs in DOD agencies. Closely related are group services, which are provided when the Institution is asked for information that actually requires a small crash research program or occasionally an extensive program of applied research. Individual staff members also take leave or use sabbatical periods to serve in a paid status in Government positions. Except for the last activity, these services are almost always given without any extra compensation to the individual. Except for extensive programs

of applied research, they are almost always given without any additional payment to the Institution.

At least a third of the research staff at Scripps from time to time renders such professional services. Several members regularly spend more than ten percent of their time doing so, and a few members have spent a third of their time over periods of several years doing so. These people are serving or have served on such bodies as the Deep Submergence Systems Review Group; Artemis Signal Processing Committee; NAS-NRC Committee on the Disposal of Low Level Radioactive Waters in the Pacific; Curriculum Review Committee, Department of Meteorology and Oceanography, USN Postgraduate School, Monterey; SUBROC Technical Advisory Group; consultant to Pacific Missile Range on beach problems; Site Selection Committee, remote sensors, NASA; NOTS Advisory Board; USN Vehicles Advisory Panel; Project Sorrento; review panel for DQQ/2 sonar; Armed Forces–NRC Committee on Vision; lecturer (on regular schedule without compensation) Fleet ASW School; ONR Deep Water Propagation Committee; and The President's Science Advisory Council.

Scripps participation at the Navy's request in operations Crossroads, Ivy, Castle, Wigwam, and Redwing amounted in each case to a major program of applied research. In each of the last three operations, a considerable part of the staff was involved for more than a year, and Scripps supplied one or more ships for several months to collect field data.

The main reason for enumerating these services (which are still merely samples) is to emphasize that this expert knowledge would be much less available to the Navy if the Office of Naval Research had not functioned as it has. First, ONR is intimately familiar with most of the oceanographic activity in the country and can locate qualified experts promptly. Many ONR contracts for oceanographic research are of wide enough scope so that urgently needed services can be provided under them immediately. Finally, oceanographers are keenly aware that they owe ONR something extra in return for many years of dependable support for worthwhile long-range research without insistence on immediate applicability. Their readiness to devote themselves to pressing Navy problems when asked to is a result of the high standards set by ONR for support of basic research.

Perhaps you have heard about the design engineer who told a pilot, "Your days are numbered. Automatic controls will soon be running everything." The pilot replied, "I'm not worried. You have yet to improve on man–a control mechanism that weighs under 200 pounds, has five senses, six degrees of freedom, is completely self-contained, self-powered, self-lubricated. Above all, you have yet to invent a control device so readily and easily produced by unskilled labor." ***From a speech by Hon. Victor M. Longstreet, Assistant Secretary of the Navy (FM), given at the Northeastern States Navy R&D Clinic, Philadelphia, Nov. 18, 1964.***

Research Notes

Launching Rockets Remotely from Unmanned Buoys

A new concept in rocket launching to obtain meteorological data on the upper atmosphere will be tested for the Navy this winter in northern Michigan. Small rockets, called weather buoy rockets (WEBROCK) will be launched automatically from a buoy platform moored in Lake Superior at the tip of Keweenaw Peninsula. The first launchings were scheduled for mid November, but they were forestalled by inclement weather.

The primary purpose of the test launches is to determine the feasibility of the WEBROCK concept, which is to fire rockets from unmanned weather and oceanographic buoys to obtain atmospheric data from altitudes as high as 100,000 feet. The concept is being developed by the Space/Defense Corporation of Birmingham, Mich., under contract to the Office of Naval Research. By installing the rockets in a series of buoys moored in oceans around the world, the WEBROCK system could provide synoptic measurements of great value to long-range weather forecasting and to the Navy's Antisubmarine Warfare Environmental Prediction System (ASWEPS).

A 2.75-inch FFAR rocket will be launched from an octagonal buoy that is kept buoyant by eight empty, sealed 55-gallon drums. The buoy, which is 11 feet in diameter and weighs about 800 pounds, has a net positive buoyancy of about 2200 pounds. Four rockets will be clustered vertically in a protective container located at the midpoint of the buoy. The first two rockets will be launched to demonstrate the feasibility of the concept. The others will have instrumented nose cones that will be ejected at approximately 22,000 feet. As this package descends by parachute, the instruments will transmit meteorological data to ground stations. As half of the mass of the atmosphere lies between the earth's surface and the 25,000-foot level, a wealth of information could be obtained from the WEBROCK system.

Buoy instrumentation includes electronic control to assure that each rocket will be launched vertically or nearly so. A time-lapse camera mounted on the buoy will record information on film which will aid in determining the initial angle of launch of each rocket and the buoy attitude at time of launch.

The site of the tests will be the Keweenaw Rocket Range, which is located in Michigan's Upper Peninsula immediately adjacent to Lake Superior. The range, which is under development by the University of Michigan, provides an excellent "ocean simulator" for the WEBROCK buoy.

When the test launches have been completed, the buoy will be moored in nearby Lac La Belle for about 30 days. In place of rockets, a camera will be installed on the buoy to obtain data on the reliability of WEBROCK equipment that is exposed to the elements for long periods of time. It is expected that the conditions under which the tests will be conducted will be comparable in severity to those of the open ocean.

By mounting somewhat larger rockets on a buoy, it should be possible to obtain data from altitudes as great as 100,000 feet. Such larger rockets could be mounted on the Navy's new long-range telemetering buoy, which is now

undergoing testing off the coast of Florida. This 40-foot dish-shaped platform is designed to collect both oceanographic and meteorological data and transmit this information on command to shore stations as far away as 2500 miles while operating unattended for a year (see *Naval Research Reviews*, October 1964). A large number of WEBROCK rockets could be placed on board and fired on command from shore at invervals over a period of several months.

NEL Installs 60-Foot Communications Antenna

As part of a project called "Microwave Space Relay," or "MISER," the Navy Electronics Laboratory has installed a 60-foot parabolic mirror on a high granite outcropping 50 miles east of San Diego. The site, which is in a remote area, was chosen in order to minimize the danger to human beings of the antenna's electromagnetic radiation and to provide a relatively static-free environment for operations.

The antenna can be used for either receiving or transmitting. Among the experimental tasks that have been outlined for it are the updating and extending of our knowledge of moon bounce signals and the investigation of various single-bodied passive "satellites of opportunity" with respect to communications.

The installation will increase markedly the capability of the NEL communications complex.

NEL's new 60-foot parabolic mirror antenna is lifted to the top of its supporting tower.

The Navy's Largest Oceanographic Survey Ship

The Navy's newest, largest, and most modern oceanographic survey ship – the 2,600-ton, 285-foot-long USNS SILAS BENT (AGS-26) – commenced an extensive shakedown cruise in the Atlantic Ocean in November in preparation for voyages it will make later for the Naval Oceanographic Office. This first member of a new class of survey ships began the cruise with a five-day run from New London, Connecticut, to Norfolk, Virginia, to enable scientists, engineers, and technicians from the Oceanographic Office and contractor firms to check on her operation. She has accommodations for 44 officers and men and 34 scientists. (See photograph on page 32.)

Installed in the BENT is the prototype "Shipboard Survey System" – the scientific complex of the ship, which is having its first operational tests during the cruise. The system, which was built under contract for the Oceanographic Office at a cost of more than $3 million, including installation, is the most sophisticated environmental measuring and recording system in oceanography today. It can acquire and record oceanographic data systematically in an immediately usable computer form while the ship is under way, hove to, or anchored on an oceanographic station. In testing the system, the data obtained are being compared with measurements made simultaneously by conventional oceanographic instruments and with the results of earlier high-accuracy surveys made in the same areas.

The scientific shakedown is expected to continue for several months, after which the ship will begin making oceanographic, acoustic, and geophysical surveys.

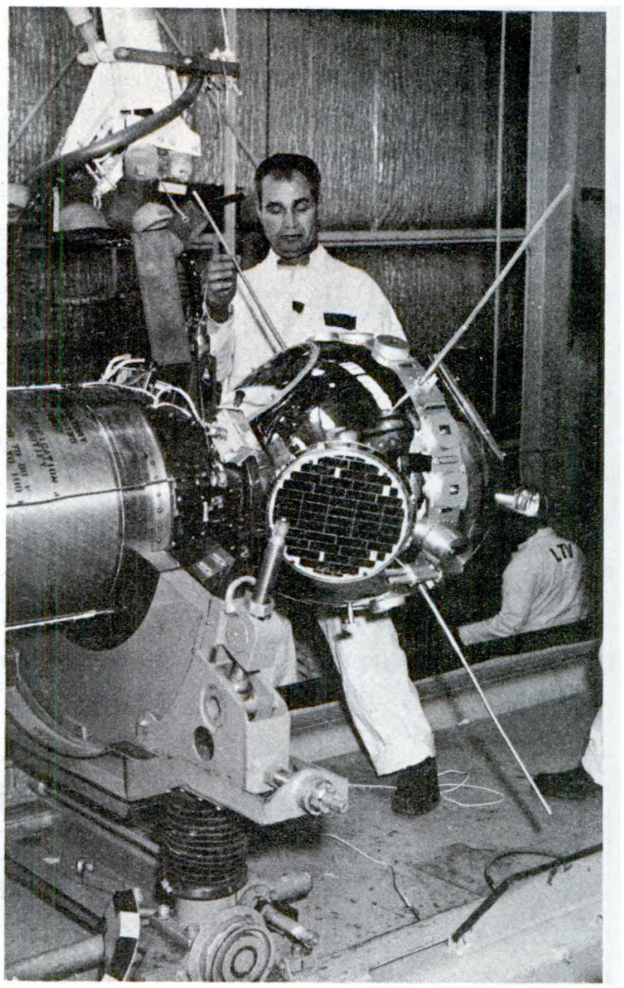
The BENT is the fifth new ship to be assigned to the technical control of the Oceanographic Office in recent years. A sister ship, USNS KANE (AGS-27), was launched shortly after the BENT began her shakedown cruise. The BENT is operated by Civil Service mariner employees of the Military Sea Transportation Service.

Navy Satellite Monitors Solar Radiation

A solar radiation monitoring satellite, called the International Quiet Sun Year Solar Explorer, was launched on November 18 from Wallops Island, Virginia, on a Scout Missile by the National Aeronautics and Space Administration for the Navy. The satellite, which was designed and fabricated at the Naval Research Laboratory, is one of a family of solar-monitoring satellites which has achieved orbit.

The mission of the IQSY Solar Explorer is to measure the short- and long-term variations in solar x-ray and ultraviolet emission in conjunction with optical and radio observations made at ground stations. The satellite contains instruments that measure six narrow x-ray bands between 0.5 and 60 angstroms utilizing Geiger counters and ion chambers.

One new feature of the Solar Explorer is an ammonia vapor-jet system that maintains the spin axis to within about two degrees of perpendicular to the satellite-sun line, thereby causing the 12 equatorially mounted solar-radiation



IQSY Solar Explorer Satellite is mounted on fourth stage Scout rocket motor.

Other photographs appear on back cover (inside).

detectors to scan directly across the sun. The system also can maintain the spin rate at any desired level by ground command. The attitude-control system is completely automatic.

A second new feature is a digital data-storage system. This system receives information from two of the solar-radiation detectors over a period of 24 hours and stores it in 12,800 small magnetic cores. This large amount of information is read out, on ground command, in four seconds. Other solar-radiation data are transmitted in real time over a standard analog telemetry link in which six subcarrier oscillators are employed.

The satellite structure is composed of two hemispheres, 24 inches in diameter, joined by a cylindrical equatorial section four inches wide. The two hemispheres have six symetrically placed solar-cell panels, 11 inches in diameter, which charge 18 "F" cell nickel-cadmium batteries.

The satellite was designed for a minimum useful life of 1 year.

The international scientific community has been invited to participate in acquiring and using the solar x-ray data provided by the satellite.

Mr. Robert W. Kreplin of NRL's Atmosphere and Astrophysics Division is responsible for the Solar Explorer experiments, and Mr. Peter G. Wilhelm of the Applications Research Division is the Project Manager for NRL.

The Vicennial: A Preview

In 1966 the Office of Naval Research will have been in existence for twenty years. This is enough time for a generation to have grown up who may not know the following facts:

- ONR was the first agency of the Federal Government specifically dedicated to the comprehensive encouragement and support of contemporary science across the board. As such, it has pioneered the patterns which today characterize the interaction of the Federal Government with the sciences basic to making things, just as a different pattern was pioneered a hundred years earlier for the Government's interaction with the sciences basic to growing things.
- ONR carried forward the tradition and experience which the wartime Office of Scientific Research and Development had built up in the mobilization of science and technology for long-term national purposes.
- ONR set American science on its way to world leadership from a post-war condition in which war-dispersed scientists, seeking their way back to the university campuses, found their equipment obsolescent and their attitude toward science jarred by what atomic weapons had done.

As acted history and as an organic institution, the Office of Naval Research, even if no longer one of the largest organizations of its kind on the national scene, continues to be a living source of information and insight regarding the ways in which science and the Government must work together.

For the Vicennial Year we have, therefore, planned a program of events which permits these

Veyl
ief Scientist
Research

matters to be voiced, heard, and appreciated. The central occasions will be a solemn Vicennial Convocation on the theme of "Science and Public Policy," to be held in Washington, D.C., on May 4, 1966, and the Ninth Navy Science Symposium, scheduled for the two days immediately following, in the course of which the most outstanding recent scientific achievements that have been made in the Navy's own establishments will be reported.

These events will be supplemented with activities carried on throughout the calendar year that are designed to highlight other parts of the story of U.S. science in the post World War II era as influenced by the Office of Naval Research. Thus *Naval Research Reviews* will carry a series of articles which might be described as "Case Histories in the Making of Science," dealing with the impact of key individuals or novel institutional arrangements on the development of science, the tracking down of technological progeny of given scientific discoveries, and the delineation of the research base which permitted given technological innovations. A series of high-prestige Vicennial Lectures will be delivered in Washington and other parts of the country, covering live areas of science and their practical results in which ONR's acitivity has played a key role. It is also hoped that a few classified seminars can be arranged to provide perspective on those portions of Naval technology which, under the impact of contemporary science, have undergone the most radical evolution—in part for the purpose of sharpening the planners' eyes for better assessment of probable futures, and in part for the purpose of engendering a livelier realization of what the Office of Naval Research has meant and can be expected to mean to the Navy.

The NATO SACLANT ASW Research Centre at La Spezia, Italy

Allen H. Schooley*
Associate Director of Research
U.S. Naval Research Laboratory

As beautiful a seascape as can be found anywhere in the world lies on the Italian Riviera on Italy's northwestern shore. Among its attractions is the Gulf of La Spezia, a tourquoise blue jewel rimmed by the pastel browns, greens, and yellows of the Italian hills. Although commonly known as "The Gulf of the Poets," because Byron and Shelley once lived by its side, its history is rich in other respects, as well. As early as 515 B. C., the Romans harbored their ships there; in the Middle Ages, the maritime republics of Genoa and Pisa fought for its control; and the Via Aurelia, the road which connected Rome and Gaul, passed along its shores (it is now Italy's major west coast highway).

In 1804, Napoleon declared the Gulf village of La Spezia a military port. The population of the village was then about 3000. Today, La Spezia, whose population has grown to 125,000, is still an important naval base, both to Italy and the North Atlantic Treaty Organization.

One of NATO's chief interests in La Spezia is a research laboratory that is helping solve the critical and persistent problems of antisubmarine warfare in waters of interest to NATO. The laboratory, called the "NATO Supreme Allied Commander Atlantic ASW Research Centre," is located on the Gulf of La Spezia between the city of La Spezia and the small fishing villages of San Terenzo and Lerici to the south. It is ideally situated, being on the shore of a protected harbor that provides easy access to the sea. The 100-fathom line is 10 miles away, and the 500-fathom line, 35 miles.

Admiral Jerauld Wright, USN, who was the NATO Supreme Allied Commander Atlantic (SACLANT) in 1959, commissioned the Research Centre on May 2 of that year and appointed CAPT K. M. Gentry, USN, as his deputy at the Centre. Dr. Eugene Booth, a physicist of broad experience, was installed as the first Scientific Director, and he served in this capacity until 1961. He is now Scientific Director and Vice President of Laser Incorporated, a subsidiary of the American Optical Company. The second Scientific Director was Dr. John Ide, who served

*In 1963, the Director of the SACLANT ASW Research Centre requested the loan of Mr. Schooley for a special antisubmarine research assignment. Mr. Schooley returned to NRL last August.

from 1961 to 1964. Dr. Ide, a pioneer in underwater sound, is now Director, Division of Engineering, of the U.S. National Science Foundation. Although the Centre was organized within the framework of NATO, the United States provided all of the money for its operation until February 1, 1963. Since that time it has been a NATO International Military Organization subordinate to SACLANT, and financing has been handled through regular NATO channels whereby all NATO countries share in the cost.

Facililities

The Research Centre facilities include a large laboratory building, which provides space for offices, technical library, workshops, electronic and oceanographic laboratories, and a modern high-speed digital computer installation. The next most significant scientific facility is the research ship MARIA PAOLINA G, a converted 2500-ton merchant freighter. The ship has accommodations for a technical party of 16 scientists and is well equipped for oceanographic and acoustic work at sea. It is supplemented by a 63-foot workboat, on loan from the U.S. Navy. The Italian Government has made available the laboratory building, security personnel, and berthing accommodations for the research vessels.

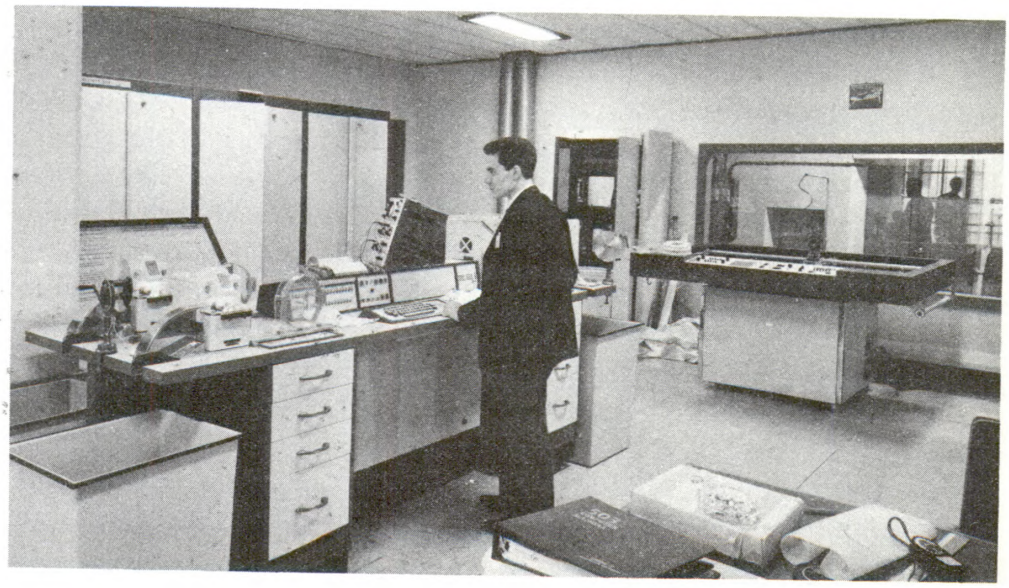
Scientific Program

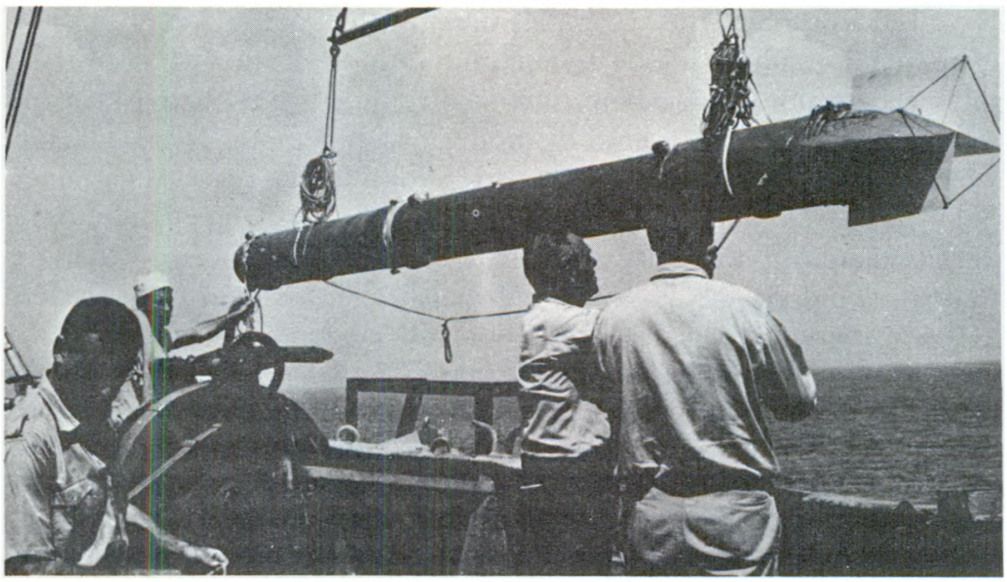
The scientific program of the Centre has been and is influenced considerably by a NATO Scientific Committee of National Representatives, which consists of one highly qualified scientist or engineer from each of the NATO countries who is familiar with the research and development work in ASW in his country. The Committee meets at the Centre two times a year. Among other things, it keeps fully informed of the Centre's scientific activities; ensures that all knowledge in possession of the NATO nations relevant to the work of the Centre is made available to the maximum extent possible; assists the Centre in the recruitment of a qualified scientific staff; and each year, in joint session with SACLANT, examines the Centre's annual progress report, upon which it bases its recommendations to NATO.

It is not possible in this brief writing to discuss specific details of the scientific program of the Centre, but the guiding philosophy, which is important and interesting, can be stated. When the Centre was established in 1959, the NATO navies had better ASW equipment than they had during World War II; however, they were plagued with the same old ASW problems: *Detection,* or finding a submarine in the vast ocean depths; *Classification,* or identifying a detected object as a submarine or as something else under the water (false contact); and *Destruction,* which means tracking a submarine until the fire-control problem can

Flags of the participating countries fly outside the SACLANT ASW Research Centre on the shore of the Gulf of La Spezia, Italy.

An Elliott 503 Computer and an X-Y Plotter facilitate research on ASW problems.





A specially designed self-recording buoy is launched from the Centre's research ship as part of an experiment conducted in the Mediterranean.

The research ship MARIA PAOLINA G.

be solved. Although the accomplishment of the total mission (the "kill" of the enemy submarine) is dependent on the execution of all of these phases, detection obviously must come first, and it must be positive and at ranges that can be covered by modern ASW weapons. Classification, which comes next, also must be made with a high degree of certainty. Since the developments in these two categories have lagged behind the developments in weapons, the policy was established early that the Centre would devote its major effort to detection and classification.

It is generally conceded that underwater sound (sonar) offers the most reliable method of submarine detection, and that an extension of operational sonar ranges is of utmost importance. As ranges are extended, successful operation becomes strongly dependent upon the environment. In view of these facts, the policy was established that a portion of the Centre's attention would be directed to fundamental research in underwater sound propagation and the ocean environment.

Many ASW strategists feel that an extensive knowledge of the ever shifting undersea environment and the ability to "forecast" its variations with an assurance comparable to that with which we now forecast atmospheric weather is absolutely necessary for significant improvement of sonar utilization. This is a staggering goal; the oceans cover 71 percent of the earth's surface, and the knowledge that is needed must come mostly from their depths. In the seas and oceans reasonably available to the Centre, research is being conducted in all major phases of oceanographic phenomena. Program efforts are devoted to bathothermometric and chemical surveys (correlated with such other factors as location, depth, time, date, and meteorological conditions); to studies of both internal and surface movements of the ocean; to geophysical and geological surveys; and to the improvement of the instruments associated with all phases of ASW research. Bottom reflection sonar techniques require a knowledge of the acoustic reflective and absorptive properties of the sea floor. Considerable geological work with corers, heat probes, and sonar bottom penetrators is being carried out. Other geophysical investigations include topographic mapping and magnetic and gravity surveys.

Another program that is being conducted is the operational analysis of detection and classification methods used in ASW. Two of the problems being investigated as part of this program are false contacts, which drain extremely large portions of time and energy from ASW forces; and optimum convoy size, spacing, and the best deployment of limited numbers of ASW escort vessels under realistic conditions. The operational research specialists often work directly with the sound propagation scientists and the oceanographers in gathering synoptic data relating to the activities of a cooperative group of NATO ships.

Considerable time is required to formulate and develop the scientific program of a new laboratory, such as the Centre, which is only

6 years old. However, results are now beginning to appear that are important to the NATO navies and to the scientific world. Reports on sound propagation and sonar techniques have gone out to the NATO countries; oceanographic data of operational significance have been collected, recorded, and published; and magnetic, gravity and bottom-material surveys have been made in the Red Sea and the Eastern Mediterranean basin. Some of the instruments developed at the Centre include a moored buoy equipped to measure and record the temperature structure at various depths in the sea over long periods, a lightweight corer designed to operate on hydrostatic pressure, and a means for recording data on punched tape to permit automatic reduction on a digital computer. The Centre's applied research in the development of sonar techniques through the use of frequency modulation and sophisticated signal processing has been active for some time and is bringing forth significant results in submarine detection and classification.

Up to October 1965, one-hundred and forty-four technical reports and memoranda had been completed and circulated to interested organizations and people, and the rate of reporting is accelerating. As may be expected, a considerable number of the publications are classified; many of them are not, however. Centre scientists participate frequently in classified and unclassified conferences in the various NATO countries, and they have served also as hosts for important international conferences on operational research and electromagnetic phenomena in the very low frequency range that have been conducted by the Centre. Exhaustive publications have resulted from the latter.

Personnel

The present Scientific Director of the Centre is Dr. Henrik Nødtvedt, who is on leave from his position as Superintendent, Division of Underseas Warfare, of the Norwegian Defense Research Establishment. Dr. Nødtvedt is known internationally as an ASW authority, having devoted his entire career to this field. He is a charter member and past chairman of the Scientific Committee of NATO National Representatives. Dr. William Wineland, on leave as chief of the physics program, U.S. Naval Ordnance Laboratory, is the present Deputy Director. He, too, has an impressive record of accomplishments related to ASW.

In October 1965, the Scientific Staff was organized into the following five groups:

Sound Propagation	*11 scientists*
Oceanography	*11 scientists*
Operational Research	*8 scientists*
Target Classification	*8 scientists*
Special Studies	*6 scientists*

The Support Staff is organized under three group heads: Financial Controller, Head of Administration, and Head of Technical Services. A Military Staff of five officers (each from a different NATO country) is headed by a U.S. Navy commander who holds the title of Naval Advisor to the Director. The officers under him assist the Scientific Staff with their projects, which often involve the use of ships and other facilities of several of the NATO countries. In addition, a U.S. Navy Supply Corps officer assists in the financial controller's office.

The total personnel number about 200. Nearly two-thirds of the staff are scientists, engineers, and technicians. The other one-third is concerned with the many activities necessary to support the technical staff. Ten NATO nations (Belgium, Canada, Denmark, France, Germany, Italy, the Netherlands, Norway, United Kingdom, and the United States) are at present represented on the Scientific Staff. The diversity of nationalities, education, and experience is very stimulating to the scientific program and also to the social activities of the Centre. Most of the scientists work at the Centre for periods of from two to three years before returning to their native countries. This arrangement has the advantage of drawing fresh personnel into the program rather frequently. Continuity is maintained by staggering the departure times of key people.

All employees, with the exception of U.S. Nationals, some Canadian scientists, and a local labor force, are employees of NATO and are governed by rules and have the advantages common to all NATO establishments. The Office of Naval Research Branch Office in London recruits U.S. citizens for "loan" to the Centre and arranges U.S. Civil Service status for them.

Associated closely with the productive scientific program of the Centre is the desire that a corps of young European scientists trained in ASW be developed. About 80 percent of the scientists on the staff are from Europe. While the directors and group leaders are senior scientists, for the most part on loan from national institutions, the average scientist is in his early thirties, married, speaks three languages, and has come to the Centre after having received an advanced university degree and having had some experience in a national oceanographic or sound laboratory. This corps-building concept is supported further by a summer student training program that provides practical experience for a limited number of advanced students who are majoring in fields associated with ASW.

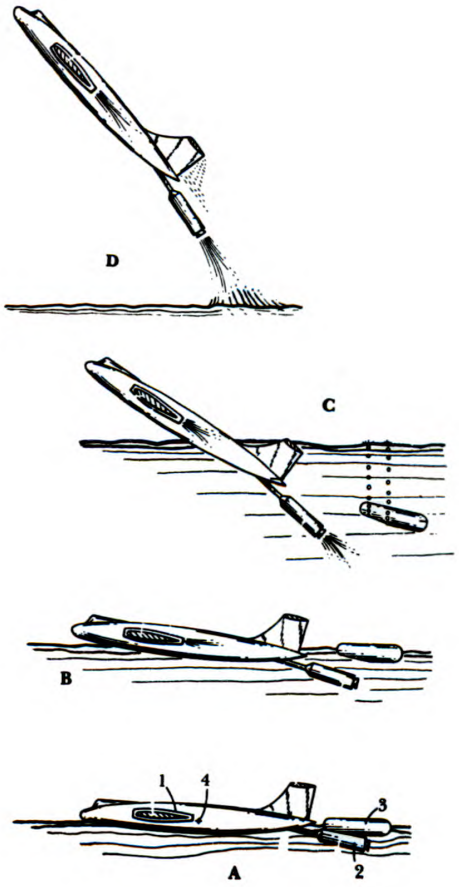
The NATO SACLANT ASW Research Centre, now well past its formative years, is an important producing organization that is helping SACLANT solve the urgent and difficult ASW problems facing the NATO nations. In addition, it is adding significantly to the world's store of knowledge of the sea.

Inventions

Launching High-Performance Aircraft from the Ocean Surface

According to the invention of a Navy engineer, aircraft having high-performance body configurations can be based on and launched from the ocean's surface. The concept, which is quite different from the one that applies to the stationing and take-off of conventional seaplanes, is described in U.S. Patent No. 3,152,779, which was issued October 13, 1964, to Eugene H. Handler of the Bureau of Naval Weapons. The patent is entitled "Zero-length Landing Device for Piloted and Unpiloted Water-Based Aircraft."

The high-performance aircraft, which may utilize one or more engines for its normal powered flight, is fitted with an auxiliary rocket engine that extends rearward from its tail section. To keep the plane in an approximately horizontal position while it is at rest in the water, a float is attached to the tail section also. When the aircraft is to be launched, the float is detached, causing the booster to pull the tail downward. At about the same time, the plane's engines and the rocket booster are fired, and take-off is accomplished. The booster is jettisoned after it has burned out.



Diagrammatic illustration of the launching of a high-performance aircraft from the ocean surface: A, Aircraft at rest on ocean; B, Float is detached; C, Rockets are fired; D, Aircraft is propelled above water; 1, Location of rocket motors used for normal flight; 2, Auxiliary rocket motor; 3, Float; 4, Aircraft's center of gravity when in flight.

Storing Rockets Safely

Because of the rapid burning times of missiles of certain configurations (ASROC, for example), considerable likelihood exists of an entire magazine exploding if one of the missiles is fired accidentally. E. N. Oeland, Jr., of the Naval Ordnance Test Station, China Lake, California, considered this problem and proposed a solution to it—the installation of a removable plug at the base of each rocket. The plug would replace a thrust deflector that generally is attached to rockets while they are in storage and being handled. The deflector neutralizes the forward thrust in case of inadvertent firing, but it also rapidly distributes exhaust gases laterally, which could cause other rockets to ignite.

The invention, Patent No. 3,185,036, entitled "Fail-Safe Device for Porting Stored Rocket Motors," was issued to Mr. Oeland on May 25, 1965. It calls for the rocket to be stored with plugs removed and for the propellant to be protected from contamination by an easily rupturable diaphragm. In this condition, the rocket's exhaust area is so increased and its motor pressure so reduced, that the burning time is of the order of five minutes instead of a few seconds, as would be the case otherwise. Thus little opportunity is afforded for other stored missiles to ignite, and the time needed for a fire-fighting system to go into operation is provided.

Air-Dropping Cargo by Balloon

Operations that involve dropping cargo by parachute to small landing sites are subject to a number of well-known, frustrating deficiencies. For example, the load is often carried off target by the wind, and it is frequently jolted severely upon landing, causing damage to its contents. In an effort to overcome these problems, a Navy inventor devised a drag balloon that can be ejected in a collapsed condition, with cargo attached, from an aircraft flying at relatively low altitude.

By means of a static line or in other ways, the balloon's gas capsule is opened as soon as the balloon begins its descent. Immediately upon inflation, which occurs quickly, a so-called landing spike is forced downward into a position beneath the balloon that enables it to take up the initial landing shock. The remainder of the shock, upon being received by the spike, is transmitted to the gas in the balloon, which absorbs it, permitting the cargo to settle to the ground with little likelihood of its being damaged.

The invention, entitled "Aerial Cargo Delivery Device," is described in U.S. Patent No. 3,202,386. The patent was issued to Mr. F. McCullough, Jr., of the Naval Ordnance Test Station, China Lake, California, on August 24, 1965.

On the Naval Research Reserve

The Drill Program of NRRC 13-1

The programs presented at the weekly drills of NRRC 13-1, Seattle, Washington, are of such compelling interest that members quickly become recruiters of fellow Reservists who share their professional interests. The method of programming may be of interest to other units.

The drill periods of each quarter have a unifying master theme, such as weather, oceanography, or traffic control. The themes complement each other, so to speak. A subject may not be exhausted in one quarter only; rather, the same master themes recur in later quarters under a fresh aspect or from another point of view.

In line with the fall quarter's theme of oceanography, the guest speaker selected was the young Seattle representative of Ocean Systems, Inc., a subsidiary of Union Carbide and General Precision Equipment Corporations—Mr. Jon Lindberg, a name which, needless to say, heightened member interest. LCDR John Grobe, USNR, a friend and former shipmate of the speaker and a member of NRRC 13-1, assisted in the program arrangements. Mr. Lindberg described a new approach to deep diving introduced by Ocean Systems and the basic reasons for developing this technique, which is called Advanced Diving Systems (ADS). ADS consists of a submersible decompression chamber with or without an additional unit kept at normal pressure for observation and supervision by non-divers. The chamber provides a warm, dry, comfortable base from which the diver may operate on the ocean floor. He may enter or leave the chamber for such purposes as to obtain tools or take his meals, and he does not need to surface during the course of his work. The system is applicable to various deep-diving tasks that must be carried out with reliability and economy, such as those of the off-shore oil industry. ADS was developed by laboratories at Tonawanda, New York, and Miami, Florida. Work on more versatile and sophisticated systems is in progress.

Although the seas around us continue to present a hostile environment to man, many people of the Pacific Northwest are now keenly aware of the possibilities of mastering them. For example, our Governor and our Senators speak of promoting the Puget Sound area for development of a wide range of research facilities in oceanography and related subjects.

Another, possibly fresh, approach to programming involves contrast. In a recent lecture entitled "Science and Society in the Eighteenth Century," Dr. Thomas Hankins of the History Department, University of Washington, gave a scholar's account of French Encyclopedists, their dominance in the Age of Enlightenment, and their many writings and lectures on science and reason in relation to society. This subject set off, in sharp contrast, the contemporary relationship between science and society, a theme which can provide NRRC 13-1 with many interesting future programs. The point is that Dr. Hankins spoke only briefly on the contemporary problem—but the outlines of that problem are clearer when viewed against the vivid historical background which

he presented. An occasional "Program for Contrast" is suggested as a stimulating addition to training schedules for Research Reserve Companies.

—CAPT John H. Avery, USNR, Commanding Officer, NRRC 13-1

Shortest Change of Command

In what is believed to be the shortest change-of-command ceremony on record—one-half second—CAPT Carl A. Hering, USNR, relieved CAPT George J. Haltiner, USNR, of command of NRRC 12-8, Naval Postgraduate School, Monterey, California, on September 21, 1965.

The unique operation was fully in keeping with the daily experiences of the company's members, all of whom are scientists. At precisely 8:00 p.m., PDT, the two Naval Reserve captains stepped smartly to an IBM "computer readout" machine, saluted, and pressed a button; before one could say "Anchors Aweigh," the ceremony was over. The usual reference to orders and the expressions "I relieve you Sir" and "I stand relieved" were transferred from the computer's memory to the printer, and CAPT Hering had the "helm". With the exception of the momentary whirr of the machines, the ceremony was silent.

CAPT Haltiner, left, and CAPT Hering salute as the latter assumes command of NRRC 12-8.

Following the ceremony in the Postgraduate School's Computer Center, the company reassembled in their usual meeting place, a classroom in the School's Spanagel Hall. There, CAPT Hering congratulated his predecessor on the company's ranking, which is first among Naval Reserve Research units in the Twelfth Naval District.

Other new officers in the company include: CDR Eugene C. Haderlie, USNR, Executive Officer; CDR Sidney H. Kalmbach, USNR, Administrative Officer; CDR Allen M. Hudson, USNR, Membership Officer; LCDR O. B. Wilson, USNR, Training Officer; and CAPT Lawrence E. Kinsler, USNR, Active Duty Advisor. Assisting these officers are Reserve captains William E. Bleick, George J. Haltiner, William D. Duthie, and CDR George D. Marshall.

The subject of the meeting following the ceremony was biological and oceanographic research. The presentation featured slides taken on a recent cruise by CDR Haderlie aboard the Stanford University research vessel Te Vega.

Research Reserve Statistics

The following figures were compiled from data submitted in the annual reports forwarded by Research Reserve Companies for fiscal year 1965:

Companies	93
Members	2,160
Ready Reserves (percent)	87
Standby Reserves (percent)	13
Attendance at drill meetings (median percent)	85
Earned satisfactory Federal year (percent)	86
Selected for promotion	154
Received active duty for training	960
(percent)	44
Captains	96
Commanders	258
Lieutenant Commanders	371
Lieutenants	200
Lieutenants (JG) and below	35
Completed correspondence courses (percent)	63

We can no longer afford the "build one and try it" approach with a subsequent "get well" effort to patch on reliability, maintainability, value engineering, and the like. We cannot afford to develop systems using men as multi-purpose gap-fillers between machine interfaces. Neither can we accept weapons systems which must be staffed by crews of Ph.D.'s. We must develop mathematical modeling techniques with which to do our systems engineering homework. These models cannot be achieved without a cohesive discipline within which they can be structured. This discipline we term "Systems Effectiveness." In the highly complex weaponry of modern warfare, this discipline is absolutely necessary. *From a speech by VADM W. A. Schoech, USN, given at the Northeastern States Navy R&D Clinic, Philadelphia, Nov. 18, 1964.*

Perhaps the most remarkable fact that is revealed in the Navy Department's budget figures of the past two decades is that although the Navy's total annual budget dropped from a high of 30 billion dollars in 1943 to less than five billion dollars for the period between World War II and Korea, the Navy's expenditures on research and development remained remarkably steady at somewhat over 200 million dollars. Thus, following World War II, the Navy showed great foresight and leadership in changing the traditional pattern of peacetime expenditures by investing substantial sums of money in research and development. The expenditures in that period did much to build up the scientific and technical competence of our universities of our government laboratories, and of our industries. And the investment has paid off many times over since. *From a speech by Hon. Robert W. Morse, Assistant Secretary of the Navy for R&D, given at the Northeastern States Navy R&D Clinic, Philadelphia, Nov. 18, 1964.*

TITLE INDEX, 1965*

*Articles are arranged under the ONR division or Navy laboratory having cognizance of the research described.

†Written by the editorial staff of *Naval Research Reviews* or adapted from anonymous sources.

Naval Applications

Inertial Guidance Sensors, by CDR M. Gussow, April
The "Main Event" in Underwater Living, March†
Military and Civilian Implications of Man's Underwater Operations, by CAPT L. B. Melson, May
SeaLab II: A Summary Report, November†

Laboratories of ONR

The Development of Deep Ocean Search and Inspection Techniques by the Naval Research Laboratory, by C. L. Buchanan, June
A New Fence in Texas, June†
The Rainbow Optical Landing Aid, by Barbour Lee Perry, July
Recent and Current Research on the Primary Cosmic Radiation, July†
SPAD – An Experimental Satellite Position Prediction Display, by H. G. Talmadge, Jr., and R. J. Orsino, September
Ultrasonic Heartbeat Monitor, May†

Miscellaneous

The First Inter-American Naval Research Conference, October†
Four Young Men in a Long, Slow Spin, March†
The Hydroballistics Laboratory, July†
The NATO SACLANT ASW Research Centre at La Spezia, Italy, by Allen H. Schooley, December
The Marriage of Science and the Navy, by RADM John K. Leydon, October
Materials Testing Unit Recovered from Deep Ocean Floor, March†
ONR and ACR Reports, by Charles DeVore, June
The Patent System: A Sword for Navy Research and Development, by Henry Hansen, January
Radioactive Tracer "Captured" by Huge Water Bag, April†
Rearing Barnacles in the Laboratory, by Arnold Freiberger and Christopher P. Cologer, October
The Recovery of STU 1-1, June†
Solar Eclipse – 1965, May†

AUTHOR INDEX, 1965

Carlston, R. C., September
Cologer, Christopher P. (co-author), October

Demboski, Henry, February
DeVore, Charles, June

Fleisher, Harry, July
Freiberger, Arnold (co-author), October

Galler, S. R., January
Glaser, Harold, March
Gussow, M., CDR, April

Hackerman, Norman, June
Hensen, Henry, January

Jennings, F. D., April

Kelly, C. F. (co-author), November

Leydon, John K., RADM, October

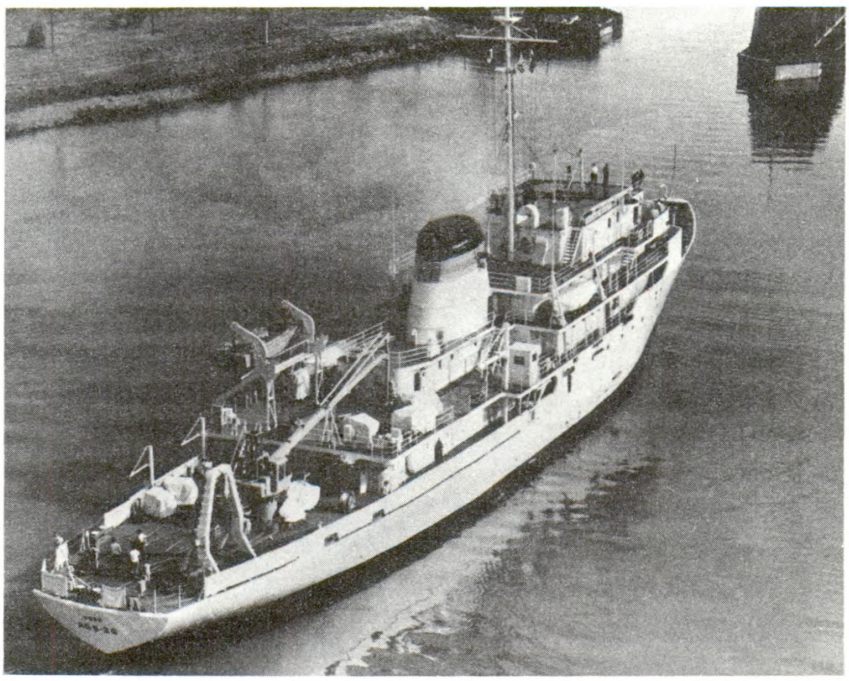
Melson, L. B., CAPT, May

Orsino, R. J. (co-author), September

Parker, James F., Jr., August and September (co-author in September)
Perry, Barbour Lee, July
Post, T. J. (co-author), September

Sargent, Marsten C., December
Schooley, Allen H., December
Smith, A. H. (co-author), November

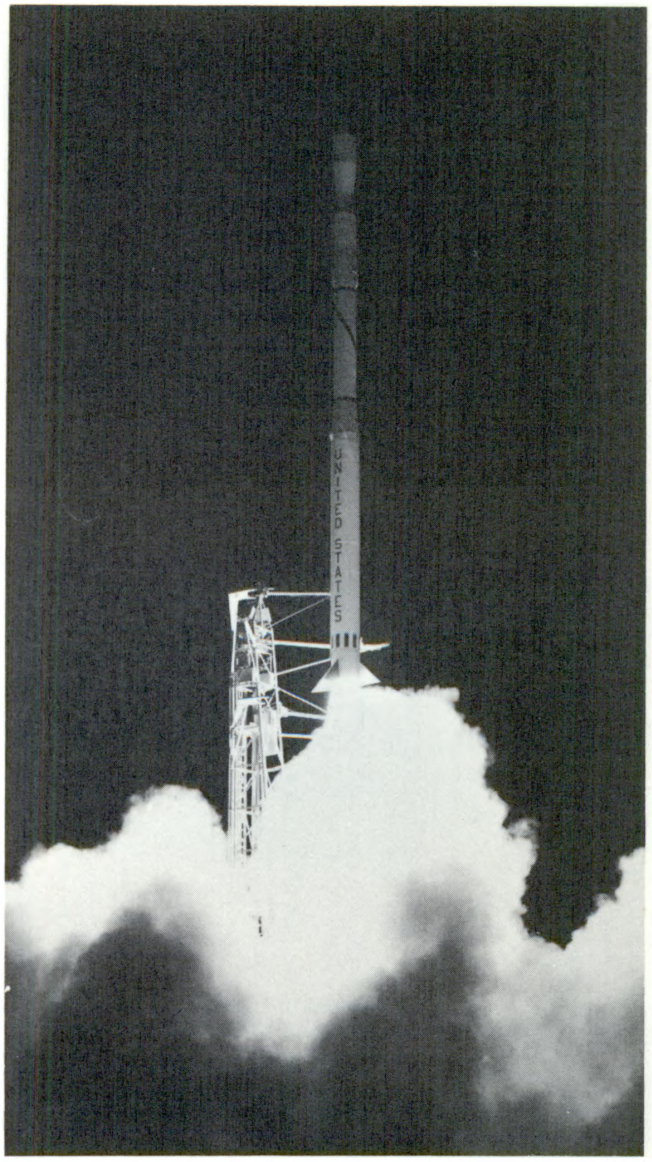
Talmadge, H. G., Jr. (co-author), September



The Navy's newest and largest survey ship, the USNS SILAS BENT (AGS-26).
See research note, page 14.

★ GPO 1965 O—797-145

A Scout rocket carrying the 125-pound Solar Explorer leaves its launching pad at Wallops Island, Virginia, on November 18.

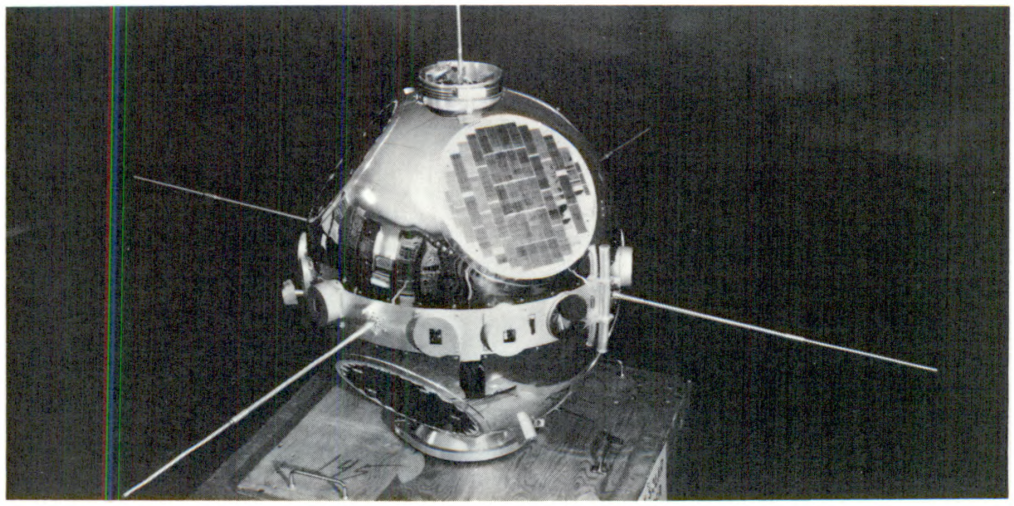


The IQSY

Solar Explorer

Another photograph and a brief discussion of the Solar Explorer appear on pages 14 and 15.

The Solar Explorer. Twelve photometers are mounted at the satellites equator to measure x-ray and ultraviolet emissions from the sun. Electrical power is supplied by solar cells mounted on the hemispheres.



IN THIS ISSUE

VOL. XVIII NO. 12

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

EDITOR: Richard D. Olson

NAVSO P-510

The Scripps Institution of Oceanography at La Jolla, California. See the article beginning on page 1, which describes representative investigations conducted here during the past two decades.