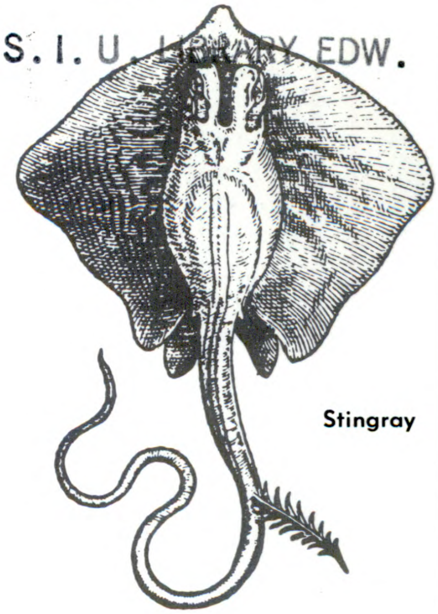
NAVAL RESEARCH REVIEWS

APRIL 1966



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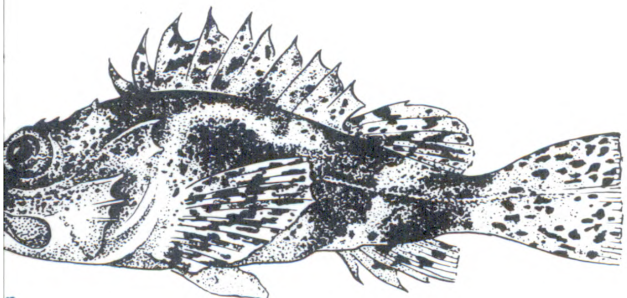

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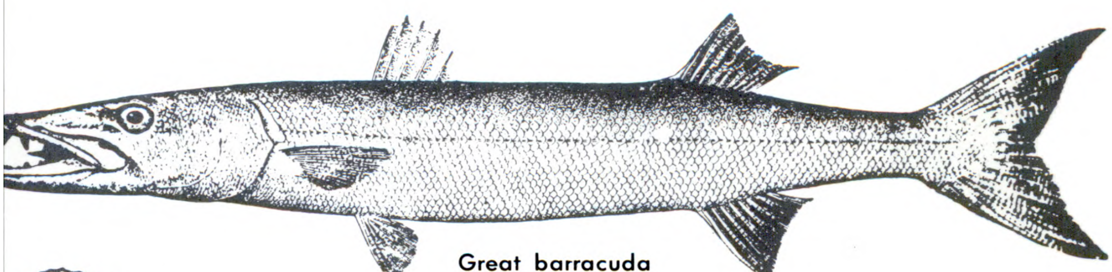

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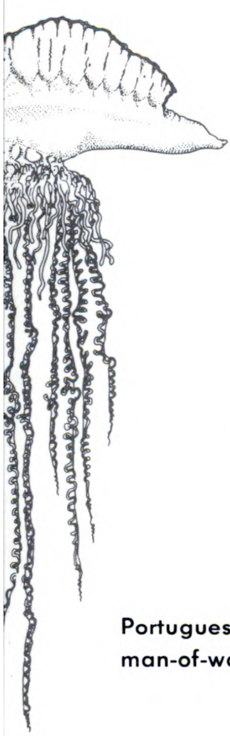
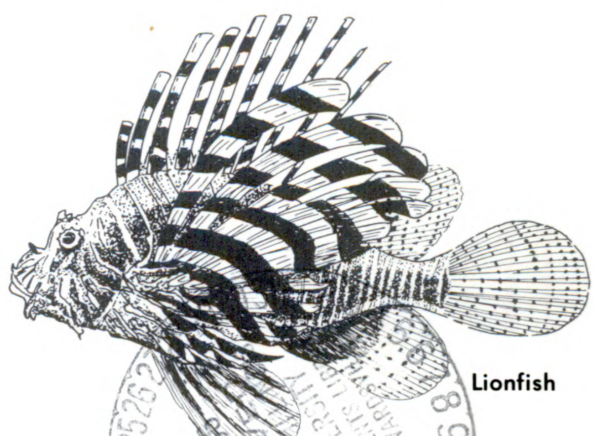


Some Toxic Marine Animals

Portuguese man-of-war



Lionfish

20th Year on the Frontier of Science

The Vicennial — Central Occasions

On August 1, 1966, twenty years will have passed since President Truman signed Public Law 588 establishing an Office of Naval Research in the Office of the Secretary of the Navy. Therefore, Secretary Nitze has designated 1966 as the Office of Naval Research Vicennial Year. The theme of the celebration is "to examine under broad historical perspective what has been achieved during the last two decades and what issues are likely to characterize the decades ahead in the interaction of science and national security.

The theme will be carried out during the year by scientific symposia, Navy conferences, and ONR publications. The central occasions will be a solemn Vicennial Convocation dwelling on "Science and Public Policy," to he held in Washington, D.C., on May 4 and the Ninth Navy Science Symposium, scheduled for the two days immediately following.

The Convocation. This event and the banquet which follows it will bring together distinguished scientists and friends of the Office of Naval Research and the Navy throughout the United States and foreign countries. The tentative program is as follows:

The Convocation chairman will be The Honorable Robert W. Morse, Assistant Secretary of the Navy for Research and Development. Session chairmen will include The Honorable Garrison Norton, Chairman, Naval Research Advisory Committee; and Dr. E. R. Piore, Vice President and Chief Scientist, IBM.

Appraisals of ONR will be given by Dr. Alan T. Waterman, formerly Chief Scientist, ONR, and Director, National Science Foundation (*appraisals by the scientific community*); by the Honorable John S. Foster, Jr., Director of Defense Research and Engineering, Office of the Secretary of Defense (*appraisals by the makers of military technology*); and by Admiral Horacio Rivero, Vice Chief of Naval Operations (*appraisals by the Fleet*).

Talks will be given also by Dr. Donald F. Hornig, Science Advisor to the President (*past achievements and future foci of the Federal Government in science*); by Dr. Frederick Seitz, President, National Academy of Sciences (*opportunities and constraints of science in the U.S.*); and by Sir Solly Zuckerman, Chief Scientific Advisor, Ministry of Defence, Great Britain (*the open world of science*).

Navy Science Symposium. Unlike the previous Navy Science Symposia, which have focused upon specific areas of research of concern to Navy laboratories, this ninth symposium of the series will scan the entire field, highlighting the most outstanding scientific achievements that have been made recently in the Navy laboratories.

The topics to be discussed and the speakers scheduled for May 5 are *Astronomy from Space Platforms,* Dr. H. Friedman, Naval Research Laboratory; *Spectroscopy,* Dr. C. J. Humphreys, Naval Ordnance Laboratory, Corona; *Generation of High Temperature Plasmas,* Dr. A. C. Kolb, NRL; *Aerophysics Research and Re-entry Vehicles,* Dr. R. K. Lobb, NOL, White Oak; *Basic Research on Semiconductors in Navy Laboratories,* Mr. J. R. Dixon, NOL, White Oak; *Study of Transition Element Intermetallic Compounds,* Mr. W. J. Buehler and Mr. F. E. Wang, NOL, White Oak; *Frontier Aspects of Fracture Mechanics,* Dr. G. R. Irwin, NRL; *Static and Dynamic Strength Analyses of Pressure Hull Structures,* Mr. J. G. Pulos and Mr. G. D. Elmer, David Taylor Model Basin; and *The Application of X-ray Structure Analysis to Chemical Problems,* Dr. J. Karle, NRL.

Scheduled for May 6 are *Motion Sickness,* CAPT A. Graybiel, MC, USN, Naval Aerospace Medical Institute; *Some Control Mechanisms in the Bioenergetics of Anoxic Fatigue Stress,* Dr. B. D. Polis, Naval Air Development Center; *The Detection of Ionizing Radiations by Living Systems,* Dr. D. J. Kimeldorf, Navy Radiological Defense Laboratory; *VLF Radio Wave Propagation Research in the Navy,* Mr. J. E. Bickel, Navy Electronics Laboratory, and Mr. W. E. Garner, NRL; *Vortex Flow Studies and Their Applications to the Solution of Navy Problems,* Dr. F. O. Ringleb, Naval Air Engineering Center; *Hydrodynamic Drag Reduction,* Dr. J. W. Hoyt, Naval Ordnance Test Station, Pasadena; *Progress in Air Cushion Vehicles,* Mr. A. G. Ford, DTMB; *Applications of Similitude in Weapons Research,* Dr. W. G. Soper, Naval Weapons Laboratory; and *The Fire Research Program of the Navy,* Dr. R. L. Tuve and Mr. H. Peterson, NRL.

Basic Research and Long-Range National Goals*

Honorable Robert W. Morse
Assistant Secretary of the Navy for Research and Development

This year the Office of Naval Research celebrates its twentieth anniversary. The significance of this event goes far beyond the Navy because the activities of this unique Office have had great influence over the years on many important areas of national life. Twenty years ago, ONR was a pioneering venture in the newly developing association between governmental organizations and the scientific research community.

During the Second World War the basic sciences and the universities were mobilized in surprisingly effective ways to support wartime objectives. Radar and atomic energy are but two of the better known products. The methods by which these scientific resources were put to work were for the most part *ad hoc,* informal, and motivated by a common desire to get the job done. At the conclusion of the War, many responsible people saw the essential national need of a continuing relationship of the Government with basic research. The problem before them was to translate the unusual involvements of wartime between the Federal Government and the universities into permanent relationships which could be pursued to mutual advantage—relationships, moreover, consistent with the institutional objectives and limitations of both sides.

The blueprint for the way ahead was provided by Vannevar Bush's report "Science, the Endless Frontier" of July 1945. The principal features of the pattern which emerged, and which seem unaffected in their validity by the intervening time, are contained in this report. The fundamental assumption was that only the systematic pursuit of scientific research on a broad front and with the support of the Federal Government will produce the choices which this society will need to continue its development along the lines on which history has set it moving. The report then outlined with great clarity the conditions under which universities should accept the inevitably required support from the Federal Government and instructed the governmental agencies of the manner in which such support should be administered. In addition to laying out the general framework for procedures, the Bush report most successfully convinced Congress to make what, at the time, was considered as unheard-of appropriations for the support of research.

*An address given at the Marshall Brown Lecture, Rhode Island College, February 24, 1966.

The Office of Naval Research resulted from the first major Congressional action taken toward implementing the Bush report. The later establishment of the National Science Foundation was a broader step in the implementation of the Bush report's recommendations for general support of the basic sciences.

In relative dollar expenditures, ONR has never counted heavily in the Navy's budgets. Today, for example, this Office's total yearly budget is less than five percent of the Navy's one and three-quarter billion dollar annual expenditure on research and development. However, the Navy's own technological growth has been accelerated significantly in many ways by activities traceable directly to research supported and encouraged by ONR. Moreover, the true effects of this technology on the Nation as a whole are magnified many times when benefits beyond the Navy are considered.

Taking stock of the present state of affairs, we can say that universities and agencies of the Federal Government have followed successfully the guidelines set out by Vannevar Bush's report of 1945. We have developed tools of both an administrative and institutional variety. We have developed understanding and support for research, not only within Government but amongst the public. Moreover, concrete measures of achievement are considerable. The universities have developed successfully a new style of graduate education and advanced training in the sciences under the kind of support made available first by ONR and later by many other Federal agencies. It has given United States universities world leadership in these respects.

Many aspects of the Government's affairs have experienced a complete technological turnover under the impact of research-accelerated innovation. Within the Navy, for example, nuclear power is replacing oil, new missiles are replacing older weapons, and the entire business of combat information and communication is handled by computer-managed electronics. The impact of research is not just on weapons, but in the long run, will be equally dramatic on such important and costly matters as logistic planning and personnel training.

The developments in the relationships between Government and research of the past 20 years have been striking demonstrations of the vitality of American institutions and the processes of American government. But this does not mean that formidable challenges do not lie ahead. Indeed, there are clear signs that we are already in the first phases of a new era in the demands which Government must put on science. It is to be noted, for example, that the machinery for using the full power of science in the pursuit of national goals has been developed to its present capacity almost exclusively in the military domain and closely related domains, such as space and atomic energy. Our society today recognizes the importance of action on other equally or more important fronts of national purpose. It is only natural to ask, therefore, how science and basic research can be directed to these ends.

There are many scientists who feel that the choices in the support of science would be easy to make if the political world were sufficiently farsighted (and, presumably, rich). Namely, they feel that all "good" scientific research should be supported, and that the choice as to what is "good" is a choice only scientists can make. Clearly, such a view is untenable in the long run. The support of the research of good scientists for their own sake is one matter, but the investment of substantial sums of public funds for particular scientific products must involve public weighing of the desirability of one course relative to others. And in the long run, these choices must be related to political objectives. Such objectives may rightfully have to do with education, defense, national prestige, national health, economic development, and even the vicarious involvement of the public in an intellectually exciting project.

Clearly, society supports science because it expects to derive benefits from such support. These benefits can be largely intellectual or cultural, and the long-range importance of these more abstract aspects cannot be underestimated. However, the evidence is abundantly clear that scientific research and its translation into technology are important keys to economic and political strength as well as to cultural vitality. Our long-range national purposes, whether they be world peace or the universal dignity and freedom of men, desperately need imaginative and deliberate use of science for their support, not in particular areas but across the board generally.

But how does one go about the process of applying science to specific purposes of the public welfare? It should be plain to an academic audience that this question can be addressed only with a certain careful understanding.

On one hand, we must continue to recognize the fundamenal approach of basic research—namely, that scientific truth must be pursued on its own terms, governed by internal standards of relevance, and free from pressures of external purpose. The very lifeblood of good science requires respect for and faith in this internal integrity of science. Let us be clear, though, that the support of science for its own sake is not quite the same as the support of scientists for their own sake. It is wise for society as a whole to support pure scientific research, not so much because it is an intrinsic virtue but primarily because it is an operational virtue. Indeed, the concept is related closely to that of academic freedom (which many young faculty members thoughtlessly assume is a personal right). Academic freedom and the independence of pure research are special protections from arbitrary interference which a wise society promotes and defends for its own long-range good, not for the privilege of the recipients. No committees of wise men have wisdom enough to anticipate where the pursuit of truth can eventually lead, and so to protect ourselves from our own errors we must protect the processes of research and scholarship.

Scientists, as special defenders of the faith, should not imply, however, that science is threatened if we care about its uses. Nor should we become so obsessed with protecting the independence of basic research that we build a mythology which suggests that the best science is the most useless or that a scientist is abandoning his profession when he concerns himself with practical problems.

At the other extreme, in our impatience to solve socially urgent problems, we must not destroy the ability to do science. We would be most shortsighted, for example, to divert resources from research in chemistry and biology into a new program to "solve" the problem of air pollution. In fact, the very work in chemistry and biology may contain the basis for progress not only in reducing pollution, but in still unanticipated problems.

Let me rephrase the situation in the following way. On the one hand, the pursuit of science justifiably needs to be insulated from the immediate purposes of society. On the other hand, society faces extremely serious problems in the development and distribution of natural resources, in pollution, in population growth, in transportation, in the continued viability of our cities, in education, and on many other important fronts. These are not, in themselves, scientific or technical problems, but one must agree that technology has much to contribute to their amelioration. Can we say that science and technology are effectively mobilized to address them coherently? Can we say that more basic research automatically will produce solutions? In my opinion, the answer to both questions is negative.

I have implied that rather new problems lie ahead in translating science into the support of national purposes. This is really more a matter of degree and emphasis than it is of newness. In fact, there are certain clearly recognized areas in which extremely well-developed procedures have been worked out for translating research into technology that supports purposes which are external to science. Agriculture, medicine, and geology typify areas in which the tradition of applied science is of long duration. These fields can trace their origins to the most ancient of civilizations, and indeed much of modern science has been derived from these practical occupations. But it has been only in recent decades that more modern science—discipline-oriented rather than problem-oriented—has had a fundamental impact on all of them. One need only point to the example of the application of radioisotopes to suggest how much these old, applied sciences have been influenced by basic science.

However, there are other areas, notably in national defense, in which a concerted effort has been made to apply all the sciences, without distinction, to the solution of problems essentially nonscientific in nature. Indeed, it is important to acknowledge that about $7 billion of the $15 billion Federal expenditures for research and development are spent by the Department of Defense. Of the total Federal expenditures on research and development, about 90 percent is spent on defense, space exploration, and atomic energy.

It is quite proper then to ask if we are devoting enough attention to directing the potential of science to other equally urgent social purposes. Such a question was explored in Congressional hearings conducted in January by Congressman Henry S. Reuss of Wisconsin. He asked whether increased support of research in the areas of water pollution, urban transportation, and housing might not help the Nation meet the pressing problems of metropolitan areas. Dr. Donald Hornig, the President's Science Advisor, stated his position as follows:

> *I reiterate that there is no doubt in my mind that great improvements are possible through research and development in these areas. But in order to proceed, we must identify and develop the ideas on how to satisfy our needs at reasonable cost and get talented people interested in these tasks.*
>
> *What we lack in many of the civilian problem areas identified by the Committee is not a consensus on their importance. Rather, it is a lack of solid R&D program proposals that will satisfactorily answer the questions I have raised. We cannot buy and create progress in a field which is not ready to progress. We need to know where we are going and have enough people of the necessary competence to work out the programs. Once a program is underway, the possibility of doing something new and useful will tend to stimulate additional allocation of resources.*

One can only agree that it takes far more than a sizable problem, good intentions, and basic research to make progress.

I should like to suggest that some of the techniques which have been used by the military departments can provide patterns for the more general application of technology. This is not to propose that military problems are identical in nature to the more general ones which I have mentioned. Problems such as population growth or pollution are far more complex for many reasons: they have much stronger cultural and human components, they are more controversial politically, and the responsibility for their solution is greatly diffused.

Two important essentials in the coordinated use of technology must be emphasized. The first of these is the most difficult intellectual task of all, for it is the rational delineation of the problem. By this I mean the identification of quantifiable and measurable parameters by which the problem can be described, the delineation of goals against which progress can be estimated, and the definition of a sub-set of tasks or objectives with which priorities can be associated.

Clearly, such an analysis is not a scientific problem, for essentially it involves the reduction of *purpose* to a set of problems which can be comprehended in more manageable terms. To put it another way, one must develop a set of tactical problems and subject them to practical analysis before he has any assurance that the overall approach is adequate.

In the area of military research and development, this process is called "systems-analysis." In a way, a systems-analysis is no more than ordered common sense, for it attempts to put in measurable terms (dollars, people, or time) the cost of a certain course of action with respect to the benefit or effectiveness that can be expected to result from their expenditure. As difficult and as intellectually slippery as these tasks of analysis and judgment are, they must be attempted if progress is to be made with large and difficult problems.

Without such analysis and the ability to measure progress one can have little assurance that the steps being taken are the most relevant ones or that the efforts being expended are commensurate with the objectives. One of the great dangers such analysis attempts to avoid is sub-optimization of effort, which can result either from a gross misestimation of the size or importance of the problem being addressed or from the shotgun method, by which all promising approaches are indiscriminately and inadequately backed even though the total resources available might be adequate if one approach was chosen.

The other important element in the translation of science to practical purposes is the involvement of governmental organizations, in many ways as "middle men," among the scientific, university, and industrial communities and the governmental organizations responsible for action in support of the public welfare. And here I would refer to the pattern set by the Office of Naval Research.

Indeed, I should like to emphasize that the Office of Naval Research has been successful in the deepest sense because it has played a *creative* role between the researcher in the private community and the long term needs of the Navy. That is, ONR has supported university research with the spirit which makes sense to the university. Deliberately, it has not compromised the motive of the research laboratory. At the same time, however, the Office has been part of the Navy and so has tried to shape an overall program of research which could contribute to solutions of the Navy's long-term problems. As technical possibilities have opened, ONR has felt a responsibility to promote them so that the line organizations within the Navy would pick them up for practical exploitation.

Thus the Office has played anything but a passive role; on the contrary, it has fulfilled a most subtle obligation to the Navy. As with all catalysts, the importance of its activity is not always recognized easily. It is only natural, for example, that some elements of the Navy that are more exposed to the pressures of immediate requirements have doubts sometimes about what ONR is up to. Perhaps we can understand the academic researcher who forgets occasionally that the Office of Naval Research is part of the Navy. Both attitudes are consequences of the special attitudes which any research-supporting organization must adopt if it is to be a link between research and practical need.

I am not here either to praise or defend ONR; its record speaks for itself. I point to it particularly because of a view which is either explicitly promoted or implicitly assumed with greater frequency; namely, that basic research, because it is a general national asset, should be centrally administered. Because there are so many governmental agencies involved in the sponsorship of research, and because the total amount of money involved is so substantial, there naturally is concern for proliferation or duplication. It does not follow, however, that because of these dangers (which can be overestimated) research should be collected into a single piece for final judgment. If, indeed, the national programs in research are to be judged in any meaningful long-term way, they cannot be separated from the purposes which they are intended to serve in the long run.

Moreover, as I have already implied, if we are to translate basic research into long-term national purposes, we very much need more ONR-like institutions that can provide the buffers and the catalytic influence between practical objectives and research programs which are relevant to them in the *long term.*

The nature of basic research is such that it cannot confront social or political purpose directly. This is not a weakness, but a deliberate characteristic which gives research its special strength.

In viewing the academic scene upon his leaving as President of Brown University, Barnaby Keeney said recently to the University Corporation:

> *The mission of the university is traditionally regarded as teaching students, and in so doing, developing character and discovering knowledge. Now we are likely to have thrust upon us the task of actively promoting social change and social improvement. We must not make a hasty positive or negative response to this demand.*

President Keeney's caution is quite appropriate. Our needs will not be served best by converting universities into institutions which are directly and immediately responsive to social or political need. Indeed, the record shows that universities generally are not too effective when they are dealt with directly by the operating arms of governmental agencies in support of specific public problems.

The essentials of the relationship were pointed to by John W. Gardner, now Secretary of the Department of Health, Education and Welfare, in a 1964 report he made to the Agency for International Development on the subject "A.I.D. and the Universities." Regarding the use of universities, he made the following statement:

> *Such collaboration with nongovernmental groups brings to bear on a national problem the full range of talent and institutional resources of our pluralistic society. But if collaboration is to be successful, three cautions are in order: (1) The Federal agency involved must have a nucleus of first-class people capable of dealing with outside individuals and institutions on terms of professional equality. The notion that a Federal agency can let its direct-hire staff deteriorate and get all of its talent on contract is a dangerous delusion. (2) The relationship between Government and the university must*

be defined in such a way as to preserve to each party independence of action in those functions that it must perform unimpeded. (3) The relationship must be such that each party not only can perform at its best but can gain added strength from its participation. Only under such circumstances will the Government be able to justify its participation and the universities be able to put their best talent and resources at the disposal of Government.

In conclusion, let me summarize:

I would say that, although science and research have achieved a new prominence in our affairs, we are far from mobilizing the potential of basic research behind the full range of our national needs and purposes. This mobilization does not occur automatically simply by liberal support of basic research. Our success in the future, as in the past, will depend upon the continued evolvement of our institutional and governmental forms to meet the needs of the times. Our hopes must flow from democracy and not science itself. And democracy is a living and moving force which is kept alive not by the past but by the challenge of the future.

Deep Submergence Vehicle Navigation

Between January 20 and 22, 1966, the Institute of Navigation and the Marine Technology Society sponsored a meeting to discuss problems and techniques related to precise positioning of deep-submergence vehicles. The meeting, held in San Diego, was attended by more than 200 representatives of Government, industry, and academic institutions. Kenneth V. MacKenzie, head of the Navy Electronics Laboratory's Deep Submergence Group, chaired the two-day session and set the tone of the meeting by outlining the requirements that must be met to position deep-submergence vehicles:

- Define as accurately as possible the geographic and physiographic boundaries of the area of interest.
- Guide the craft and its associated support system to the predetermined location.
- Provide self-contained precise three-dimensional positioning aids for the submerged vehicle.
- Provide means of revectoring the craft to a given target.

Mr. Norman Tibbals, of NEL, gave a very noteworthy paper on the latest status of the OMEGA navigational system. A four-stations network (Norway, Trinidad, Hawaii, and upstate New York) will be operational by the beginning of April 1966 to provide coverage for most of the Atlantic and portions of the northern and eastern Pacific. The system is designed to provide the broadest service to a wide variety of users. Its accuracy is limited by the stability of the propagation path and by the quality of the receiving equipment. Under average conditions, position can be pinpointed between better than 1 mile (night) to better than 1/2 mile (day). For greater accuracy, additional subsystems can be provided which furnish necessary corrections for fluctuations in the propagation path, in which case position can be pinpointed to better than 0.5 nautical mile. At present, receiver availability is still very limited.

—Continued on back cover (inside).

Programmed Instruction Goes "Operational"

George Douglas Mayo
Head, Research Division
Staff, Chief of Naval Air Technical Training

Glenn L. Bryan
Head, Personnel and Training Branch
Office of Naval Research

Vicennial Article

Although science has always been the focal point of the interests of the Office of Naval Research, a lively interest has been maintained in technology as well. This article describes one of those instances in which scientific achievements have been brought to practical fruition through technological application.

Early in 1963 it became clear that the instructional technology known as "programmed instruction" had progressed to the point that it was ready for development in a typical Navy training situation. Some nine years earlier, Professor B. F. Skinner of Harvard University had introduced programmed instruction in his now historic article "The Science of Learning and the Art of Teaching." In essence, Skinner provided both the impetus and the rational foundation for a new instructional technology stemming from the learning laboratories. Principles of learning that had proved to be effective in the training of laboratory animals were applied to the teaching of academic material to human students. The experimental results were gratifying. They indicated that those principles were sufficiently general to serve as the basis for a new science of behavioral engineering. At the risk of oversimplification, the essential points of Skinner's conditioning approach called for the student to be exposed to a graduated series of lessons under controlled conditions which encouraged and "rewarded" correct responses. Material cast in that form was called "an instructional program"—hence, the movement came to be known as "programmed instruction." Skinner's article was the signal for a greatly intensified research effort in this area. The armed services, including ONR, played a major part in the effort.

As noted previously, in 1963 ONR began to look for an appropriate typical training situation in which to apply and further develop programmed instruction technology. All desired criteria appeared to be met by the Naval Air Technical Training Command, headquartered at Memphis, Tennessee, which provides most of the nonpilot training for Naval aviation. In all, 96 courses are conducted. These courses

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are completed by approximately 33,000 trainees per year. The training ranges from that relating to Navy occupations or ratings concerned primarily with electronics to that on aircraft engines and structures, aerography, survival equipment, and air-traffic control. An agreement was reached between the Chief of Naval Research and the Chief of Naval Air Technical Training in December 1963 whereby the latter would be responsible for the development of programmed instruction throughout the Naval Air Technical Training Command and the former would provide financial support and technical advice.

The Programmed Instruction Project

The Chief of Naval Air Technical Training moved quickly to establish a special project for programmed instruction and to designate a Special Project Officer to be responsible for all aspects of programmed instruction development throughout the Command. One of the first actions of the Special Project Officer was to train an initial cadre of ten personnel in instructional programming theory and techniques. Upon completion of this training, five of the personnel were formed into a pilot programmed-instruction team that began programming course material in one of the schools and developing procedures which would be used by the much larger number of instructional programmers that would be available within a few months. The second group of five personnel was assigned the task of developing and conducting a course for instructional programmers. In accordance with the plan, personnel to be trained in this course would be drawn from each of the seven training centers or units of the Command.

Before the course for instructional programmers was established, a one-day workshop was held at each training activity of the Command, attended by about 25 of the activity's key training personnel. The workshop served the function of acquainting training administrators with the new technology and dispelling any erroneous impressions that might otherwise have arisen. Included in these sessions was a discussion of the policy of the Chief of Naval Air Technical Training with respect to programmed instruction.

In July 1964, the course for instructional programmers was ready for its first class of 15 students. It consisted of three weeks of formal instruction followed by two weeks of instructional programming under the supervision of the pilot programmed-instruction team, which by this time had completed and published several successful instructional programs.

By December 1964, all seven training activities of the command had at least one team of instructional programmers preparing material on a full-time basis. A team normally consisted of four petty officers, at least one of whom was a chief petty officer, and one civilian educational specialist. The latter served the dual function of giving the team continuity and providing specialized knowledge of training matters, learning theory, and programming techniques.

Success of the Project

At the end of two years, on January 1, 1966, the project had achieved all of its objectives, and programmed instruction technology was declared fully "operational" in all training activities of the Command. In his final report to the Chief of Naval Research concerning the success of the project, the Chief of Naval Air Technical Training could point to the following achievements: A total of 70 personnel, formed into 14 teams, was engaged in full-time instructional programming. Based on feasibility studies conducted by these teams, the Special Project Officer had approved a total of 1600 hours of conventional instruction material for programming. A total of 77 programmed-instruction booklets had been demonstrated to be appropriate for teaching at the level prescribed and had been approved for use in the schools. The performance specification for a program, in order to be approved, was that 90 percent of a representative group of students taking the program achieve 90 percent of the objectives of the program. The 77 booklets called for 119 hours of programmed instruction, which represented 213 hours of conventional instruction — a time saving of 44 percent. A considerable number of additional programs were in the later stages of validation and final preparation of printing. Each team had produced and validated one or more programs, and each was well established in its work.

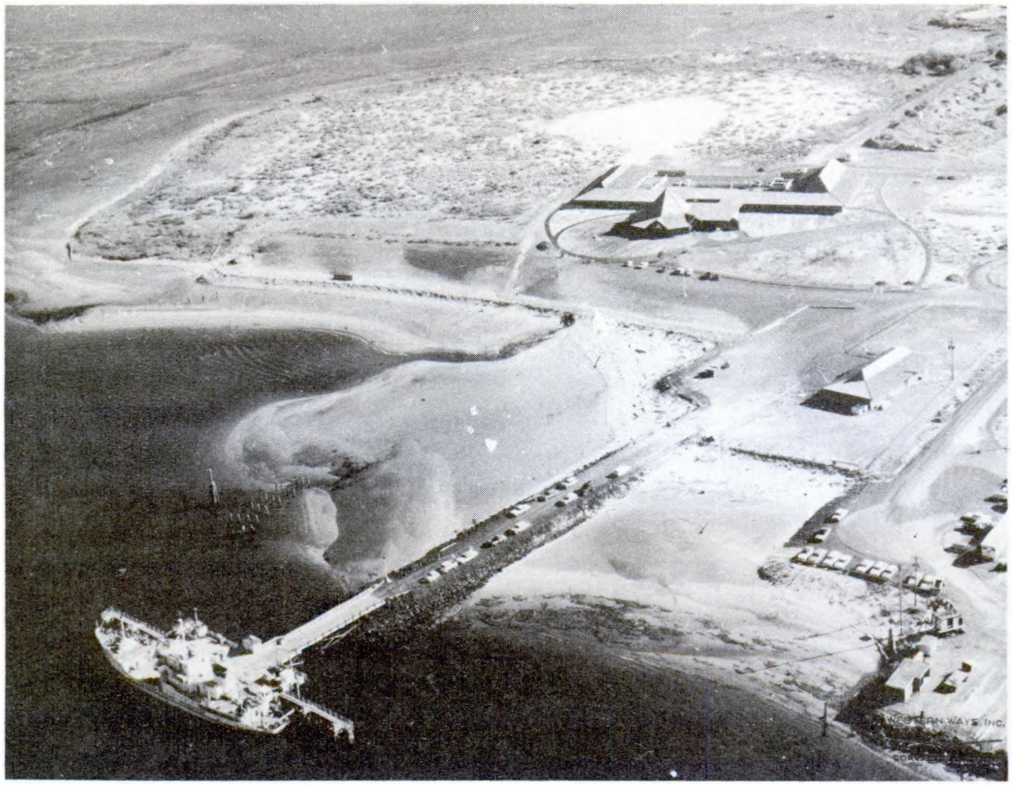
Two research studies had been conducted comparing programmed instruction with conventional instruction. The first study compared 13 hours of conventional instruction with 9 hours of programmed instruction covering the same material. The second study compared 26 hours of conventional instruction with 19 hours of programmed instruction. The results of those studies indicated that the students learned well from programmed instruction and in a substantially shorter period of time. Several other studies are being conducted or are in the planning stage. These studies have two primary objectives: first, to provide a more general statement than can now be made concerning the extent and limits of the contribution of programmed instruction to training in a typical Navy situation; and second, to further improve existing programmed-instruction technology.

To date, the development effort reported here has involved only printed programs. No teaching machines have been used. The relatively simple teaching machines that sprang up in response to the initial enthusiasm for the new technology have not shared equally with printed programs in the growth and acceptance of the technology.

— *Continued on page 32.*

Second of a series of articles highlighting oceanographic institutions that receive support in large measure from the Office of Naval Research.

OCEANOGRAPHIC INSTITUTIONS



The Marine Science Center at Newport, Oregon. The research ship YAQUINA is docked at pier.

The research ship YAQUINA

The Department of Oceanography at Oregon State University

Wayne V. Burt
Chairman, Department of Oceanography
Director, Marine Science Center
Oregon State University

HISTORY

Oregon State's Department of Oceanography had its real beginning in 1954 with $10,000 and a rowboat. With these resources, the author began research on the physical characteristics of Oregon's coastal and estuarine waters. In the spring of 1958, he expressed in a letter to the National Academy of Sciences' Committee on Oceanography why he thought oceanography should grow at Oregon State. NASCO sent a copy of this letter to the Geophysics Branch of the Office of Naval Research, and as a result, ONR included Oregon State in the first TENOC budget of 1958. On July 1, 1959, Oregon State University responded to the TENOC plan by establishing a graduate Department of Oceanography.

The new department then went to work to satisfy both the need for trained oceanographers and the need for basic oceanographic research in the northeastern Pacific Ocean. "Home port" for the Department is the Oregon State University campus in Corvallis, 56 miles from Pacific shores. Research and office facilities are now housed in the new Oceanography Building, occupied in 1964. Research cruises embark from Newport, Oregon, which is also the location of the new OSU Marine Science Center. From Newport, our researchers can reach open sea in a matter of minutes.

The department grew rapidly from the very beginning. Increased contract support from ONR included funds for a research vessel, the ACONA, which, when commissioned in May 1961, became the first ocean-going United States vessel to be constructed since 1932 specifically for oceanographic research.

Prior to the advent of the ACONA, OSU oceanographers chartered fishing boats or relied upon local U.S. Coast Guard vessels for their work at sea. Despite the obvious disadvantages of this arrangement, they were able to uncover many useful facts about Oregon coastal waters. Several historical studies that are continuing today had their beginnings in the pre-ACONA era.

When the ACONA went to sea for OSU, our area of research expanded from 45 to 165 miles offshore between the Columbia River and the Oregon-California border—an area that was relatively unknown, oceanographically speaking. Despite rugged weather conditions, the 80-foot ACONA was at work year around, for nearly 200 days annually. In the fall of 1964, the ACONA left OSU for more northern waters. The University of Alaska now uses her services in establishing a broader oceanographic program in that area.

The ACONA was replaced by a larger vessel, the 180-foot YAQUINA, formerly the FS-210, which has proved herself a splendid success. She was converted into a modern oceanographic research vessel with funds from a National Science Foundation grant. Because of her stability and size, she has proved even more efficient in days spent at sea than the ACONA. Her greater cruising range has allowed us to extend studies even farther from our shores and to remain at sea for longer periods of time. Her first major expedition—a four months' cruise to Hawaii and the Aleutian Islands—will be made this spring.

The newest facility for marine research at Oregon State is the Marine Science Center at Newport. This laboratory is the first in a planned complex of marine research facilities to be built at the Newport site. A portion of the laboratory, under the direction of Dr. Joel W. Hedgpeth, is the base for several coastal and estuarine research projects and provides shoreside support for our open-sea investigations. Several other departments of the University, in addition to other agencies interested in water research, are carrying on work at the laboratory under the direction of Dr. Thomas G. Scott.

The department has grown rapidly in manpower as well as facilities. In the beginning, it listed five staff members and one graduate student. Now, six years later, it has 96 full-time staff members, 83 graduate students, and an annual budget of nearly $2 million.

At the June 1962 commencement, Oregon State granted its first degree in Oceanography—a Ph. D. We anticipate that in June 1966 at least eight students will receive the Ph. D. in oceanography, and 15 will be awarded M.S. degrees. By that time, Oregon State will have graduated 38 oceanographers at the M.S. level and 15 at the Ph. D. level.

Research

Oregon State University is one of the few institutions conducting research in all phases of oceanography (physical, chemical, geological, biological, and geophysical). The exchange of ideas and information among these areas has led to new approaches and significant advances in our knowledge of the oceans.

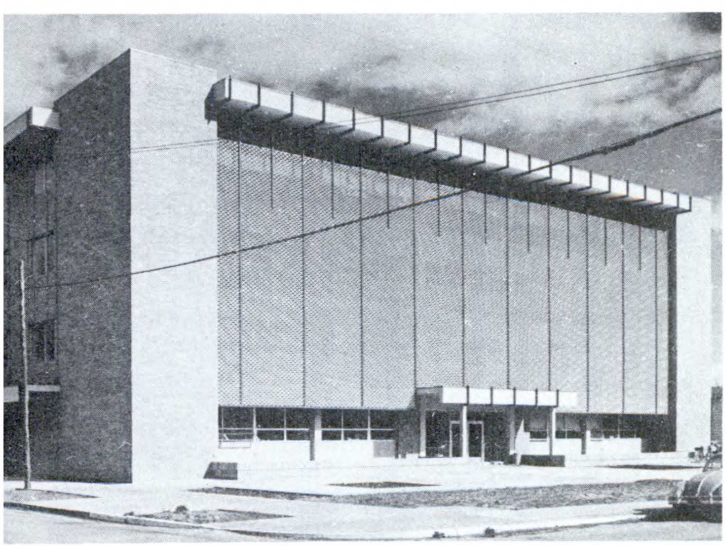
Physical Oceanography

In physical oceanography, we have been concerned mainly with the water masses off our coast. Currents are being examined by both float and flow methods, as well as from inferences made on the basis of hydrographic data. The cause of the winter flow to the north, commonly called the Davidson Current, has been a subject of continuing speculation. Direct measurements made over the past several years show that this current near shore is not related closely to any subsurface flow from the south and that it is more likely to be wind induced. The apparent paths taken by drift bottles released off our coast suggest that the Davidson Current extends to at least 50° north latitude and may at times be 165 miles wide.

Subsurface currents are under intense study. Horizontal currents and vertical shear are being investigated by tracking drogues set at various depths. These studies have revealed the presence of distinct north-south shear, with minimum velocities near the base of the pycnocline. East-west shear is evident also. In general, surface waters tend to drift onshore and subsurface waters, offshore.

The interest in oil exploration off our coast has given us the opportunity to make much more detailed studies of currents on the continental shelf. We have developed special instruments for making observations from "platforms of opportunity," such as oil-drilling rigs, and have been working from several of these locations for nearly a year. Fixed arrays of current meters also have been moored near these platforms. The wealth of time-series data obtained from this cooperative program promises to contribute significantly to the understanding of tidal currents off our coast. Such information is vital to the safety and efficiency of all marine operations in our area.

Coastal engineering and military operations will benefit also from a program of wave prediction now underway in our department. Pressure sensors installed offshore on the continental shelf are measuring actual



The new Oceanography Building at Corvallis, Oregon.

wave heights and velocities. These records are being compared with the predicted values to check and improve the validity of the prediction method.

In an effort to understand better the connection between the weather and the sea, we have been examining energy exchange at the air-sea interface. Classical energy equations were used to compute an over-all heat budget for offshore Oregon. This picture is now being refined through direct measurement of some of the terms involved. Since measurement of long-wave radiation was hampered by the lack of suitable instrumentation, a new total hemispherical radiometer was developed to measure both long-wave and total radiation.

The variation in heat stored in the upper 328 feet of the sea off Oregon indicates a difference in regime between waters within 65 miles of the coast and those farther offshore. Upwelling and seasonal currents appear to play an important role in influencing these variations.

We are studying upwelling by classical methods as well as from other points of view. The expected relationship between winds and upwelling pointed the way to a unique set of observations of an early stage of this phenomenon off Brookings, in southern Oregon. These closely spaced observations have given a much clearer picture of the upwelling mechanisms.

Goephysics

In 1962, the department welcomed geophysics into its program of research and graduate training. Since then, Oregon State University has become the largest geophysical training center in the Northwest.

Our seismograph station is now a part of a network of such stations established around the world to improve the recording of earthquakes and the detection of underground nuclear explosions. Our geophysicists also operate a subsidiary seismic station at Klamath Falls, Oregon. On the basis of records obtained from these and other stations, we have computed earthquake travel-time curves which are used for locating the centers of local earthquakes and investigating crustal features.

We have found that the earth's crust east of the Cascade Range is about 28 miles thick and that the underlying mantle is a normal one. West of the Cascades, however, the crust is only about 15 miles thick. The underlying mantle rocks seem, from all evidence, to be very different in composition. Preliminary results of seismic profiling offshore show that the crust under the ocean is unusually thin just beyond the continental slope.

In addition to these studies, the geophysicists are investigating the details of the earth's gravitational attraction over both the land and the ocean. ONR has contributed greatly to this work by supplying a LaCoste-Romberg gravity meter.

We are also studying magnetic susceptibility and heat flow through the ocean floor. These studies show that the San Andreas fault zone of California continues 100 to 300 miles off the Oregon coast.

Geological Oceanography

The basic aims of the geology program are to determine the geologic nature of the continental margin, to map sediments, and to examine the ways in which sediments arrived where they are. This program involves the marine geology of the coastline, estuaries, and related coastal features, as well as the area offshore. The northern Oregon coast is retreating in some places as much as two feet per year and in a few places as fast as ten feet per year. The areas susceptible particularly to landslides have been mapped, and we have been able to make rough predictions of landslide occurrence.

Studies of estuarine sedimentation have revealed that most sediment transport takes place during the winter. Coarse-grained sediments are moving into the estuaries from both the rivers and the ocean, while the finer grained, suspended sediments are moving out.

We are studying living microorganisms, such as foraminifera, in order to determine the habitats of their fossil counterparts. On the basis of such studies, we have determined that rocks now exposed in shallow water on the continental shelf off Oregon were formed originally at great depth. This finding implies that the material that forms the present continental shelf has been uplifted from its original position. From such investigations, we have determined that the continent has grown from five to ten miles during the last few million years. Although the shoreline is receding, the continental margin, marked by the continental slope, is actually growing. The coast of Oregon may be one of the few places in the world where continental accretion can be so well demonstrated.

Chemical Oceanography

One of the basic programs in chemical oceanography has been to understand the nature and distribution of the chemical elements in the ocean off Oregon. As a result, we can trace the movement of the plume of relatively fresh water from the Columbia River into the Pacific with some accuracy. We have discovered that measurements of carbon dioxide and dissolved oxygen are often better indicators of upwelling that are the conventional measurements of temperature and salinity. We have also determined the rates of exchange of several gases across the air-sea interface. These rates are important terms in the calculation of turbulence, and they are useful in studying the spread of radionuclides into the oceans and the effect of winds on the sea surface.

Theoretical studies have resulted in new ideas about the circulation of deep oceanic waters, the physical chemistry of sea water, and ocean chemistry through geologic time.

Biological Oceanography

Biologically, the northeastern Pacific Ocean, particularly off Oregon, has long been neglected. Before Oregon State oceanographers entered the picture, the only deep-water collections from this area were made by the ALBATROSS around 1900. Now, the deep sea off Oregon is considered to be one of the best studied in the world. In almost every collection, we find animals whose very presence in our area was formerly unknown. Several unusual specimens have been discovered, including a fish with four eyes.

Our marine biological program includes all major categories of organisms in the sea, including primary producers of protein (phytoplankton), grazers (zooplankton), predators (fish), bottom-dwelling organisms, bacteria, and parasites. Each of these groups is being studied independently, and their integrated study is resulting in a much better understanding of the "life-web" in the sea.

Studies of phytoplankton distribution are giving a better idea of the amounts, conditions, and rates of food production in the waters off Oregon. Our training program for phytoplankton ecologists interested in aquatic pollution is unique in this country and possibly in the world.

Another training program involves the systematic sampling of zooplankton in Yaquina Bay, Oregon. This program is providing information vital to culture and harvesting of commercially important marine crops within the bay and knowledge of physical and chemical characteristics of the bay waters. Knowledge of present conditions can serve as a yardstick for measuring any future pollution of this area.

A similar study has been made in the Columbia River estuary. Here, however, the pollution problem is different. Far upstream, the Columbia waters are diverted to cool atomic reactors at the Hanford Atomic Laboratories. While levels of radionuclides in the water are low, they are readily detectable and provide a unique opportunity to study radioactive uptake by marine and estuarine organisms. Taking advantage of this natural laboratory is a new brand of oceanographer—the radioecologist.

To accommodate studies in radioecology and radiochemistry, the first and largest gamma-ray spectrometry laboratory in Oregon was established in our department for the measurement of low levels of radioactivity. As part of this program, a special probe was constructed for direct measurement of radioactivity on the ocean floor. Several important discoveries have been made in this relatively new field. We have measured radioactivity as far as 350 miles from the mouth of the Columbia River, and we have used radioactivity levels to estimate physical-transport rates of water masses off Oregon. Radionuclides produced at Hanford were measured in marine organisms collected hundreds of miles from the river's mouth. Radionuclides contributed by atmospheric fallout were found in organisms taken from depths as great as two miles.

Navy Support

The overlapping character of the research mentioned points out more clearly what we have known all along: The ocean is a complex environment that is not easily or neatly categorized. A comprehensive approach to its study is essential.

Throughout all of these studies, the Navy's continuing support is evident. Historical data, collected in the early years of our operation when our work was done almost totally under ONR sponsorship, provide a background for the more specialized studies underway today. The Navy's support of our vessel operations and of various research projects is the backbone of our program.

Although much of our research support now comes from other agencies, too, the phenomenal growth of oceanography at Oregon State could not have occurred and could not continue without the cooperation and help of ONR.

Dr. Weyl Leaves ONR

Dr. F. Joachim Weyl resigned from his position as Chief Scientist of the Office of Naval Research on April 1 to accept the post of Special Assistant to the President of the National Academy of Sciences, Dr. Frederick Seitz.

Dr. Weyl has served ONR for 19 years and has been Chief Scientist since August 1961. In 1964, he was selected as one of the ten outstanding public servants to receive Career Service Awards presented by the Civil Service League. He has also received the Navy Distinguished Civilian Service Award and the Department of Defense Distinguished Civilian Service Award for his significant contributions to the utilization of science to advance the national defense effort.

Dr. Weyl is leaving the Department of Defense to take a position which will keep him in touch on an even broader basis with the problems of science as related to the concerns and goals of this country. His new job will permit him to maintain his ties with the national defense community, including ONR. One of his first assignments will be to serve as Executive Secretary of the newly formed Committee on Scientific and Technical Information, which was established by NAS at the request of the National Science Foundation.

By the end of World War II, there had emerged within the Navy the concept of a broadly based research organization with a mandate to contract for basic research at universities—something which no federal agency was set up to do at that time. This concept materialized through an Act of Congress "to establish an Office of Naval Research in the Department of the Navy to plan, foster, and encourage scientific research in recognition of its paramount importance as related to the maintenance of future Naval power and the preservation of national security."

Toxic Marine Animals*

Findlay E. Russell
Laboratory of Neurological Research
Loma Linda University
Los Angeles County General Hospital

Dr. Russell has devoted the greater part of his career to the study of venomous and poisonous organisms. Part of this research—on marine animals, which is the subject of this article—has been conducted with the support of the Biology Branch of the Office of Naval Research. The author is indebted to B. W. Halstead for certain of the photographs that accompany the article.

When CDR Scott Carpenter became one of last year's 300 victims of "sculpin stings" along the southern California coast, he added another "first" to his enviable career. He became the first cosmo-aquanaut—or even plain human being—to make headlines for this happenstance.

The sculpin, *Scorpaena guttata,* is a small venomous fish common to the coastal waters of California from Point Arguello south to Abrejos Point, Baja California. It has a decided preference for rocky bottoms and may be found at depths greater than 200 feet. Some of the best sculpin fishing grounds in California are in the area in which SeaLab II came to rest. As one old fisherman remarked when learning of the whereabouts of the Navy unit, "They won't have to worry about stingrays out there; the sculpins will sting them all to death."

As man embarks on a new era of study and life under the sea, he faces a fauna far more complex, more unpredictable, and perhaps more dangerous than that which he has known upon land. He must attack the problem of how he will react to marine animals or, perhaps more important, how marine animals will react to him. Reports like the one from SeaLab II, from divers in the Persian Gulf, from engineers dredging the mouth of the Amazon, from landing parties in Viet Nam, and from sailors who have eaten unidentified poisonous fish off Pacific coral reefs, all indicate that a number of biomedical problems relating to toxic marine creatures will need to be solved before man can explore and live in the sea with a fair degree of impunity.

One of the important disciplines in the marine sciences is the study of venomous and poisonous marine organisms, of which approximately 1000 species are known to exist. For the most part, these species are distributed widely throughout the marine fauna—from the unicellular protistan *Gonyaulax* to certain of the chordates. They have been found in almost all of the seas and oceans of the world. While their numbers

*Excerpts from a paper presented at the first Inter-American Naval Research Conference, San Juan, Puerto Rico, July 1965. A more complete review of this subject appears in *Advances in Marine Biology,* Vol. 3, edited by Sir F. S. Russell and published by Academic Press, 1965.

sometimes may be quite large, they do not produce major ecological effects by virtue of their toxicity alone, although sometimes they may present a serious danger to man's health and economy in a particular locale.

Marine Poisons

The toxins of marine animals vary considerably in their chemical properties. Some are proteins of low molecular weight, and others are proteins of obviously high molecular weight. Some are amines, quaternary ammonium compounds, polypeptides, or mucopolysaccharides, while the structures of others are unknown. Some marine poisons contain enzymes, but these substances are not nearly as common in the venoms of marine organisms as they are in those of reptiles. The toxicological properties of marine toxins vary as remarkably as do their chemical properties. Some of the venoms provoke rather simple effects, such as transient blood-vessel constriction or dilatation, while others provoke more complex responses, such as changes in blood-vascular dynamics. These effects may be complicated by specific responses of the tissues of the victim.

Protista

The simplest of the toxic marine organisms are of the order Dinoflagellata. These organisms are distributed widely throughout shallow waters and in the high seas from the polar oceans to the tropics. "Blooms" of toxic dinoflagellates are referred to generally as "red water," "red tide," or "brown water." However, the bloom may appear yellowish, greenish, bluish, or even milky, depending on the protistan involved and certain ecological factors. When excessive numbers of these unicellular organisms collect, there may be a mass mortality of fish and other marine forms in the area.

Paralytic shellfish poisoning may occur following the ingestion of certain molluscs, echinoderms, and arthropods which have fed upon toxic dinoflagellates. The toxin responsible for this poisoning has been obtained in large quantities from certain California mussels and Alaskan butter clams. It is one of the most lethal biological toxins known. The minimal lethal oral dose for man may be as low as 1.0 mg.

Porifera (Sponges)

Of the 5000 or so species of sponges, only a few tropical and subtropical forms are known to be dangerous to man. Some are known to eject substances which are toxic to certain of the animals in their environment. The poisoning of humans probably occurs through deposit of the toxin in the superficial abrasions produced by the fine, sharp spicules of the organism. "Sponge fisherman's disease" probably is caused by Actiniae, which are found frequently with sponges, rather than by the sponges themselves.

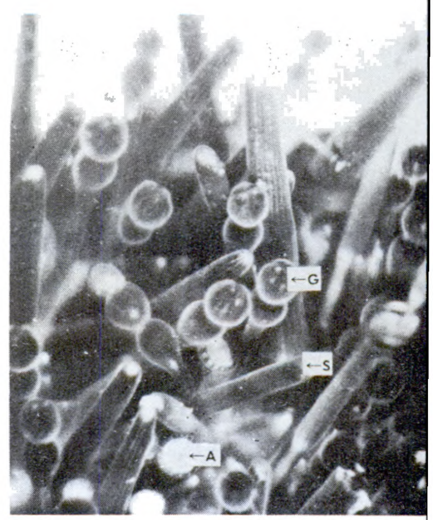
The toxic component in sponge poisoning has not yet been isolated, although some 38 substances have been identified in extracts from the organism. In man, "stings" by certain sponges are characterized, in the less severe cases, by localized burning, itching, swelling, edema, and redness and, in the more severe cases, by systemic manifestations, such as malaise, weakness, sweating, nausea, and loss of consciousness. The symptoms and signs are transient and rarely serious.

Cnidaria

Among the venomous cnidarians are certain hydroids, hydromedusae, jellyfish, sea anemones, and corals. While all members of the phylum have stinging units, called "nematocysts," only those of a few species are capable of penetrating the skin and poisoning humans.

It is thought that the lethal and paralyzing effect of cnidarian toxin is caused, for the most part, by proteins of low molecular weight, which may act directly on cholinergic neurons. Some of the symptoms and signs of cnidarian poisoning are localized edema, redness, itching, pain, and vascular changes.

Portuguese man-of-war, *Physalia physalia.* Stinging cells are abundant on the tentacles.



Test of sea urchin, *Tripneustes gratilla*, showing globiferous pedicellariae (G), ambulacral tube feet (A), and spines (S). From Alender thesis, University of Hawaii, 1964.

Echinodermata

There are approximately 6000 species of echinoderms, of which at least 80 are known to be venomous or poisonous. The most venomous echinoderms are found among the sea urchins. Certain of these animals are covered with calcareous spines, which may be poisonous, and by small, pincer-like organs, the pedicellariae, which are distributed over the body between the spines. The pedicellariae are modified spines with flexible heads. The globiferous type of pedicellariae serves as a venom organ. In most of these echinoids, the so-called "head" of the globiferous pedicellariae is composed of three calcereous jaws, each of which has a fine, rounded tooth-like fang. The venom glands are located in the jaws. Very little is known about the chemistry and mode of action of sea-urchin toxin. In mammals, it causes a marked fall in systemic arterial pressure, probably through its direct effect on the heart.

Besides the sea urchins, certain sea cucumbers are capable of discharging a substance that is toxic to fish and certain other marine animals. A toxin, holothurin, has been extracted from approximately 30 species of sea urchins. A cholesterol-precipitated fraction, which represents 40 percent of the crude holothurin, resembles digitonin and other saponins in both its chemical and biological activities.

Mollusca

Of the 80,000 species of molluscs, approximately 85 have been implicated in poisoning man or are known to be toxic under certain conditions. As noted previously, paralytic shellfish poisoning is caused by certain molluscs which have ingested toxic dinoflagellates and which are eaten subsequently by man. The site of concentration of the toxin may vary with the different species of shellfish, with the different seasons of the year, and with certain other factors. In most instances, the poison is concentrated in the digestive glands.

Most of the venomous species of molluscs are found in the families Gastropoda and Cephalopoda. The most dangerous gastropods are members of the genus *Conus.* These animals have a venom which is capable of paralyzing its prey and which may produce serious effects, including death, in man. Humans stung by these cones complain of immediate, sometimes intense, localized pain. Numbness and blanching may be noted about the wound, and a tingling sensation may develop about the mouth, lips, and tongue. In the more severe cases, respiratory distress and chest pain, difficulties in swallowing and phonation, blurring of vision, and muscular incoordination have been reported.

Paralytic shellfish poisoning is characterized by the onset of paresthesia, or sensory changes, about the mouth, lips, and tongue 30 minutes or so following ingestion of the offending mollusc. The paresthesia then spreads over the face, scalp, and neck and to the finger tips and toes. Sensory perception and proprioception (the activity of small nerve endings that tell one how his body is situated in space) are affected. Muscular incoordination, incoherent speech, and loss of voice are prominent signs in severe poisonings. Weakness, malaise, and respiratory distress may develop. The pulse is usually thready and rapid. Death may ensue. If the victim survives the first 10 or 12 hours, the prognosis is good. The case fatality rate varies from 1 to 10 percent.

Certain octopuses secrete a venom in their salivary glands that has a deleterious effect, particularly paralysis, on certain animals and occasionally on man. The component or components responsible for this effect are not known, although some workers believe that one of them is *eledoisin,* a polypeptide. Bites by octopods are very rare and seldom serious, although at least one death has been attributed to them.

Poisonous Fishes

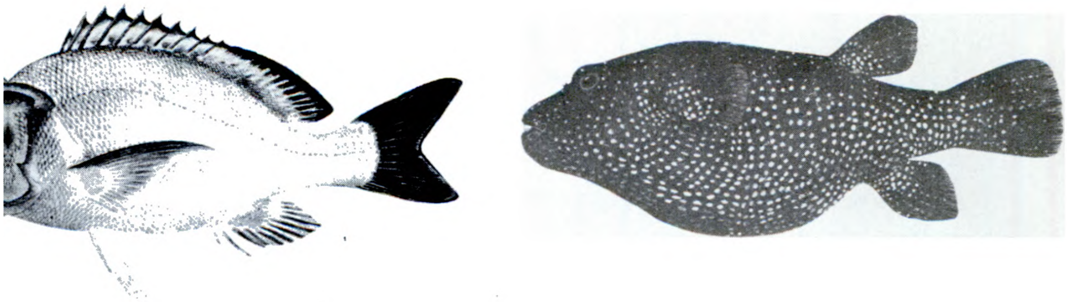
Approximately 500 species of marine fish are known to be toxic or, on ingestion, may be poisonous to man. Most, but by no means all, of these species are found in the coral-reef belt. As a whole, their distribution is spotty, even in a particular part of the ocean or around an island. They tend to occur in greater numbers around islands than along continental shores. Most of them are nonmigratory reef fish, either herbivores or carnivores. Some poisonous species have tissues which are toxic at all times; other species are poisonous only during certain periods or in certain areas, while in others only the tissues of specific organs are toxic, and the toxicity of these tissues may vary with time and location.

Icthyosarcotoxism is the general name for fish poisoning. The disease is caused by the ingestion of fish containing a poison in their musculature, viscera, or skin. It is identified usually with the kind of fish involved: ciguatera, tetraodon, scombroid, clupeoid, cyclostome, or elasmobranch. Fish poisoning that causes hallucinations also is classified with this type of poisoning.

Ciguatera poisoning may occur following the ingestion of certain tropical reef and semi-pelagic marine species, such as the barracudas, groupers, sea basses, snappers, surgeonfish, parrotfish, jacks, wrasses, and perhaps certain gastropods. Approximately 300 species of marine fish have been implicated in ciguatera poisoning. Almost all of these species are found between latitude 35°N and 34°S. They are usually bottom-dwellers or coral-dwellers. Most toxic species are carnivorous or benthonic algae feeders. The liver is usually the most poisonous part of the fish, although the flesh is often toxic, too.

This poisoning is characterized by nausea, tingling about the mouth, tongue, throat, and sometimes over the face and distal parts of the fingers and toes. Weakness, abdominal pain, vomiting, and chills often are experienced. Muscular weakness, incoordination, restlessness, and insomnia may develop. The victim often experiences a paresthesia which is almost classical in type: hot objects feel cold, and cold objects feel hot. In severe or fatal cases, incoordination becomes more pronounced, breathing becomes labored, and cyanosis may develop.

Tetraodon poisoning is the most dangerous form of ichthyosarcotoxism. Japanese statistics show a mortality rate of 61.5 percent for



me poisonous fishes. Left, red snapper, *Lutjanus gibbus;* right, puffer, *Tetraodon meleagris.*
e also Great barracuda (*Spyraena barracuda*) on front cover. From Jordan, 1905; Hiyama, 1943.

this type of poisoning. Tetraodon, puffer, or fugu poisoning may occur following ingestion of certain puffers, ocean sunfish, or porcupinefish. Of the approximately 100 species of these fish, over 50 have been involved in poisoning man or are known to be toxic under certain conditions. The toxin is concentrated for the most part in the ovaries or testes, the liver, and the intestines. The occurrence and amount of toxin is related to the reproductive cycle, both appearing to be greatest just prior to spawning.

The toxin has pharmacological properties not unlike those of certain local anesthetics, although it is far more potent. It appears to have a particular effect on the axons of certain nerve fibers.

Tetraodon poisoning is characterized by the rapid onset of weakness, dizziness, pallor, and paresthesia about the lips, tongue, and throat. Nausea is usually present, but vomiting is uncommon. In severe poisoning, the victim may complain of "numbness all over," giving rise to a feeling of "floating in air." Sweating, increased salivation, pain on inspiration, muscular weakness, and hypotension often are experienced. In the fatal cases, severe respiratory distress, marked hypotension, cyanosis, paralysis, and small hemorrhages may develop. In most fatal cases, death occurs 6-24 hours following ingestion of the toxic fish.

Scombroid poisoning is caused occasionally by the ingestion of certain of the mackeral-like fish: the tunas, skipjacks, and bonitos. Some investigators feel that it is just another form of ciguatera poisoning, but the clinical manifestations appear to be quite different, and it is generally considered as a separate entity. If scombroids are inadequately preserved, a toxic substance is formed within the body musculature. This substance, called "saurine," has properties not unlike those of histamine. Following ingestion of the offending fish, the victim usually complains of nausea, vomiting, diarrhea, flushing of the face, headache, and generalized skin rashes. Most of the signs and symptoms appear within two hours of the meal and subside within 16 hours. The poisoning is rarely serious.

Clupeoid poisoning occurs sometimes following ingestion of certain herring-like fish of the tropical Pacific. About 15 species of Clupeidae have been found to be toxic. It has not yet been established that the toxin of this form of poisoning is different from that responsible for ciguatera poisoning.

Cyclostome poisoning is caused by the ingestion of certain lampreys and hagfish. The slime and flesh of these animals contain a toxin which may cause gastrointestinal disturbances.

Elasmobranch poisoning may be caused by a toxin found sometimes in the musculature of the Greenland shark and the livers of several tropical sharks. It is characterized by nausea, vomiting, abdominal pain, diarrhea, headache, and sensory changes about the mouth. Again, this form of poisoning is sometimes considered to be a type of ciguatera poisoning.

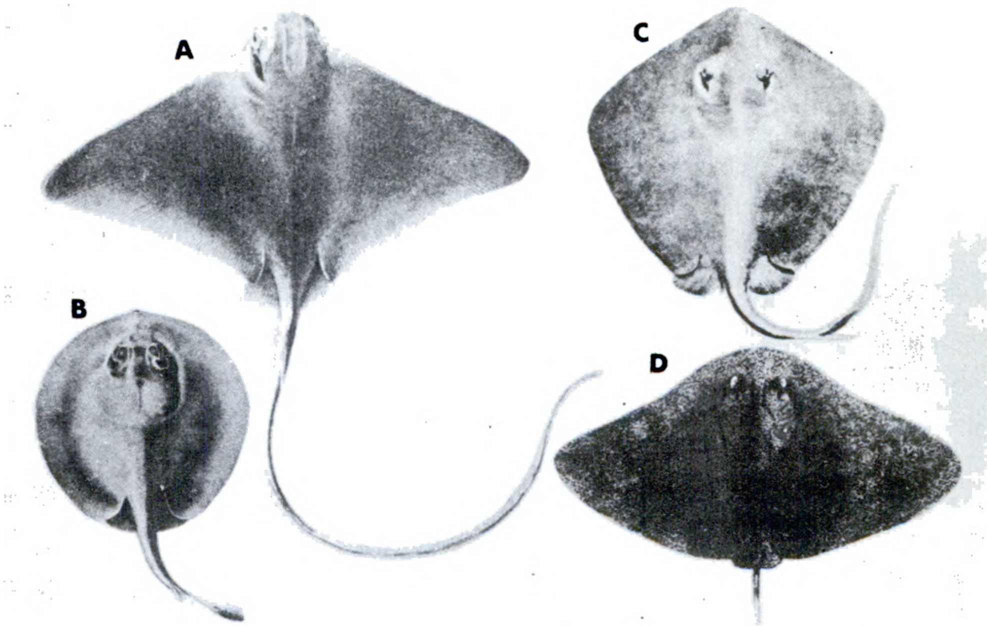
A number of of fresh-water fish and a few marine species produce a toxin which appears to be restricted to the gonads. In these fish, the body musculature and even the gastrointestinal organs are edible. Poisoning occurs following ingestion of the roe or the gonads and roe. These fish are known as "ichthyotoxic fish." Some fish and eels have a toxic component in their blood, following the ingestion of which poisoning may occur. Needless to say, this type of poisoning, ichthyohemotoxism, is extremely rare.

Venomous Fishes

Well over 200 species of marine fish, including the stingrays, scorpionfish, zebrafish, stonefish, weevers, toadfish, stargazers, and certain of the sharks, ratfish, catfish, and surgeonfish are known or thought to be venomous. For the greater part, venomous fish are shallow-water reef or inshore fish that are found most frequently in the Pacific area. They tend not to migrate and to be slow swimmers. Most species use their venom apparatus as a defensive weapon, chiefly against other fish.

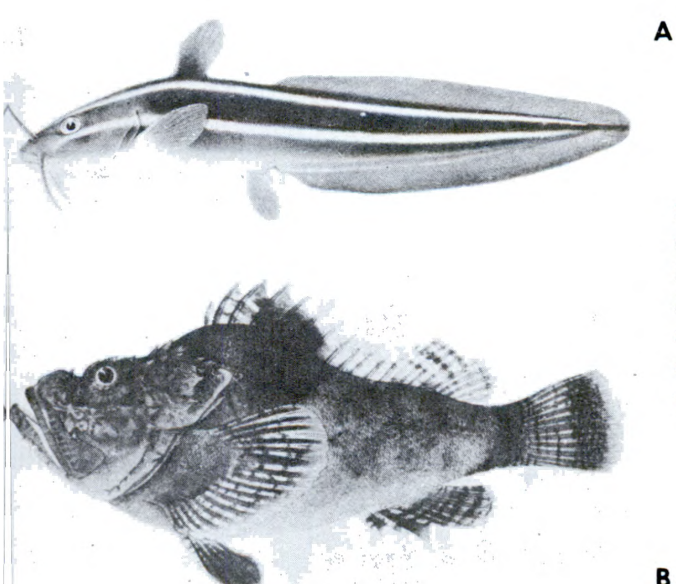
Stingrays. These elasmobranchs range in size from several inches in diameter to over 14 feet in length. Their venom apparatus consists of one or more spines that are bilaterally serrated and encased within an integumentary sheath. The venom, which is contained within the ventrolateral grooves, is extremely unstable. The toxic component is a protein with a molecular weight in excess of 100,000, although this component probably consists of several fractions. The venom is known to exert a deleterious effect on the mammalian cardiovascular system. It has little effect on the nervous system.

Injuries inflicted by stingrays are common in many areas of the world. Approximately 750 people a year are stung by these animals along the North American coasts. Stingings occur usually when the unwary victim treads upon the fish while wading in the ocean surf or mud flats of a bay, slough, or river. The fish often buries itself in the sandy bottom,



Stingrays. A, bat stingray, *Myliobatis californicus;* B, round stingray, *Urolophus halleri;* C, diamond stingray, *Dasyatis diperurus;* D, butterfly stingray, *Gymnura marmorata.* From Walford, 1935; Hiyama, 1943; and Halstead, 1959.

and when stepped upon, thrusts its tail upward and forward, driving its sting into the victim. The venom provokes intense pain, a fact of importance in the differential diagnosis, since "stingings" by broken beer bottles and broken bivalve mollusks are far more common along North American shores than stingings by stingrays. The pain and other deleterious effects of the toxin can be relieved quickly by submerging the injured part in hot water for 30-90 minutes.



Some venomous fish. A, oriental catfish, *Plotosus lineatus;* B, scorpionfish, *Scorpaenopsis gibbosus.* See also lionfish (*Pterois volitans*) on front cover. From Hiyama, 1943; and Halstead.

Weeverfish. The weevers are small fish found along the eastern Atlantic and Mediterranean coasts. They are taken often by inshore vessels engaged in shrimping. The venom apparatus consists of two spines at the gills and five to eight dorsal spines and the tissues contained within the integumentary sheaths surrounding the spines. The venom contains several toxic proteins and other substances. Like the injuries produced by stingrays, wounds inflicted by the weeverfish respond to hot water.

Scorpionfish. At least 80 members of the family Scorpaenidae, the scorpionfish or rockfish, have been implicated in poisonings or have been studied by venomologists. Included in this group are the zebrafish, sculpins, stonefish, bullrot, and waspfish. They are distributed widely throughout all tropical and most temperate seas, and a few scorpionfish are found in arctic waters. Many species are strikingly colored, and several are of unusual shape. They are found most often in or around rocks, coral reefs, or kelp beds, with which they often blend very favorably. Some species have the habit of lying motionless and partially concealed for long periods of time and thus often are handled or trodden upon unknowingly—that is, until envenomation occurs.

The venom apparatuses of scorpionfish vary considerably. In general, the venom is contained within 10-13 dorsal spines and several anal and pelvic spines. These fish have true venom glands within their spines. The venoms vary somewhat in their chemical and zootoxicological properties. All appear to be proteins, and all appear to have a marked effect on the cardiovascular system. Stingings are more common than is generally appreciated, and injuries by the stonefish may result in localized destruction of tissues and may be fatal. Hot water is again the first-aid measure of choice. An antivenin has been prepared against the venom of the stonefish *Synanceja trachynis.*

The Shrike and Cleansweep IIIB

A missile system designed to collect and bring back samples of debris from nuclea clouds is being tested currently at the Pacific Missile Range (PMR). The system, calle Cleansweep IIIB, is being developed by the University of California's Lawrence Radiatio Laboratory, a prime contractor for the U.S. Atomic Energy Commission, as a part of th national readiness program to resume nuclear testing in the atmosphere should the pres ent test ban treaty be broken.

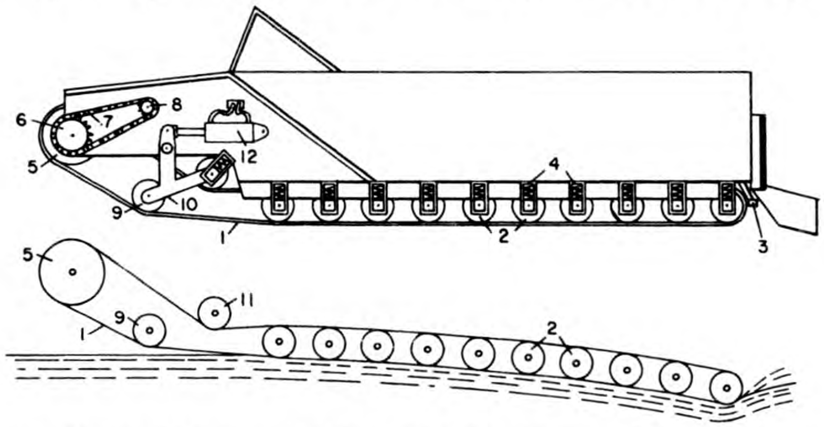
The single-stage air-launched ballistic missile is propelled by the Shrike rocket moto which was developed by the Bureau of Naval Weapons.

The missile is launched over the PMR inner-sea test range by an Air Force RB-57 (Canberra) jet aircraft at an angle of between 40 and 85 degrees to the horizontal. Twent seconds after launch, the nose tip and aft port covers of the missile payload are ejecte Air now passes through the vehicle, and sampling begins.

As the missile descends, the rocket motor is jettisoned, the payload is sealed so as t be watertight, and a parachute opens to lower the vehicle into the water.

Boat that Rides on a Belt

In patents issued in 1907 and 1925, a rather unusual body configuration and ›ropulsion system for a boat are described. According to these patents, the boat ıas a closed lower portion, comparable to that of a conventional boat, and a vide, endless movable belt that traverses the bottom from stem to stern on ransversely arranged rollers. The closed lower portion acts as a displacement



Above, side view of the conveyor bottom boat. Below, diagram showing the configuration of the belt while the vehicle is underway. 1, endless track; 2, supporting rollers; 3, blade that prevents water from being carried forward; 4, springs; 5, drive roller; 6, drive pulley; 7, drive chain; 8, sprocket; 9, adjustable roller; 10, support lever for adjustable roller; 11, belt tension roller; 12, hydraulic motor assembly.

ıull when the craft is at rest or moving at low speeds, and the belt supports the ›oat at or near the water's surface at high speeds. The main advantage of the ›elt is to minimize the effect of friction between the vessel and the water when he craft is traveling at high speeds. In effect, such a vehicle rolls forward over he water, although the belt actually travels backward with respect to the water.

Two fundamental problems arise in the construction and operation of a boat f this type. They are an inflexible angle of attack of the belt at the bow of the ›oat and a "clinging" of belt to water at the stern.

In order to provide maximum lift and thrust and minimum drag at all speeds, : is necessary that the belt enter and travel through the water as nearly horiontally as possible. According to previous conceptions, the forward belt-sup›orting roller is at least partially submerged when the boat is at rest, and it ecomes tangent to the water surface only under optimum conditions when the oat is in the planing stage. Accordingly, during the transition from the floating › the planing stages, the belt exhibits considerable drag. The clinging of the elt to the water at the stern also causes drag.

In an invention of Berger M. Shepard of the Naval Ordnance Laboratory, Vhite Oak, Maryland, both of these problems are overcome. His "Conveyor ›ottom Boat" (U.S. Patent No. 3,205,852, issued September 14, 1965) includes pair of movable rollers near the bow which permit wide variation of the angle f attack of the belt. The invention also calls for a small enough roller to be ıounted at the stern to produce high centrifugal forces to assist in breaking the dhesion between water and belt.

On the Naval Research Reserve

New Reserve Assistant at Chicago

CDR Joseph W. Tilford, USNR, reported as Assistant to the Commanding Officer (Research Reserve), Office of Naval Research Branch Office, Chicago, in February 1966.

For the last five years, CDR Tilford served as Commanding Officer of the U.S. Naval Reserve Training Center, Indianapolis, Indiana. Previously, CDR Tilford was Executive Officer of the USS CAMBRIA (APA36), which landed the Marines at Lebanon in 1958; and he was assigned to the Training Division, Bureau of Naval Personnel, 1955-58; Operations Department of Commander Amphibious Group 3, 1954-55; and Commandant's staff at Headquarters, Ninth Naval District, 1952-53.

CDR Tilford has been in the Naval Reserve Program since 1946. His home is Indianapolis, Indiana, and he is a graduate of Butler University in that city.

CDR Tilford

NRRC 4-1 Holds 17th Annual Dinner

Naval Reserve Research Company 4-1 held its seventeenth anniversary dinne at Nassau Inn, Palmer Square, Princeton, New Jersey, on January 22, 1966

The principal speaker was CAPT Roland Rieve, USN, Executive Officer o the Aviation Supply Office, Philadelphia. His subject was "Logistic Support o the Airborne Navy."

Among the distinguished guests were the local Group Commander, CAPT H. S. Prescott, USNR, and CDR Eleanor Kehoe, USNR, of the Office of Nava Research. Former Commanding Officers present were:

CDR H. G. Dyke, USNR—(fiscal years 1950 and 1951); CAPT F. J. Tros USNR—(1953 and 1954); CDR R. R. Goldberg, USNR—(1959); CAPT C. W Logan, USNR—(1960 and 1961); CDR R. E. Borup, USNR—(1963 and 1964) and LCDR Joseph E. Kearns, USNR—(1965).

Commander Edmund C. Reichard, USNR, present commanding officer, acte as toastmaster, introducing the speaker and the guests.

The Remaining Seminars

There are two remaining Research Reserve seminars scheduled for fiscal year 1966. They are as follows:

	Convening Date
• Midwest Research in Oceanography Seminar, Ann Arbor, Michigan	May 2, 1966
• Naval Research Laboratory Seminar, Washington, D.C.	June 6, 1966

Seminars Planned for Fiscal Year 1967

Seven Research Reserve seminars are planned by the Office of Naval Research for fiscal year 1967. The titles, places, and dates of the seminars are as follows

	Convening Date
• Third Research Reserve Seminar in Applied Research, Albuquerque, New Mexico	August 1, 1966
• Research Reserve Horizons in Oceanography Seminar, Quonset Point, Rhode Island	August 15, 1966
• Research Reserve Electronic Computers Seminar, College Station, Texas	August 29, 1966
• Research Reserve Nuclear Sciences Seminar, Oak Ridge, Tennessee	November 28, 1966
• West Coast Research Reserve Seminar, San Diego, California	January 23, 1967
• Research Reserve Seminar, Argonne National Laboratory, Argonne, Illinois	May 1, 1967
• Research Reserve Seminar, Office of Naval Research, Washington, D.C.	June 5, 1967

Promotion Selections

Three hundred and eighty three Naval Reserve line officers were selected for promotion to captain and 908 to commander by the Fiscal Year 1966 Reserve Selection Boards. Of these numbers, 11 Research Reservists were selected for captain and 18 for commander.

FOR CAPTAIN

	NRRC		*NRRC*
Bassham, James A.	12-5	Leeper, Wesley R.	11-9
Callahan, Francis J., Jr.	4-8	McConnaughey, William E.	5-11
Daniels, Albert O.	6-18	Reiff, Glenn A.	5-10
Kleinhenz, William A.	9-6	Warchol, Edward J.	13-4
Kovach, Eugene G.	5-10	Winslow, Eugene C.	1-7
Land, James E.	6-2		

Nine of the officers selected were from the new field, and 2 were from the old field. Other statistics based on the records of the Research Reservists selected for promotion are as follows:

Date of Rank		*Designator*
Earliest	8-1-57	1105:5
Latest	7-1-61	1405:5
		1515:1

Year of Birth		*Education*	
Earliest	1915	Doctorate	4
Latest	1923	Masters	3
Median	1922	Bachelors	4

FOR COMMANDER

	NRRC		*NRRC*
Armstrong, John E.	9-14	Godfrey, Edward C.	5-11
Bollinger, Edward H.	4-8	Gugenheim, Milton, G., Jr.	8-4
Bost, Howard W.	8-8	Kennedy, Anna H (WAVE)	11-7
Buchner, Bernard	3-8	Kupferberg, Lazarus L.	5-3
Camougis, George	1-5	Nawrocki, James T.	12-3
Chereek, Benjamin	6-17	Rhodes, Richard A.	6-4
Colegrove, Forrest D., Jr.	8-12	Rogers, Calvin B.	8-7
DeMars, Sylvester A.	6-16	Truslow, Thomas W.	5-12
Eldridge, Ralph G.	1-1	Wilson, Oscar B., Jr.	12-8

Twelve of these officers were from the new field, and six from the old field. Other statistics based on the records of the Research Reservists selected for promotion are as follows:

Date of Rank		*Designator*
Earliest	9-1-57	1105:9
Latest	8-1-61	1405:5
Median	7-1-60	1355:2
		1515:2

Year of Birth		*Education*	
Earliest	1916	Doctorate	8
Latest	1930	Masters	7
Median	1924	Bachelors	3

Programmed Instruction—Continued from page 11.

It is quite possible, although not entirely clear at this time, that the next major advance in Navy training technology may result from the union of programmed instruction and computer technology in the form of computer-assisted instruction. Should such be the case, the instructional programming capability reported here will not only be of operational value in the years that lie immediately ahead, but will greatly facilitate the next major advance in training technology.

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Deep Submergence Vehicle Navigation—Continued from page 8.

E. C. Buffington, also from NEL, gave a stimulating paper on the need to pre-survey a given area by conventional surface means before directing a small submersible to perform a number of specific tasks. He discussed his work related to the use of Cousteau's saucer to investigate a number of bottom geological features off the coast of southern California. The area of the dive had been surveyed previously, by means of MORAN (a circular range-range electronic navigation aid capable of coverage for distances in excess of 45 nautical miles) to provide precise position control for mapping physiographic and morphological details of the sea floor with echo-sounders and sub-bottom profilers. Buffington commented on the value of the pre-survey, which enables marine geologists to study the sub-bottom records at leisure and delineate the area in which the saucer will be needed to provide factual scientific information and settle the interpretation of sub-bottom records. With the aid of MORAN, Buffington was able to dive in the saucer at a carefully selected position and correlate sub-bottom data with checks on the extent of the thickness of overlaying sediments and nature of rock outcrops.

A. H. Roshon, head of the High Resolution Sonar Division at NEL, gave an excellent talk on the AN-BQS 8 and 9 narrow-beam sonars used for under-ice piloting. He showed a series of dramatic slides of sonar displays taken during part of a 1000-mile journey under the arctic ice cover during which the submarine operated frequently with less than 2 fathoms under the keel. The underside of the ice cover consists of a maze of ridges, often numbering more than six to the mile, extending below the surface between 35 and 80 feet. With the aid of the AN-BQS Sonar, the submarine was able to travel through the area at an average speed of 12 knots. Dr. Roshon commented that the upper surface of the ice does not always reflect the degree of subsurface roughness. An apparently smooth ice cover can exhibit very well developed ridges reaching several tens of feet below the surface. Dr. Roshon commented that TV was of little value for day-to-day operational needs.

The result of the ION/MT meeting on Deep Submergence Vehicle Navigation can be summarized as follows:

- Acoustics is emerging as a powerful means of guiding and controlling the subsurface operations of either tethered or untethered vehicles; it will supplement effectively the present and future electromagnetic navigational techniques.
- The development of equipment and techniques for subsurface navigation is expanding rapidly.
- Local acoustic characteristics of the medium, close to the sea floor, will have to be studied in detail to insure that an optimum location of acoustic beacons and transponders is provided for precise positioning of undersea craft.
- Pre-survey of the area and use of operational surface-bound techniques is still essential to delineate the features of the oceanic environment that must be studied by means of undersea craft.

—*M. P. Wennekens,*
Office of Naval Research
Branch Office, San Francisco

IN THIS ISSUE

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NAVSO P-510

EDITOR: Richard D. Olson

Drawings of some of the poisonous and venomous marine animals that are discussed in the article beginning on page 20.