MARINE PROGRAMS

at the

UNIVERSITY OF RHODE ISLAND

JAMES J. NAPOLI

MARINE ADVISORY SERVICE
SEA GRANT

UNIVERSITY OF RHODE ISLAND MARINE BULLETIN NUMBER 5

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JAMES J. NAPOLI, MARINE AFFAIRS WRITER

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INTRODUCTION

Marine science at the University of Rhode Island is an orientation, a direction. It is not an isolated activity of one department or even of one college. URI has a commitment to a total effort in marine science that is expressed in the cooperation, and, indeed, the interdependence of departments and personnel in many aspects of marine education, research and public service.

The Region

If URI's scientific attentions are turned so conspicuously toward the sea, it is because the sea is itself so conspicuous in the state. Rhode Island is only 48 miles long, from north to south, and only 37 miles wide -- just 1,038 square miles for nearly a million people. Yet the state has 419 miles of shoreline in bays, harbors and oceanfront, all providing easy access to deep navigable waters.

Jutting deep into the state is Narragansett Bay, one of the finest natural harbors in the world. It provides an avenue for commerce; rich fish and shellfish grounds; anchorage for pleasure, commercial and naval vessels of all types and sizes; and an inexhaustible, fascinating subject for marine research.

Early History

Marine research in Rhode Island did not begin at URI. Alexander Agassiz, Harvard's world-renowned marine zoologist, built a summer home and a small laboratory for himself and his students at Castle Hill in Newport in 1875. He chose Newport because the water is warmer and richer in marine life than the water along the Massachusetts coast where he usually summered.

Not until 17 years later, in 1892, was URI founded as Rhode Island State College. A land grant college, it is located in the village of Kingston in historic South County, 30 miles south of Providence and six miles from the bay. Shortly after its founding, in July, 1896, Dr. George Wilton Field, a newly appointed biologist at the Rhode Island Agricultural Experiment Station at the college, began an investigation into the decline of the oyster population in Point Judith Pond, about five miles from the Kingston campus.

During the first year, work was done in a small summer cottage on Gooseberry Island in the southern part of the pond. In 1897, a frame laboratory suitable for year-round use by four to six investigators was built on Buttonwood Point on the northwest side of the pond. Dr. Field and his assistants studied and published reports on oysters, plankton of brackish water, "scientific aquiculture," general biology of the white perch, and a dozen other topics generally concerned with the economic value of the pond.

This early impulse toward marine biological research at URI was arrested after only four years, reportedly because of "stress and of other work and the lack of financial assistance." Dr. Field left to accept a position at Massachusetts Institute of Technology in September, 1900.

Narragansett Marine Laboratory

After a long hiatus, marine research at URI resumed in 1935 when a marine biological program was started as an activity of the Department of Zoology under the direction of Dr. Charles J. Fish. He, his wife, Marie Poland Fish, and associates developed what later became the Narragansett Marine Laboratory.

A small research building was built in 1937 on one acre of ground at an Army post, Fort Kearney, on the west shore of Narragansett Bay, officially marking the beginning of the laboratory. Initial research involved a series of projects designed to provide information on the more important commercial species of fish and shellfish in the bay.

In April, 1938, a small new vessel, the ***Judith,*** was assigned to the laboratory by the owner, a member of the staff. However, on September 21, as the staff was finishing that summer's work at the laboratory, a hurricane destroyed the building, equipment and the vessel.

Another vessel was chartered in 1940 and a new wooden laboratory, the present North Laboratory, was opened the same year. Only limited studies were made during World War II, when Dr. Fish was in the Navy. The laboratory was reactivated for year-round operation as an independent unit of the College of Arts and Sciences in September, 1948, with three staff members. In addition to the North Laboratory, the staff also began to use the so-called "old stone" laboratory in 1949, the former officer's club at Fort Kearney.

The stone laboratory was destroyed by fire in 1959, and a large share of the Narragansett Marine Laboratory's scientific records was destroyed with it.

A Period of Expansion

After the 1959 fire, the University administration secured immediate state support for a new building and on October 8, 1960, the Charles J. Fish Laboratory was dedicated. In addition, a number of World War I artillery bunkers on the grounds were converted into laboratory and shop areas.

In the meantime, however, education programs were drawing more students and personnel into marine-related fields. In 1949, the School of Arts and Sciences inaugurated a master of science program in biological oceanography. A doctoral program in the same field began in 1958, and in 1960, a master's program in geological oceanography began. Finally, in 1961, the URI Graduate School of Oceanography was created to provide educational programs in all major fields of oceanography: biological, geological, physical and chemical. Dr. John A. Knauss, formerly of the Scripps Institution of Oceanography of the University of California, was appointed dean.

To accomodate the added marine activity, two new buildings were constructed at the Bay Campus in 1968. One of the buildings, the Horn Laboratory, is a

million-dollar, two-and-a-half story structure financed primarily by the National Science Foundation for expanded research and graduate training programs. The other is a scientific library, the Claiborne Pell Marine Science Library, which was funded by state bond issues.

The University plans to make the Pell Library one of the most complete marine science repositories in the country. Besides its ever-expanding collection of scientific books, which now totals about 8,000, the library contains reports of nearly all major oceanographic expeditions. It has 1,500 serial and periodical titles and 9,000 reprints. The Pell Library has also been designated the National Sea Grant Depository to house a collection of every publication of the National Sea Grant Program for reference by scholars, scientists and the public.

A small, prefabricated laboratory building was built with University funds in 1967. It is called the Butler Building.

And a 1,200-foot research aquarium, funded by a $500,000 state bond issue passed in 1968 and expected to be completed in 1971, is located near the Bay Campus waterfront below the bunkers of old Fort Kearney. The aquarium includes a large tank room, small isolation laboratories, freezing rooms, controlled temperature rooms and an acoustically-isolated room. Studies of fish sound, animal behavior, and shellfish rearing and pollution, and physiological experiments will be carried out at the new facility by biological oceanographers, zoologists and botanists.

Also being built in 1971 were two linked, prefabricated laboratory facilities for ocean engineering and geological oceanography.

In 1962, for research on the oceans, the University purchased for $500 a 180-foot, 840-ton Army maintenance and supply ship for conversion into a research vessel. The *R/V Trident* can carry scientists anywhere on the earth's oceans for months at a time. Funds for her operation and maintenance have been provided by the Office of Naval Research and the National Science Foundation.

The URI fleet grew with the donation of a 47-foot motor cruiser, *Gail Ann,* used extensively for commercial fisheries training. The Graduate School of Oceanography also charters a 40-foot dragger, *Billie II,* for year-round work on Narragansett Bay and Rhode Island Sound, and the Department of Fisheries and Marine Technology in the College of Resource Development charters a 21-foot work boat. The Marine Experiment Station has, on loan, a 54-foot steel boat, *La Nina,* for research on fishing gear and electronic equipment. In 1970, URI received two boats from private donors: the Department of Ocean Engineering was given a 36-foot power boat, *Islander,* for research, and the Graduate School of Oceanography was given a 26-foot bass boat, *Blue Jacket,* for diving, survey and utility work. Late in 1971, URI was also the recipient of a 45-foot cabin cruiser, *Crowsnest VI,* to be used primarily for ocean engineering research. Another dozen skiffs and outboards are available for use by researchers in various departments.

Research facilities also include standard and specialized apparatus for studies in various phases of oceanography and allied sciences; both a

transmission and a scanning electron microscope; the University's Computer Center, linked by remote console with the Pell Library at the Bay Campus; and the Rhode Island Nuclear Science Center, which operates the state's atomic research reactor on the Bay Campus. The reactor, designed for five megawatts, is now operating at two megawatts. A subcritical reactor is located on the main campus. For scientists and engineers interested in research on the bottom of the bay, an underwater habitat, which will provide a safe base platform and dry, heated, air-filled refuge for several divers at a time, was readied in 1971 and will be placed about 1,000 feet from shore where the pier at the Graduate School of Oceanography is located.

URI's Marine Experiment Station was built on state land on the westerly shore of Point Judith Pond in Jerusalem, about ten miles from the Narragansett Bay Campus. This facility provides a base of operation for research in aquaculture, fishing gear and fish population dynamics. The station, administered by the Graduate School of Oceanography, includes a laboratory building with a saltwater system, a shop building, both indoor and outdoor holding tanks for marine animals and a dock for small boats. A new nutrition physiology center for vertebrates and invertebrates became operational in 1971. The National Marine Water Quality Laboratory also maintains a floating laboratory and dock at the experiment station.

The Environmental Protection Agency (EPA) has authorized the Water Quality Laboratory to build a new facility at the Bay Campus. It is presently located in temporary facilities in West Kingston. Already cooperating neighbors of the Graduate School of Oceanography at the Bay Campus are EPA's Northeast Water Hygiene Laboratory, the Narragansett Sport Fisheries Marine Laboratory of the National Oceanic and Atmospheric Administration, as well as the Nuclear Science Center.

A 90-acre oceanographic research park abutting the Bay Campus on the west was under construction in 1971 and will provide sites for private, oceanographic-oriented industry. During 1971, the University also received a gift of 41 acres of waterfront land from the South Ferry Corporation for addition to the Bay Campus. The Campus now comprises about 165 acres along both sides of South Ferry Road in Narragansett and includes about 2200 feet of shoreline along the West Passage of the Bay.

Total Commitment

The first sea grant national conference was co-sponsored by URI and held in Newport in 1965. At the conference, Dr. Athelstan Spilhaus, noted author, inventor and scientist, outlined his plan for a system of federally-supported universities that would specialize in helping develop ocean resources much in the same way as the land grant colleges of agriculture had helped develop farm resources. The U.S. Senate hearings on the proposed Pell-Rogers Sea Grant College Act were held at URI on May 2, 1966; the act was passed by Congress and signed into law by President Johnson the same year. The Congressional mandate that created the program calls for the development of marine resources for economic and social benefits to the nation, and for the education and training of personnel to carry out such development.

Consonant with the sea grant philosophy of a coherent and balanced approach to marine affairs, four new marine degree programs were established at URI subsequent to the first sea grant conference. The College of Engineering instituted a master's and doctoral program in ocean engineering in 1966; a two-year associate degree program in fisheries and marine technology was begun by the College of Resource Development in 1967; and two interdepartmental programs, the Master of Marine Affairs and the doctorate in economics with a marine resource option, were established in 1969. By that time, nearly one-seventh of the entire URI faculty was engaged in some aspect of marine-related research.

This concerted effort in marine science had been accentuated in 1968 as URI became one of the first three colleges in the nation to receive an institutional grant under the sea grant program.

It became evident that a central administrating office was necessary to coordinate these efforts in marine science and to insure leadership and direction in their development. On January 1, 1969, Dr. Knauss, the dean of the Graduate School of Oceanography, was given the added title of provost for marine affairs. Under the vice-president for academic affairs, he was made responsible for coordinating all marine activities at the University, including the sea grant institutional program.

In September, 1971, Secretary of Commerce Maurice Stans announced that the University was among the first four institutions in the country to be designated sea grant colleges. The designation is an honor symbolizing the mutual recognition of the continuing responsibility for the Department of Commerce and URI to maintain and develop the excellence and relevance of the University's sea grant program.

MARINE EDUCATION PROGRAMS AT URI

GRADUATE DEGREE PROGRAMS

Although each maintains its own distinct character, educational programs in marine-related subjects at URI are linked. For the interdisciplinary degree programs, such as the Master of Marine Affairs and the Ph.D. program in economics with the marine resource option, the links are obvious. But in other areas, they may only be expressed as joint faculty appointments, such as those between the Departments of Zoology and Botany and the Graduate School of Oceanography or as courses offered jointly by departments for the mutual benefit of their students. The educational benefit to the student is also a corollary to the many interdepartmental research projects and to the sharing of research facilities among the departments. In addition, by agreement with the New England Board of Higher Education, students from one state can enter certain exchange programs of another New England state at the same tuition as a resident. URI's oceanography and ocean engineering curricula are among the designated exchange programs.

The box below summarizes programs offering graduate marine degree programs available.

GRADUATE MARINE DEGREE PROGRAMS

Graduate School of Oceanography:	M.S., Ph.D.
Ocean Engineering:	M.S., Ph.D.
Economics, Marine Resource Option:	Ph.D.
Master of Marine Affairs:	M.M.A.

Graduate School of Oceanography

Academic standards for admission to the Graduate School of Oceanography are high. The school receives from three- to four-hundred applications a year; it accepts about one in every seven applicants, and about one-half of those accepted finally enroll. The number of students who finally do attend the school depends largely on the amount of money available for their support in the form of graduate assistantships or graduate fellowships from such sources as the National Defense Education Act, the National Marine Fisheries Service, the National Science Foundation, the National Sea Grant Program, and the University.

Perhaps because the school originated as a center of biological studies, half of its approximately 28 faculty members and 125 students have biological backgrounds. But the school also accepts students with degrees in physics, chemistry, geology, mathematics, engineering, and nearly every other scientific discipline. While recognizing the desirability--indeed, the necessity--of such classical scientific backgrounds, the educational program of the school reflects a philosophy that the complex of interactions in the oceans demands an integrated outlook by the ocean scholar.

Thus, the Graduate School of Oceanography offers instruction leading to the master's and doctor's degree in oceanography with research emphasis on biological, chemical, geological and physical oceanography; all of its graduate students are required to take core courses in each of the four areas. These core courses are thought to be important not only for their intrinsic merit, but also for the integral part they play in developing in the student a comprehensive and balanced approach to the study of the sea.

Physical Oceanography: The course in physical oceanography covers the physical properties of seawater, heat budget, distribution of variables, dynamics, water masses and general circulation. It also includes an examination of waves, tides, and the history and interrelationships of marine sciences.

Chemical Oceanography: The chemical oceanography course deals with the processes regulating the composition of seawater, and the distribution of chemical species. The interactions of marine chemistry with the ocean floor, the atmosphere and marine organisms are also examined.

Geological Oceanography: Geological oceanography is concerned with the nature of marine geology and its relationship to other marine sciences. It stresses the study of beaches and coastal evolution; geo-morphology, sedimentary processes, structure, volcanism and tectonics of continental margins, the ocean basin floor, and mid-oceanic ridges; and the origin of ocean basins. The laboratory aspect of the course emphasizes instrumentation, procedures and interpretation.

In addition to the four core courses, all students in the school are required to take the seminar in oceanography in each semester of their residence, and each candidate for second-year standing or above is required to present one seminar a year. The students in the seminar give reports on problems and current work in various areas of research relevant to their own studies.

A graduate student in oceanography may take the offerings of related departments in other colleges of the University if he and his program committee consider them relevant. Thus, students in the Graduate School of Oceanography have taken such courses in other colleges as design and analysis of experiments, hydrodynamics, physiological ecology, biochemistry, probability, aquatic plant ecology and physical chemistry.

Special cooperative programs are developed for students in physical and chemical oceanography. The Environmental Protection Agency also supports a training program in marine pollution at the school for selected students studying for a master's degree and specializing in some aspect of marine pollution. The normal period of time required to earn degrees beyond the

baccalaureate is two years for the master's and five years for the doctorate. All graduate students must produce a thesis embodying an original piece of research.

Tempering theory with application, all degree candidates in the course of their research are required to participate in at least one regular oceanic research cruise aboard the *Trident.*

Ocean Engineering

Already a productive center for marine science, URI was a natural spawning ground for marine technology. An ocean engineering program was established in 1964 and was administered by a committee of the College of Engineering with cooperation from the faculty of the Graduate School of Oceanography. In effect, to complete the program, students earned a M.S. or Ph.D. degree in one of the engineering departments, took two or more courses in oceanography and wrote a thesis on some ocean engineering topic.

In 1966, the College of Engineering established the Department of Ocean Engineering, believed to be the first in the country. At URI in 1971, there were about 88 graduate students in ocean engineering, compared to the first-year enrollment of eight students.

The ocean engineering program depends upon a close cooperative arrangement with each of the classic engineering departments, as well as the Graduate School of Oceanography. Of the 14 faculty members in 1971, five were full-time; the others had joint appointments with the Departments of Electrical, Civil, Chemical, Industrial, Mechanical or Chemical Engineering.

An ocean engineering graduate student can form his program of studies from a broad range of academic areas. These include civil engineering, computer science, electrical engineering, geology, industrial engineering, mechanical engineering, chemical engineering, physics and mathematics, as well as oceanography and ocean engineering.

Besides the laboratory facilities in his own department, the ocean engineering student also has access to the shore and sea research facilities of the Graduate School of Oceanography. This easy exchange of facilities and information between departments--an important part of the University's total effort in marine-related sciences--makes possible a wide choice of areas of specialization for the ocean engineering student.

These areas include the desalination of seawater, nuclear energy applications, corrosion, physical properties of marine sediments, acoustic properties, of sediments, sediment transport, coring techniques, coastal and underwater acoustics, applications of information theory to underwater communications and data acquisition, turbulent boundary layer flow noise, underwater instrumentation, guidance and control of underwater vehicles, dynamics of towed body shapes, design of underwater pressure vessels, inelastic behavior of buoyant materials, wave motion and current studies.

Graduate students in ocean engineering have undergraduate degrees in conventional engineering, engineering science, geology, physics or mathematics, with prerequisite courses in thermodynamics, fluid flow, strength of materials

and electronics. All degree candidates, in consulation with their major advisors, are required to take certain core courses in ocean engineering and oceanography, and to attend an ocean engineering seminar in each semester of residency. Like oceanography students, ocean engineering students must take an ocean research cruise.

Fellowships are available from the Link Foundation, the National Science Foundation, the National Institutes of Health, the National Defense Education Act, and from the University. The department also offers graduate assistantships and research assistantships through its supported research projects, including those of the sea grant program.

Economics, Marine Resource Option

The graduate program in economics, marine resource option, is an example of a situation in which the special competence of the faculty can be an innovative force in curriculum development. The University had not previously offered a Ph.D. in economics, but the inclination of many faculty members in different departments toward research in marine resource economics encouraged the beginning of a plan for a doctoral program in that area in 1967. In October, 1969, a Ph.D. program in economics, marine resurce option, was approved. Students in the Department of Resource Economics are also able to earn a master's degree with a specialization in marine economics.

The doctoral program is directed by the faculties of the Department of Resource Economics of the College of Resource Development, the Department of Economics of the College of Arts and Sciences, and the Department of Finance of the College of Business Administration.

At its inception, five students enrolled in the interdisciplinary program, but in the next year, 1970, the number tripled. All the graduate students in the program are receiving some support either from the University's Agricultural Experiment Station, the University, or sea grant.

The program includes a core curriculum in economic theory, mathematics and statistics as well as at least 18 hours of courses especially designed for the marine resource option. The remainder of the program is developed in consultation with the student's doctoral committee and can include courses in oceanography, engineering, political science and geography as well as economics.

The dissertation is written on a special problem concerning marine resources or an associated industry, such as minerals, petroleum, fisheries, water utilization, transportation, recreation or waste disposal. A master's degree is not required for entrance into the program.

Master of Marine Affairs

The Master of Marine Affairs program, approved in 1969, grew out of a realization that the job of making decisions about the oceans and coastal policy by industry and government agencies is often left to men with little or no training for it.

Prospective students in the program, first of its kind in the nation, must already have a degree in a marine-related subject, or equivalent experience

connected with the oceans, and must be interested in the problems of evaluation, use and control of the marine environment. The program is multi-disciplinary, providing a 30-credit, non-thesis course of study that can be completed in a minimum of nine months.

Those who have undertaken the program include anthropologists/marine archaeologists, biologists, journalists, lawyers, marine cinematographers, marine transportation experts, marketing/management experts, naval architects, ocean engineers, oceanographers, operations research analysts, physicists, political scientists, public administrators, psychologists, sociologists, and systems analysts. About half of the average yearly enrollment of 20 students has consisted of persons who were also students at the Naval War College in nearby Newport.

The program is administered by a committee from the Departments of Resource Economics, Geography, Geology, Ocean Engineering, Political Science, and the Graduate School of Oceanography. The range of courses reflects the inter-disciplinary administration of the program and is intended to provide a general knowledge of the oceans and their problems. Two research papers are required in most of the courses. There are also a required six-credit marine affairs seminar and various elective courses.

Areas of specialization within the program include regimes for the deep seas, decision inputs for coastal zone regulation, jurisdictional requirements for pollution controls, criteria for deciding among competing uses for the continental shelf, arms control in the oceans, applications of cost-benefit analysis to systems models for coastal decision, implications for treating ocean basins as distinct regions, regulation of the high seas fisheries, impact of ocean engineering advances on the definition of the continental shelf, and the legal problems of international scientific expeditions.

Support is provided by sea grant funds and the Department of Geography.

GRADUATE MARINE SPECIALIZATIONS

Marine-related graduate study at URI is not limited to the formal marine degree programs. The study of the oceans has so many facets that a student seeking expertise in virtually any science can, with justification, turn that expertise toward the sea (see chart, pg. 14).

The University offers master of science and doctoral degrees in the biological sciences, and the biological science departments offer their students specializations with a marine orientation. The following are the biological science departments at URI and their marine specializations:

Animal Pathology: the multiplication and the recovery of viruses in shellfish, and marine histopathology

Botany: aquatic botany

Food and Resource Chemistry: chemistry of marine products

Microbiology: marine bacteriology

Plant Pathology-Entomology: water quality

Zoology: fisheries biology, behavior and habitat selection

Students can work toward an M.S. in civil and environmental engineering with a specialization in deep-ocean sediments, or toward an M.S. in industrial engineering with a specialization in industrial ocean engineering.

Both M.S. and Ph.D. degrees are offered by the Department of Electrical Engineering with specializations in underwater acoustics and ocean electronic systems; the Department of Mechanical Engineering and Applied Mechanics with specializations in hydrodynamics and thermal pollution: and Chemical Engineering, or its program in nuclear engineering, with a specialization in water resources.

An M.S. degree is also available from the Department of Resource Economics, with a specialization in marine economics. But since the institution of the interdepartmental Ph.D. program in economics with the marine resource option, students have tended to enter the doctoral program directly.

Salt marsh ecology is an area of study available in the M.S. program of the Department of Plant and Soil Science. Among the areas of concentration in the M.S. program in the Department of Food and Nutritional Science in the College of Home Economics are marine and new food sources, nutrition of fish and marine food organisms, preservation of marine foods, utilization of fish protein concentrates and biochemical and microbiological changes in marine foods.

Work beyond the master's degree in plant and soil science or in food and nutritional science can be developed in cooperation with departments offering the Ph.D. degree in biological sciences.

Offering an M.S. degree in the College of Arts and Sciences, the Department of Geology has specializations in coastal geomorphology, sedimentation and shore processes. The Physics Department, which has both M.S. and Ph.D. programs, has a specialization in underwater propagation of acoustic waves.

The Department of Geography offers an M.A. with a specialization in marine geography, in which students may study aspects of exploitation and control, both in the coastal zone and the deep ocean. The URI program is the only marine geographical concentration at the M.A. level in the United States. In the Department of Political Science, which offers an M.A., students are able to take a seminar in marine policy and public law.

As an adjunct to the M.A. in geography or in political science, students can enroll in a program leading to a graduate certificate in North Atlantic Regional Studies. The program is designed to take advantage of Rhode Island's location, with its tradition of involvement in maritime and naval affairs, and with its strong commercial and cultural ties with Western Europe.

The program is open both to URI master's degree candidates in political science or geography and to those who already have received an equivalent master's degree from another institution. They must take two core courses and four electives. The core courses are the Geography of the North Atlantic Basin and a

directed study or research course in geography or political science in which the student must prepare and defend a substantial paper under the direction of a faculty member. The electives are chosen from the Departments of Geography, Political Science or History.

Since spring, 1971, the Departments of Economics, Geography, Political Science, and Resource Economics have offered a 15-credit program leading to a graduate certificate in International Development Studies, awarded by the dean of the Graduate School. The Department of Sociology and Anthropology also participates in certain aspects of the program.

Sponsored by the University's Planning Committee on International Studies and supported by the URI International Center for Marine Resource Development, the graduate certificate program is designed to provide a supplemental, interdisciplinary concentration on the problems and processes of modernization and international development. The program is open to holders of a master's degree (or equivalent) in one of the participating disciplines, as well as to candidates for such a degree at URI.

In the College of Pharmacy, students working toward a M.S. or Ph.D. in either the Department of Pharmacognosy or the Department of Pharmacology and Toxicology can specialize in drugs from the sea.

UNDERGRADUATE PROGRAMS

The University of Rhode Island is a state university and, as such, the predominant number of its undergraduates are Rhode Islanders. Many of those who have been graduated from the state's public schools since 1960 have had the opportunity to become acquainted with ocean science through the special Saturday course in oceanography at URI run jointly by the University and the local school districts. About 700 Rhode Island high school students participated in the course in its first ten years. Another oceanography course, funded by the National Science Foundation and the National Youth Science Foundation and first offered in 1970, is given for 50 high school students from throughout the country for six weeks each summer. It is natural, therefore, that the interest in marine science among URI undergraduates is high, although for most of them a marine specialization is not possible until graduate school, after they have obtained a groundwork in scientific knowledge.

However, an introductory survey course in oceanography is available to undergraduates with junior or senior standing who have had at least one laboratory course in a physical or biological science. Further, undergraduates in many scientific areas may take courses that lend themselves to marine-related study. At the undergraduate level, research is undertaken primarily for its educational *value,* but it is not unusual for an upperclassman seeking a marine orientation in such an area as zoology or botany to lay the basics for an original scientific investigation in the context of a course such as invertebrate physiology or ecology. And, although there is no undergraduate curriculum in ocean engineering at URI, selected seniors in other engineering disciplines are allowed to elect graduate courses in ocean engineering. In addition, upperclassmen in engineering are often chosen to work as research assistants on ocean engineering projects during the summers.

Fisheries and Marine Technology

For those who are specifically interested in an education to fit them for commanding a commercial fishing vessel or for finding employment in almost any other aspect of the commercial fishing industry, the College of Resource Development established the Department of Fisheries and Marine Technology in 1967. The department offers a two-year commercial fisheries program leading to an associate in science degree.

The program requires that students take a total of *72* credits, 21 in general education subjects and the rest in professional fisheries courses.

Two training vessels are also in regular use during the academic year: the 47-foot *Gail Ann* and a 21-foot work boat. The *Gail Ann* has been specially fitted for training in commercial fisheries to allow trawling, purse seining, gill netting and longlining. All fishing equipment is hydraulically operated and a complete complement of electronics equipment is fitted, including sonar, Decca navigation, two radar sets, a recording depth sounder, fish scope and ship-to-ship radio. The boat is used in regularly scheduled class sessions.

Under the guidance of instructors, the students operate the vessel themselves on each trip, rotating jobs as skipper, engineer, navigator, mate and deckhand. During the final semester, trips of between 12 and 36 hours are taken in this manner.

Some of the jobs taken by graduates have been mate of an offshore fishing vessel, technician aboard an Antarctic research vessel, crewman aboard a dragger at Point Judith, skipper-owner of an inshore lobster operation, and assistant fish plant manager.

In Addition

The College of Resource Development also offers an undergraduate curriculum in natural resources, begun in 1970. Although it does not have a specific marine orientation, the curriculum encourages students to take a broad look at the problems of all our natural resources, among them the oceans. Students may direct their course of study toward the marine sciences.

GRADUATE PROGRAMS WITH MARINE SPECIALIZATIONS

DEPARTMENT	DEGREE	FIELD OF SPECIALIZATION
COLLEGE OF ARTS AND SCIENCES		
Botany	M.S., Ph.D.	aquatic biology
Geography	M.A.	marine geography
Geology	M.S.	coastal geomorphology sedimentation shore processes
History	M.A.	course in American Maritime history
Microbiology (& Biophysics)	M.S., Ph.D.	marine bacteriology
Physics	M.S., Ph.D.	underwater acoustics
Political Science	M.A.	seminar on marine polocy & public law
Zoology	M.S., Ph.D.	fisheries biology, behavior and habitat selection
COLLEGE OF ENGINEERING		
Chemical Engineering	M.S., Ph.D.	water resources
Civil & Environmental Engr.	M.S.	deep ocean sediments
Electrical Engineering	M.S., Ph.D.	underwater acoustics ocean electronic systems
Industrial Engineering	M.S.	industrial ocean engineering
Mechanical Engr. & Applied Mech.	M.S., Ph.D.	hydrodynamics thermal pollution
Nuclear Engr. (Chem. Engr.)	M.S.	desalination
COLLEGE OF RESOURCE DEVELOPMENT		
Animal Pathology	M.S., Ph.D.	shellfish viruses marine histopathology
Food & Resource Chemistry	M.S., Ph.D.	chemistry of marine products
Plant Pathology-Entomology	M.S., Ph.D.	water quality
Plant & Soil Science	M.S.	salt marsh ecology
Resource Economics	M.S.	marine economics
COLLEGE OF HOME ECONOMICS		
Food & Nutritional Science	M.S.	marine & new food resources
COLLEGE OF PHARMACY		
Pharmacognosy	M.S., Ph.D.	drugs from the sea
Pharmacology & Toxicology	M.S., Ph.D.	drugs from the sea

MARINE RESEARCH AT URI

All marine research is ultimately interdisciplinary, but this is most clearly seen in its application to specific, practical problems. For example, a program such as Sea Grant, which has a pragmatic orientation, can help focus the research in many different disciplines on a single problem. The following section is concerned with providing a survey of what research is being done in individual colleges. Specific URI faculty members engaged in marine research projects are listed in an appendix at the end of this report.

GRADUATE SCHOOL OF OCEANOGRAPHY

Biological Oceanographic Research

The diversity of life in the sea is matched by the broad scope of marine biological research at the Graduate School of Oceanography. These investigations range from the study of bacteria and phytoplankton to shellfish and whales. Knowledge is also sought of the intricate web of physical and chemical factors that contribute to an understanding of marine organisms and their life history.

Phytoplankton are enormously diverse unicellular and colonial plants distributed throughout virtually every fresh and marine body of water in the world. They are at the base of all aquatic food chains and, together with chemosynthetic and photosynthetic bacteria, provide the food of all other aquatic organisms, as land plants do for all terrestial forms of life.

URI has one of the largest phytoplankton collections in the United States and it helps to provide living organisms for research by the government, industries and schools throughout the country.

The phytoplankton laboratory at the school has a collection of more than 300 different cultures, most of which were collected from Narragansett Bay, although some have also been taken from off Puerto Rico and from the Sargasso Sea in the North Atlantic.

Phytoplankton research at the school attempts to describe and account for phytoplankton behavior in the oceans. It seeks to trace the life cycle, morphology and distribution of marine phytoplankton. Although this research is not directly concerned with applied problems, it helps provide material and knowledge for research that may have immediate practical application.

The phytoplankton are, for example, used in experiments in various aquaculture projects at the school. Researchers are culturing the larval stages of marine invertebrates, such as scallops and crabs, as well as larger fish of economic importance. The bulk of the aquaculture research is funded by sea grant.

Much of the work done by biologists at the Graduate School of Oceanography centers around Narragansett Bay. For example, a weekly fisheries survey of the bay has been conducted by a fishing trawler for ten years. The survey shows the seasonal abundance of major fish species and allows oceanographers to spot any long-term trends in abundance changes.

The biological oceanographers, in cooperation with other oceanographers and scientists from several other disciplines, are also performing a biological dissection of salt marshes on the bay and of the bay itself to develop a mathematical systems model that could be of invaluable assistance to resource managers concerned with the Rhode Island coastal zone. The persistent biochemical effects of stress from pollution on clams and plankton relationships important to the ecosystem are among the things being studied in support of the systems model.

The possible subjects of marine biological research are multifarious. At URI, they include such topics as the characteristics and significance of underwater sound production by marine animals, and the possibility that certain marine animals can emit protective smells analogous to protective coloration. One research project alone is concerned with the distribution, migration and bioacoustics of eels, parrot fishes, alewives, toadfish, and humpback, beluga and pilot whales.

Geological Oceanographic Research

Geological processes on the ocean bottom play a prime role in shaping and modifying the topography and physical and chemical properties of the oceans, and can profoundly affect the entire earth. Geological oceanographers at URI have, for example, posed a theory linking deep earthquakes, increased volcanic activity, the extinction of certain microscopic animals, and climate changes. The theory is based on information gleaned from a study of core samples taken from deep under the Pacific Ocean.

Some other major areas of geological concern at the school are bottom formation processes, continental margins, submarine volcanism and rare earth geochemistry, and deep-sea geology.

Considerable attention has been given to studies of bottom formation processes. Their purpose is to investigate the morphological, structural and compositional character of the sea floor and to evaluate the relations and interactions of bottom formation processes with the sea-floor spreading mechanism.

Geological studies of the Atlantic continental margins are designed to investigate the present bottom surface of the ocean and its relief and sediment. They are also concerned with the structural framework of the continental margin and the geologic processes that account for the genesis and evolution of the margin.

The importance of volcanism and its effects have become increasingly obvious in the light of deep-sea oceanographic research in recent years. Volcanism not only models the morphology of mid-ocean ridges, but also considerably affects, physically and chemically, the nature of the bottom of the sea. An understanding of sea-bottom chemical and physical properties and their variations, in turn, should allow for environmental predictions about the sea floor-water interface.

In research trips aboard R/V *Trident,* geological oceanographers have surveyed the water depth, sediment structure and rock magnetism and have taken rock samples of the central North Atlantic and the western Caribbean Sea. The intention of this research is to develop an understanding of the geological structure and evolution of the two areas.

Research interests have taken the geological oceanographers to a wide range of places, from the Gulf of Mexico to study sediments to New Zealand to study marine sequences.

Physical Oceanographic Research

Physical oceanography is concerned with describing and explaining the movements and behavior of the oceans. It encompasses the physical properties of seawater, water masses, general circulation, and the countless variables that affect ocean systems and subsystems and their interactions.

Physical oceanographers at the Graduate School of Oceanography are measuring the major features of the general circulation in the oceans. Studies have focused on the transport and the velocity structure of the Gulf Stream and on the current measurements in the Western Boundary Undercurrent.

Other aspects of ocean circulation being studied are the mechanisms of deep water renewal, vertically averaged density distribution in selected regions, and the capability of computers to perform various physical analyses.

At another level, physical oceanographers are researching the mechanisms that cause the microstructure of the thermocline, the layer of ocean water marked by sharp changes in temperature. Experiments are being performed to determine the significance of these mechanisms, which appear to be molecular processes, in both the total energy budget of the ocean and in the local modifications of physical properties.

Physics is also being applied to the ocean to increase our understanding of ocean waves, in particular the interaction of waves with themselves and with their environment, and to gauge various aspects of Narragansett Bay, including its water temperature variations through a tidal cycle and its climatology.

Chemical Oceanographic Research

Understanding the chemical environment of the sea involves understanding such processes as the regulation of the composition of seawater and the distribution of chemicals in the sea.

The techniques of analytical chemistry have already enabled oceanographers to measure the concentration of nearly every naturally occurring chemical in the sea. Chemical oceanographers are going beyond analytical chemistry to explain the chemical processes in the sea. Those engaged in physical-chemical studies frequently draw upon field observations to define particular problems, and they examine these problems intensively in the laboratory.

Chemical oceanographers are also pursuing a series of studies on the distribution, dynamics and chemistry of several trace elements in seawater, especially iron, silica, cesium-137, and arsenic. The importance of these investigations

lies in the insights they provide into the fundamental problems of seawater chemistry and problems associated with transport, turbulence and general mixing processes in the deep ocean.

The chemical entities of the ocean are also known to interact with the atmosphere. Researchers at the Graduate School are exploring such problems as the cycles of iodine, bromine and chlorine from the ocean to the atmosphere and back again, and the extent to which certain trace metal and organic air pollutants are being transported great distances by the global wind system. The effect of these air pollutants on the surface of the ocean is also being assessed.

By measuring the freezing point and osmotic pressure of seawater under various conditions, oceanographers are attempting to calculate the thermodynamic properties of seawater. Such knowledge is applicable to a variety of studies of oceanic processes and in evaluating desalination processes.

Other related research ranges from chemical studies of the organic matter in estuarine waters and sediments to studies of the chemistry and microbiology of algal substances in the sea.

COLLEGE OF RESOURCE DEVELOPMENT

Resource Economics

Much of the marine-related research in the Department of Resource Economics is of a practical nature. Aspects of the research include simulation of dynamic properties of interacting commercial fisheries, the economic impact of conflicting marine resources use, bio-economic models for fishery exploitation, and a distribution network of fishery resources.

Also underway in the department is a survey of New England's marine industries to define their special characteristics and to develop an information source useful to the firms in expanding markets for their products.

In cooperation with the Graduate School of Oceanography, URI resource economists are attempting to develop commercially feasible models for lobster exploitation. The potential for the development of commercial aquaculture in New England is also being assessed. This study is based on economic research into the cost of production and market potential as well as a program of genetics and other biological research, and experimental growing methods.

Analyses are being conducted on the impact of international trade regulations on the commercial fishing industry and on the legal and institutional constraints affecting the efficiency of the U.S. commercial fishing industry.

In other work, researchers are studying the economic contribution of fishing and other marine activities to the southern New England region. Also, the cost of operating various types of vessels has been investigated to determine the sizes and types most profitable.

Coastal zone research in the department has concentrated on determining the costs and returns of different uses of the coastal zone areas. Data is being gathered on the economic effects of offshore oil exploitation and on the physical

suitability of the coastline for various uses, such as marinas, houses, beaches, and nature reserves. These and other studies are providing input into an interdisciplinary effort to derive mathematical systems models for the bay. The object of the models is to help planners determine the uses of the coastal areas, especially along Narragansett Bay, that best *serve* society.

Some work with a sociological orientation is also being carried out in the department. One project, for example, is concerned with analyzing the social and motivational characteristics of people who engage in various outdoor recreational activities, such as boating, fishing, hunting and hiking.

Food and Resource Chemistry

The Department of Food and Resource Chemistry devotes a major portion of its research effort to marine foods and resources.

What are the biochemical pathways in marine animals that allow them to change the carotenoids contained in the food they eat into the carotenoids that give the animals their characteristic color? That is a question for basic biochemical research, but the answer can provide necessary information for practical nutrition studies in aquaculture. Research is being done on both levels in the Department of Food and Resource Chemistry.

Work is also being done in the department that could have significance for the world hunger problem. For example, scientists are developing low-cost, high-protein foods to stave off malnutrition that is killing or debilitating thousands of infants in Chile. On an even larger scale, URI scientists, together with scientists from the University of California, are exploring the feasibility of marketing and utilizing fish protein concentrate to help feed the hungry of the world. Other URI researchers are evaluating processes for using commercially available equipment to produce the concentrate.

Other studies include an assessment of the magnitude of pesticide pollution in Rhode Island and an attempt to establish the organic geochemical factors that determine the productivity of nearshore sediments, particularly those affecting economically important shellfish.

As is the case in most departments, much of the applied research in food and resource chemistry is done on an interdisciplinary basis.

Fisheries and Marine Technology

The research program, like the educational program, of the Department of Fisheries and Marine Technology is geared to practical problems.

Much of the research done by department members is undertaken in cooperation with the commercial fishing industry. For example, researchers in the department have helped to develop resource and processing data on the red crab, have experimented with the use of the European wing trawl in the commercial harvesting of herring, have developed a high-opening combination trawl suitable for both bottom- and higher-swimming fish, have researched the effectiveness of various fishing gear and developed new gear, and have tested the potential of mid-water trawling for the capture of herring.

In addition, faculty members in the department are engaged in aquaculture and fish population studies, particularly of salmonids, at the URI Marine Experiment Station. The station is also utilized by oceanographers, biologists, ocean engineers and others interested in fish studies.

Animal Science

Researchers in the Department of Animal Science are working on the processing and consumption of fish in cooperation with the Department of Fisheries and Marine Technology.

The long-range objectives of the study are to improve the nutritive quality of industrial fishery products, especially fish meals; to increase knowledge of such products' nutritional values for poultry and livestock consumption, as well as to improve processing methods for increased economic returns to fishermen, processors and the feed industry.

A related project is devoted to developing and testing methods for evaluating the available nutrient contents of fish meals to help improve and control the quality of their production.

Plant and Soil Science

As part of an interdisciplinary sea grant project that is developing an analytical systems model of Narragansett Bay, plant physiologists in the Department of Plant and Soil Science are helping to provide information on the biological roles played by the salt marsh ecosystem in the coastal environment. Acquiring such information entails research into the emergent plants and birds in the salt marshes and the physiology of salt marsh vegetation.

Work has also been done by agronomists in the department on American beachgrass and on the restoration and retention of coastal sand dunes.

Animal Pathology

As a necessary adjunct to the large number of University aquaculture projects and state hatchery projects, the Department of Animal Pathology began a histopathology laboratory in 1970 to diagnose fish diseases.

The laboratory is used to survey and classify diseases found in free fish populations and in conjunction with aquaculture projects in Rhode Island, to help control and prevent mortality due to disease in economically important fish, and to determine the impact of disease on fish populations in their natural environment.

Shellfish, which are often incriminated as reservoirs of virus pathogens, have also been studied in the department to determine whether or not human intestinal viruses actually multiply in them.

Forest and Wildlife Management

Researchers in the department are attempting to draw a clear picture of the motivations of those people who gather shellfish on a non-commercial basis--digging clams for fun and food in a well-known Rhode Island estuary. Also being

studied are problems, such as pollution, that threaten the continuance of this kind of activity. It is hoped that such studies will help prevent the demise of such recreational shellfishing. Another project is assessing the value of tidal marshes as resting and feeding areas for migratory birds.

COLLEGE OF ENGINEERING

Ocean Engineering

Much of the marine-related research in the College of Engineering at URI is done in connection with the Department of Ocean Engineering. In fact, many faculty members in the classic engineering departments who are involved with marine research have joint appointments with the Department of Ocean Engineering. The department also offers an engineering focus for marine activities throughout the University by helping to provide the techniques and instrumentation for marine research in many fields.

The major research concerns of the department are deep ocean sediments, underwater sound, bottom profiling, diver safety, oceanographic data systems and basic studies of water volumes and circulation patterns of specific areas in Narragansett Bay. Much of the data-gathering equipment and designs developed by ocean engineers are used in larger, interdisciplinary research projects, such as the attempt to develop and verify models of the physical, biological and chemical characteristics of Narragansett Bay.

The models are essential for planning existing and potential uses and problems of the bay, such as commercial and recreational boating, fishing, aquaculture, channel design, marina design, power plant site selection, control of oil spillage and others.

Related to the many laboratory studies being performed in the department on deep-ocean sediment cores are the experiments with deep-ocean sediment probes able to obtain cores with relatively undisturbed sediment structures. The disturbance of the structure of the sediment by standard core sampling techniques is a problem that has vexed oceanographers for many years.

Research being done in underwater sound and acoustics has relevance to both basic research, such as fish behavior studies, and to applied problems, such as skin--and scuba--diver communication and safety. Bottom profiling with electronic equipment can also have both basic and applied research value for such projects as determining sedimentary characteristics in the bay, locating pipelines in the bay, detecting and enumerating biological populations, and, perhaps, detecting certain kinds of pollutants.

The department has developed a four-course graduate sequence in underwater acoustics that includes advanced topics such as long-range propagation loss prediction in the ocean, finite amplitude effects, high amplitude acoustic sources, and general underwater acoustic communication.

Four ocean engineering faculty members have their primary research interest in the field of underwater acoustics. One is concerned with target and boundary reflection characteristics; a second with long-range propagation; a third with finite amplitude effects; and the last one with advanced signal processing techniques as applied to underwater sound, such as in submarine profiling.

Other specific projects include the development of flow measurement devices; water sampling with a shipboard electrochemical system; studies of the optical properties of the water column, done in conjunction with diver visibility experiments; a study of the relationship of sediment to pollution analyses; the development of drifting buoy techniques to measure bay currents; the hydrodynamics of fishing gear and towing power for bottom trawls and underwater propulsion systems.

Some engineers not directly connected with the ocean engineering program are also conducting some marine-related investigations, however. The engineering departments involved are described in the remainder of this section.

Electrical Engineering

The Department of Electrical Engineering has a number of research projects that are specifically marine-related, as well as some that will, when completed, have obvious applications to the marine environment.

Several studies are in the general area of underwater acoustics. For example, one is attempting to ascertain the properties of the acoustic field produced by a point source in a random underwater sound channel. Others are concerned with underwater acoustic tracking, measurements, and communications systems, and the guidance and control of unmanned submersibles. Analyses are also being done of digital data transmission systems; such systems are applied to marine telemetry, monitoring and control. One researcher, working in cooperation with URI oceanographers is attempting to extract modeling parameters from records of on-site underwater measurements.

Acoustic pulse data is being processed by one electrical engineer to ascertain the capabilities of undersea acoustic channels for data transmission. Another is processing signals in random, inhomogeneous mediums, such as the ocean; this problem is particularly important in its sonar applications. Research is concerned with developing a general approach to designing and evaluating systems for detecting signals in noise backgrounds where the dominant interference is reverberation.

Two projects in the department that will have obvious marine applications are the research programs in remote sensing with infrared photography and in photoelectronic imaging devices.

One engineer, who has already successfully used a three-dimensional infrared photography system in high-flying airplanes, is investigating the feasibility of equipping a satellite with the system. Such a satellite could take infrared pictures-of-the eye of a tornado,map the upward movement of air pollution over a city or probe the heart of a thundercloud. Just as it can be applied to these meteorological problems, the system could also be applied to oceanographic problems.

The photoelectronic imaging devices being developed in the department can convert infrared, visible or ultraviolet radiation to electrical impulses, or can convert electrical impulses to optical displays. Further research on the devices may be concerned with underwater television pickup tubes and other aspects of underwater optics.

Chemical Engineering

Several chemical engineers are engaged in an interdisciplinary evaluation of commercial processes in the production of fish protein concentrate. Three different engineering methods are being studied by the researchers to obtain the concentrate--which can be used as a high-protein food additive--from a specially produced fish cake using only commercially available equipment.

Chemical engineers are also involved in studies of desalination processes and other water resource problems. In desalting methods involving evaporation, the effect of scaling on heat transfer surfaces is of prime economic importance. Departmental research has been concerned with evaluating additives to reduce or eliminate the build-up of scale.

Another interdisciplinary project involving faculty members from chemical engineering (and its program in nuclear engineering) and community planning is concerned with socio-economic factors in a study of the potential benefits of integrating a new community and a nuclear power reactor, while taking into account the water ecology of the bay on which they would be located.

Other research projects pursued by chemical engineers in conjunction with the Department of Ocean Engineering involve a study of the mechanism of pitting corrosion in seawater and a study of the mechanism of stress-cracking of high-strength aluminum alloys in contact with seawater.

In Addition

URI mechanical engineers are studying ways to introduce heated water, a by-product of power plants, into waterways so as to minimize the disturbance to the environment; civil and environmental engineers are investigating the mercury and other heavy metal pollutants in the sediment of Narragansett Bay; and industrial engineers are researching aspects of the ocean engineering industry.

A large proportion of the marine research and laboratory equipment used at URI is designed and developed at the University's Engineering Instrument Shop, which is funded by the state. The instrument shop consists of about a dozen machinists, experimental machinists, and draftsmen who can fabricate machines and instruments necessary for research by persons throughout the University, including students. Since it was instituted in 1963, the biggest customers of the instrument shop have been the Graduate School of Oceanography and the College of Engineering.

Some marine-related projects of the instrument shop in recent years include an isolation cabinet for raising and hatching fish, a deep-ocean sediment probe, floatation devices, flow meters, a hydrostatic anchor, plankton splitter, incubators, rotating basin for flow studies, oscillators, and a vibratory core sampler.

COLLEGE OF ARTS AND SCIENCES

Zoology

Marine-related research in the Department of Zoology is of two types. First, marine animals are used for experimentation merely because they have certain convenient characteristics. For example, the comparative study of biological control

systems involves a study of marine invertebrates and their neural control of muscular rhythmicity.

Second, marine animals are used in experiments to discover things about specific animals in the marine environment. Research centers around such questions as the diurnal migratory habits of certain deep-sea fish, the ecology of protozoa and micrometazoa living between the sand grains on the beaches of the New England coast, studies in behavior and habitat selection of lobsters, and life history studies of shore fish.

According to the foregoing definitions of marine-related research in zoology, nearly half of the approximately 50 graduate students in the department are involved in marine-related research projects.

Several faculty members in the Graduate School of Oceanography have joint appointments in the Department of Zoology. They are involved with various aquaculture projects and with studies of marine bioacoustics and bio-orientation.

Botany

There are four general areas of marine interest in the Department of Botany.

The first is the identification and classification of marine plants--both algae and the flowering plants. These taxonomic questions involve research in both the oceans and in their estuaries.

The second is the occurrence of marine plants around the world. It involves determining the distribution of plants (plant geography) and their relative abundance (biomass).

The productivity of plants--how quickly they produce--is the third area of concern in the department. In productivity studies botanists keep track of the change in number, biomass and carbon intake of certain plants around the world.

Finally, the botanists are studying the factors affecting the occurrence, biomass and productivity of marine plants; these factors include light intensity, nitrates, currents, tides and pollution. In all these areas, the Botany Department is concerned mainly with basic biological research.

The department has developed many relationships with other URI departments while pursuing its research interests. Botanists cooperate in research on phytoplankton with the Graduate School of Oceanography; with the Department of Plant Pathology-Entomology, on aquatic pollution; and with the Department of Forestry and Wildlife Management, on conservation.

Geology

One of the three major emphases of the Department of Geology is coastal geology. The other two--petrology and geochemistry, and micropalaeontology--can also be given marine orientations, however.

A prime concern of the department is coastal pollution; criteria are being developed for the recognition of water pollution in the estuarine environment by

aerial remote photographic sensing. Geologists are also engaged in such diverse projects as the preparation of a reference index of coastal geology and of coastal geologic engineering studies relating to the New England states, and an investigation of the feasibility of conducting a long-term study of beach sediment transport along the eastern shore of Cape Cod.

Other marine-related projects include a study of the distribution of transition elements in Hawaiian lavas in an attempt to learn more about their genesis. A study of the transition elements in certain rocks collected along a profile across the Reykjanes Ridge in the North Atlantic is also underway.

Geography

The Department of Geography has one of the few marine geographical concentrations for graduate students in the United States. Young geographers at URI are researching the uses of the coastal zone, considered in terms both of competing economic areas and of international boundary and use problems.

One project involves making a broad survey of the coastal zone regions of the United States in terms of their size and physical nature, of the functions they perform, and of the interaction of their activities. Such studies can provide information to help in the establishment of coastal zone authorities. The Department of Geography also plays an integral part in the Master of Marine Affairs program and the Law of the Sea Institute, which was established at URI to provide for the exchange of information and ideas on the use and control of the sea.

Sociology and Anthropology

To effectively exploit and utilize the world's marine resources, certain social as well as managerial, economic and technological problems must first be met.

URI sociologists are trying, for example, to understand the sub-culture of persons in the fishing industry by determining what social, cultural and psychological factors are associated with working in the sea. Such knowledge will not only add to the body of theoretical knowledge of occupational role adaptation, but will also add to practical knowledge of how to best recruit, retain, and retrain the fisheries' labor force.

Harvesting food from the sea has been described as one way to alleviate world hunger, but the acceptance of high-protein fish foods depends on fitting them into the traditional eating patterns of the people for whom they are intended. Understanding the fishing and eating patterns of different societies is a goal of URI anthropologists.

In Addition

The Department of Biochemistry is conducting studies in the embryonic development of sea urchins; the Department of Physics has conducted studies in marine physics, particularly on the underwater propagation of acoustic waves; the Department of Community Planning and Area Development conducts some marine-related planning studies; and the Department of Political Science has conducted studies of the legal aspects of various pollution control laws and of salt marsh preservation.

COLLEGE OF PHARMACY

Pharmacognosy

The establishment of the Sea Grant program at URI spurred research by the Department of Pharmacognosy in the field of marine drugs. The purpose of the drugs-from-the-sea project is to isolate and identify compounds from marine sources, both plant and animal, of potential importance as drugs or diagnostic agents that are otherwise useful in determining metabolic pathways or processes relevant to the health of man or other animals, or both.

Researchers in the department are also studying marine sterols--unsaturated alcohols occurring widely in plants and animals--to try to establish the sources and routes to convert these compounds to various therapeutically-useful steroid agents. A study of algal steroids could open a route to use these agents for the manufacture of steroidal hormones, whose sources are now primarily from land plants.

A study of starfish toxins is intended to establish the nature of these compounds, which have been found to have antiviral properties and also to act as a repellant to other animals. A better understanding of the action of these toxins could lead to better methods of eradicating these organisms, which are currently causing great concern because of their effects on other marine life in parts of the Pacific Ocean.

Other compounds from marine algae have shown anti-inflammatory, anti-curare, hypnotic and anti-viral activity after being submitted to various pharmacological tests. It is conceivable that once these compounds are isolated and identified, they may become useful therapeutic agents or at least have a role as biochemical tools.

Pharmacology

The Department of Pharmacology and Toxicology works closely with the Department of Pharmacognosy on the drugs-from-the-sea project. One objective of the pharmacologists is to investigate marine drugs supplied by the Department of Pharmacognosy for possible biological activity on organisms. One method used is to inject the drugs in varying doses into mice, and then to observe their effects.

Another objective of the pharmacologists is to study the metabolizing of foreign organic compounds by marine organisms. Particular emphasis is placed on the handling of pollutants such as pesticides by economically valuable species such as clams and lobsters.

The information obtained from submitting marine drugs to various pharmacological tests is part of a continuing search for new and useful therapeutic drugs, diagnostic aids and biochemical tools.

Studying the metabolizing of foreign organic compounds by marine organisms increases knowledge of the chemical changes in the organism that yield either more or less toxic substances. This is of critical importance *to the* health of the organism itself and to other species in the food chain, including man.

In addition

A researcher in the Department of Medicinal Chemistry is studying the toxicity of various chemicals to shellfish. Specifically, chemical means are being sought to eradicate snails as intermediary hosts in human disease. Another researcher in the department is using shark organs to develop potential anti-hypertensive drugs for humans.

COLLEGE OF HOME ECONOMICS

Food and Nutritional Science

The Department of Food and Nutritional Science is involved in several research projects relevant to both the development of marine species and their marketing.

The aim of one project is to produce a manageable eco-system that could, in turn, produce marine species that are germ-free or carry only known or controlled microorganisms. Such research could produce knowledge of value to studies in ecology, disease control, pollution effects, nutrition and aquaculture. Also applicable to aquaculture is a project concerned with ascertaining the nutritional requirements of marine fish and translating these requirements into practical diets for rearing marine species.

The marketing of fish presents a whole new set of problems to food and nutritional scientists. For example, the enzymatic blackening of shrimp and crab, which does not spoil shellfish, but does make them unmarketable, is one of the problems being studied. Efforts are also being made to more fully understand and control the rapid spoilation of fish after death, and to develop chemical preservation and processing methods to extend the quality and shelf-life of fish products.

In addition, the use of fish protein concentrate to help feed the undernourished of the world is also being studied. Different foods are being fortified with the concentrate and then evaluated for their potential use as enriched foods. Fish protein concentrate is also being treated enzymatically and evaluated for new applications in foods and beverages.

SEA GRANT AT URI

The National Sea Grant College and Program Act of 1966, sponsored by Senator Claiborne Pell of Rhode Island and Representative Paul Rogers of Florida, established the National Sea Grant Program and provided it with the following major responsibilities:

> To initiate and support programs at colleges and other suitable institutes, laboratories, and public or private agencies for the *education* of participants in various fields related to the development of marine resources.
>
> To initiate and support necessary *research* programs in the various fields relating to the development of marine resources, with preference given to research aimed at practices, techniques, and design of equipment applicable to the development of marine resources.
>
> To encourage and develop programs consisting of instruction, practical demonstrations, publications and otherwise, by colleges and other suitable institutes, laboratories, and public or private agencies through marine *advisory* programs with the object of imparting useful information to persons currently employed or interested in various fields related to the development of marine resources, the scientific community and the general public.

Initially administered by the National Science Foundation, the sea grant program became a component of the new National Oceanic and Atmospheric Administration of the U.S. Department of Commerce on October 3, 1970.

Sea grant at URI has the same three responsibilities as the national program: education, research and advisory services. In spite of the fact that the program was established during a time when federal science funds were generally being cut back, sea grant funding at URI has increased steadily. URI received $477,198 from sea grant for fiscal 1968-69; $685,054 for fiscal 1969-70; $900,000 for fiscal 1970-71; and $1,125,000 for fiscal 1971-72.

EDUCATION

The Master of Marine Affairs program and the doctoral program in economics with a marine resource option were begun and are supported primarily with sea grant education funds. These funds are used mainly for faculty salaries and for the support of graduate assistants.

Graduate students throughout the University, but particularly in the graduate marine science and engineering degree programs, also receive some sea grant funds in connection with various sea grant research projects.

Of 42 faculty members engaged in sea grant research in fiscal 1970-71, a total of 19 received partial or full salary from sea grant. During the same period, 46 graduate assistants and three undergraduates received some sea grant funding.

In addition, 33 non-faculty members, including technicians, writers and laboratory assistants, as well as nine secretaries and clerks received sea grant support. Eight URI deans and other administrators, although not funded by sea grant, helped to implement sea grant educational programs.

RESEARCH

In an attempt to develop a research philosophy in line with the concept of a sea grant college, two all-University committees were appointed in 1969 by the provost for marine affairs, one for fisheries and one for the coastal zone. Their charge was to review the total University effort, to consider future research needs, and to develop a coordinated research program in these areas. Most of the research programs sponsored by sea grant are cast in the framework of these two groups' recommendations, but a third area of sea grant support is marine pharmacology and pharmacognosy.

Coastal Zone Research

Several programs in the total URI coastal zone effort are directly designed for the development of mathematical, integrated systems models of Narragansett Bay that would be useful in decision-making and in planning the uses of the bay. Much of the work in the coastal zone is carried out to provide and verify information for the models. The models are being developed cooperatively by the Departments of Ocean Engineering, Resource Economics, Food and Resource Chemistry, Plant and Soil Science, and Forest and Wildlife Management, as well as the Graduate School of Oceanography.

Other sea grant coastal zone research includes a study of the economic impact of petroleum extraction and a study of the nature of the coastal zone environment.

Fisheries Research

The basic goal of the sea grant fisheries research program at URI is to develop information that can be used for public, private and business decisions relating to fisheries. Research areas within the program include marine food technology, gear, aquaculture, population dynamics and economic-social topics.

Marine food technology research centers around industrial fishery products and fresh or frozen fish technology. Gear research is aimed at improving the commercial fishing industry's ability to harvest, hold and transport its catch. Aquacultural research involves nutrition of selected marine species, pathology of marine species, culture of marine invertebrates, bacterial aggregation and larval nutrition, and economic analyses of the aquacultural potential of selected marine species. Population dynamics research is devoted to developing mathematical models designed to synthesize biological and economic data, a critical link in fishery

resource management programs. And finally, economic-social research entails studies of the marketing of fish and the social and cultural factors associated with work in the sea.

Marine Pharmacology-Pharmacognosy

Research in the Department of Pharmacognosy and the Department of Pharmacology-Marine Toxicology is described in the previous section ("Marine Research at URI," page 26). The program is funded by sea grant.

To stimulate interest in the field of marine drugs, the College of Pharmacy co-sponsored a Drugs-from-the-Sea Conference at URI in 1967. The College was also a co-sponsor of the expanded Food-Drugs-from-the-Sea Conference in 1969, also held at URI. A second conference on food-drugs-from-the-sea is to be held at URI in August, 1972.

ADVISORY SERVICES

Two public service programs are conducted by the University through the sea grant program. The first, the New England Marine Resources Information Program, was established in 1968. Based at URI, it provides information services to individuals and organizations in the six-state New England region. The second, the URI Marine Advisory Service, was started in January, 1970. The advisory service provides field services to Rhode Island's marine community, along with other programs in the tradition of the agricultural extension service.

New England Marine Resources Information Program (NEMRIP)

The function of NEMRIP is to serve as an information clearinghouse, to generate materials of benefit to the marine community of the six regional states, to respond to individual inquiries concerning marine resources and their development, and to conduct programs such as demonstrations, workshops and conferences for information dissemination and exchange.

During 1971, NEMRIP responded to 2,044 requests for information, compared to the 1,289 handled by NEMRIP in 1969. It also received 11,444 requests for individual NEMRIP publications in 1971 compared to the previous year's total of 10,975, and the mailing list for the NEMRIP monthly newsletter, Information rose from 10,588 to 13,078.

Marine Advisory Service

The Marine Advisory Service was established by sea grant to provide for the application of marine knowledge to the needs of the Rhode Island community. The advisory service utilizes field specialists, publications, conferences, workshops and demonstrations to assist in the development and understanding of the marine resources in Rhode Island. For administrative purposes, the advisory service is integrated with NEMRIP.

A full-time commercial fisheries specialist handles much of the fisheries extension work for the advisory service. A staff resource economist, however, has also begun projects involving statistical analysis and business management for fishermen and others in the marine community. Other fisheries extension

services are provided by personnel in the Department of Fisheries and Marine Technology.

In close cooperation with URI Department of Resource Economics, an advisory service marine extension specialist has developed innovative programs for marinas and the recreational boating industry. In addition, another staff member helps expand marine education in the state by arranging programs and supplying educational material for teachers, and arranging for short courses and educational tours. The information services of the advisory service are handled through NEMRIP.

OTHER PROGRAMS

The University has a number of other programs that are directly or indirectly concerned with the development of marine science. These are the Law of the Sea Institute, the International Center for Marine Resource Development, the Rhode Island Water Resources Center, the Institute for Environmental Biology, the Marine Resources Program, and the Coastal Resources Center.

Law of the Sea Institute

The Law of the Sea Institute was established at URI to provide for the exchange of information and ideas on the use and control of the sea. Media used are conferences, seminars, workshops and publications.

The idea for the institute emerged in 1965 when it was decided to hold a summer conference at URI to bring together experts from around the world to discuss the problems of the law of the sea each year. The first Law of the Sea Conference was held at URI in 1966, under the institute's sponsorship.

The institute also publishes an occasional paper series on various aspects of marine law, organizes international workshops on marine legal problems, and has compiled a bibliography of marine law and economics.

Another institute activity is its Fisheries Incentive Management Program. The program is a series of seminars with fisheries personnel--including commercial fishermen, fish processors, scientists, and state and federal officials--aimed at developing rational management systems for certain of the nation's coastal fisheries.

The institute also serves as an information exchange for local marine jurisdictional problems, and supplements the educational program of students studying for the Master of Marine Affairs degree.

The institute is administered by an executive committee consisting of eight scholars and lawyers from all over the country. It is funded by Sea Grant, the Ford Foundation, the National Marine Fisheries Service, the Office of Naval Research, the U.S. Coast Guard and the University.

Intemational Center for Marine Resource Development

To help emerging nations formulate and carry out sound resource development policies, the United States government, through the Agency for International Development, has given initial support to a number of international centers at U.S. universities. In 1969, such a center was established at URI to develop expertise in problems associated with the development of marine resources.

The program at the International Center for Resource Development is interdisciplinary. Its activities include:

providing fellowships and assistantships for graduate students in such areas as biology, food technology, economics and sociology to prepare them for resource development work;

encouraging research useful in international resource development by grants-in-aid to faculty members involved in such research;

encouraging and building, through existing departments, programs of study related to marine resource development in underdeveloped countries, and providing the library and research support for such programs. The graduate certificate program in International Development Studies is supported by the center;

bringing outstanding scholars together in seminars and symposia to discuss subjects that are related to resource development assistance;

publishing material resulting from symposia or from individual research that furthers the work of the center;

bringing each year distinguished workers with experience in the problems of economic and social development to campus to pursue scholarly work and exchange ideas with faculty and students;

cooperating with other institutions in the United States and abroad on development programs;

offering consulting and other services on projects dealing with marine resource problems of developing countries.

Rhode Island Water Resources Center

The Water Resources Center was established at URI in 1965 to carry on a program of applied and basic research and training in water resources and other water-related problems. The center has interdisciplinary programs with the Colleges of Arts and Sciences, Business Administration, Engineering, and Resource Development, and the Graduate School of Oceanography; these focus on regional water resource problems. There is a similar center or institute in each of the 50 states and Puerto Rico; each receives a Congressional appropriation to carry on its research.

At the URI center, to help preserve the state's supply of fresh water, emphasis is given to research on conservation, storage, pollution, re-use and alternate sources, such as desalination. The center works closely with the state Water Resources Board and the New England River Basins Commission.

Institute of Environmental Biology

In response to the need for an interdisciplinary approach to the problems of environmental biology, an active faculty group in several departments, colleges, and associated laboratories at URI established the Institute of Environmental Biology. The institute is an administrative organization consisting of faculty

members active in environmental biological research in the Departments of Botany, Civil and Environmental Engineering (biomedical), Food and Nutritional Science, Forest and Wildlife Management, Pharmacology, and Zoology, and the Graduate School of Oceanography, as well as adjunct faculty members in associated federal and private laboratories. Other departments may join the institute as they become involved in programs in environmental biology.

The primary objectives of the institute are to (1) promote an interdisciplinary approach to environmental biology by bringing together the resources, personnel and facilities of member organizations to solve common problems in training and research; (2) stimulate, guide and encourage research in environmental biology; (3) develop a training program in environmental biology; and *(4)* provide consultation services and aid to community agencies in problems related to environmental health and renewable natural resources.

Marine Resources Program

An interdepartmental University Committee on Marine Resources administers a program to encourage the expansion of marine resources interests and helps researchers to find other sources of funds. As these new interests find substantial financial support and direction from larger agencies, such as the sea grant program, the function of the Marine Resources Program is accomplished. Another purpose of the committee is to develop liaison between the University and federal, state or other agencies in the field of marine resources.

Coastal Resources Center

The Coastal Resources Center was established at URI in 1971 to provide the Rhode Island Coastal Resources Management Council the information it needs to make decisions about the uses of the state's coastal zone.

Administered by the University, the center is directly responsive to the management council, which was created by the state's General Assembly to plan the uses and manage the resources of the coastal region.

Plans are to establish a small technical and professional staff for the center that can help the management council by providing it with information to handle situations requiring immediate attention as well as long-term planning in Narragansett Bay and other Rhode Island waters. Although the center may require permanent facilities in the future, it does not have a single physical base at present.

APPENDIX A: MARINE RESEARCH AT URI

The following is a list of faculty members involved with marine research projects or projects with a marine orientation. It includes only permanent, full-time faculty members. It does not include other staff members, such as research associates and adjunct professors, who may also be engaged in marine research at the University. Much of the compilation for the list was done during the summer of 1971 and some material may be dated or incomplete. Following each funded project, the funding source is listed in parentheses.

Key to abbreviations:

AES:	Agricultural Experiment Station
EPA:	Environmental Protection Agency
FDA:	Food and Drug Administration
GSO:	URI Graduate School of Oceanography
HEW:	Department of Health, Education and Welfare
NIH:	National Institutes of Health
NMFS:	National Marine Fisheries Service
NSF:	National Science Foundation
ONR:	Office of Naval Research
PHS:	Public Health Service
SG:	Sea Grant
U.S. AID:	U.S. Agency for International Development
USC:	Naval Underwater Systems Center
USCG:	U.S. Coast Guard
WRC:	R.I. Water Resources Center (Office of Water Resources Research)

GRADUATE SCHOOL OF OCEANOGRAPHY

Dr. Frank T. Dietz, professor of physics and oceanography
Research area: underwater acoustics
Funded projects: Underwater Noise Measurement (SG)

Dr. Robert A. Duce, associate professor of oceanography
Research area: atmospheric chemistry
Funded projects: Lead and Gaseous Iodine and Bromine in Polluted Air (NSF)
Trace Metals and Halogens in the Antarctic Atmosphere (NSF)
Trace Element Enrichment in Sea Surface Films (NSF)
Baseline Study of Atmospheric Particulates and Sea Slick Materials (NSF)
Continental Trace Element Air Pollution in Hawaii (PHS)
Symposium on Non-Gaseous Chemical Transport from Ocean to Atmosphere (NSF)

Dr. H. Perry Jeffries, associate professor of oceanography
Research area: productivity and ecology of inshore waters
Funded projects: Biochemical Studies in the Ecosystem (SG)
Chemical Responses of Marine Organisms to Stress (EPA)
Fisheries Survey of Narragansett Bay (URI)

Dr. James P. Kennett, associate professor of oceanography
Research area: marine paleoecology and paleo-oceanography
Funded projects: Paleoclimatic and Biostratigraphic Studies of Sediments from the Gulf of Mexico (NSF)
Study of Possible Relation Between Paleoclimatic Changes and Volcanic Particulate Input Variation in High Latitudes of the South Pacific (NSF)
Purchase, Installation and Operation of a Scanning Electron Microscope Facility (NSF)
Paleomagnetic Polarity History and Biostratigraphy of Selected Upper Tertiary-Quaternary Marine Sequences in New Zealand (NSF)
Micropalaeontological and Palaeoenvironmental Studies of Marine Sediments from the Southern Ocean (NSF)

Dr. Kern E. Kenyon, assistant professor of oceanography
Research area: wave studies and small-scale circulations
Funded projects: Wave Studies (ONR)

Dr. Dana R. Kester, assistant professor of oceanography
Research area: seawater chemistry
Funded projects: Physical Chemistry of Seawater (ONR)
Colligative Properties of Seawater (NSF)

Dr. John A. Knauss, provost for marine affairs, dean of the Graduate School of Oceanography, and professor of oceanography
Research area: ocean circulation and current observations
Funded projects: Study Program to Identify Problems Related to Oceanic Environmental Quality--North Atlantic (NSF)
General Oceanography (ONR)
General Oceanography (Navy)
Mineral Resources of the World Ocean (Navy)
TRIDENT Operations (NSF)
Student Science Training Program (pre-college) (NSF)
Development and Utilization of Marine Resources (U.S. AID)
Sea Grant Program (SG)
Rosentiel Fund
Tai Ping Foundation
Mode-l: Bottom-Mounted Current Meter Array (NSF)

Dr. Dale C. Krause, associate professor of oceanography
Research area: origin of the sea floor
Funded projects: Deep-Sea Geology (ONR)
Geological, Geochemical and Geophysical Research on the Evolution of the North Atlantic Sea Floor in the Azores Region (NSF)

Dr. Richard B. Lambert assistant professor of oceanography
Research area: turbulent mixing and small-scale structure of the oceanic thermocline
Funded projects: Vertical Mixing Processes and Measurements of the Oceanic Microstructure (NSF)

Dr. Nelson Marshall, professor of oceanography
Research area: estuarine ecology and coral reefs

Dr. Robert L. McMaster, professor of oceanography
Research area: geology of continental margins
Funded projects: Geology of Continental Margins (ONR)

Dr. Theodore A. Napora, assistant professor of oceanography and assistant dean of the Graduate School of Oceanography
Research area: zooplankton ecology
Funded projects: Ocean Acre (USC)

Dr. Scott W. Nixon, assistant professor of oceanography
Research area: ecological systems and modelling
Funded projects: Systems Ecology Studies of Narragansett Bay (SG)

Dr. Michael E. Q. Pilson, associate professor of oceanography
Research area: chemistry of sea water; biochemistry and physiology of marine organisms
Funded projects: Diffusion from Sediments (NSF)
Distribution of Trace Elements in Sea Water (ONR)
Studies of Vertical Mixing Processes in the Ocean (NSF)

Dr. David M. Pratt, professor of oceanography
Research area: chemical detection of prey by predators

Dr. James G. Quinn, assistant professor of oceanography
Research area: organic chemistry of seawater and marine sediments
Funded projects: Characteristics of Organic Substances in Tidal Marshes and Shoal Benthic Environments (SG)
A Baseline Study of Lipids as Indicators of Pollution in Sea Slick Material and Atmospheric Particulates (NSF)

Dr. Saul B. Saila, professor of oceanography and zoology
Research area: fisheries and population ecology
Funded projects: Gear Development (SG)
Pilot Demonstration of the Production of Salmonids under Intensive Rearing Conditions (N.E. Regional Commission)
Population Dynamics (SG)

Dr. Akella N. Sastry, associate professor of oceanography
Research area: physiology and ecology of marine organisms
Funded projects: Culture of Marine Invertebrates under Controlled Conditions (SG)
Purchase, Installation and Operation of a Scanning Electron Microscope Facility (NSF)
Life Cycle Studies of Crabs (Tai Ping)

Dr. Jean-Guy Schilling associate professor of oceanography
Research area: submarine volcanism and rare earth geochemistry
Funded projects: Submarine Volcanism-Rare Earth and Sediment Geochemistry (ONR)
Bottom Formation Processes (ONR)
Submarine Geology of Azores Region (NSF)

Dr. John McN. Sieburth, professor of oceanography and bacteriology
Research area: algal substances in the sea
Funded projects: Nutrient Thresholds for Indicator Species and Pathogens in the Coastal Zone (EPA)
Binding and Precipitation of Trace Elements by Humic Substances (WRC)
Algal Microbial Interaction in the Marine Food Web (NSF)
Purchase, Installation and Operation of a Scanning Electron Microscope Facility (NSF)

Dr. Theodore J. Smayda, professor of oceanography and botany
Research area: phytoplankton ecology and physiology
Funded projects: Purchase, Installation and Operation of a Scanning Electron Microscope Facility (NSF)
Collection and Establishment in Culture of Species and Strains of Marine Phytoplanktonic Organisms (EPA)
The Causes of Phytoplankton Succession and Blooms in Narragansett Bay (NSF)

Dr. Lucian M. Sprague, professor of oceanography and director of the International Center for Marine Resource Development
Research area: genetics, biological oceanography
Funded projects: International Center for Marine Resource Development (U.S. AID)

Dr. Melvin E. Stern, professor of oceanography
Research area: geophysical hydrodynamics
Funded projects: Vertical Mixing Processes in the Sea (NSF)

Dr. Wilton Sturges, III, associate professor of oceanography
Research area: ocean circulation
Funded projects: General Oceanography (ONR)
Mode 1: Bottom-Mounted Current Meter Array (NSF)

Dr. Elijah Swift, V, assistant professor of oceanography
Research area: biology of marine phytoplankton
Funded projects: Purchase, Installation and Operation of a Scanning Electron Microscope Facility (NSF)
Biology of Pyrocystis: A Genus of Oceanic Dinoflagellate (NSF)

Dr. Norman D. Watkins, professor of oceanography
Research area: Paleomagnetism of igneous rocks and deep sea sediments
Funded projects: Paleomagnetism of the "Eltanin" Deep-Sea Sedimentary Cores (NSF)
Magnetic Properties and Geochemistry of Dredged Basalts (NSF)
Paleomagnetism, Radiometric Dating, and Geochemistry of Oceanic Islands (NSF)
Study of Possible Relation Between Paleoclimatic Changes and Volcanic Particulate Input Variation in High Latitudes of the South Pacific (NSF)

Dr. Howard E. Winn, professor of oceanography and zoology
Research area: animal behavior bioacoustics orientation
Funded projects: Marine Bioacoustics and Bio-Orientation (ONR)
Fishway Evaluation Study (R.I. Dept. of Natural Resources)

COLLEGE OF RESOURCE DEVELOPMENT

Animal Pathology

Dr. Pei Wen Chang, professor of animal pathology
Research area: enteric viruses
Funded projects: Fecal Bacteria and Coliphage in Relationship to Enteric Virus Pollution in Sewage and Rivers (WRC)

Dr. Richard E. Wolke, assistant professor of animal pathology
Research area: histopathology of fish
Funded projects: Marine Pathology (SG, AES)

Animal Science

Dr. Lawrence E. Ousterhout, associate professor of animal science
Research area: fish meal
Funded projects: Utilization of Industrial Fishery Products by Poultry (SG, AES)
Industrial Fishery Products in Poultry Feeds (AES)

Fisheries and Maxine Technology

Dr. Thomas L. Meade, associate professor of fisheries and marine technology
Research area: aquaculture, fish protein concentrate
Funded projects: Pilot Demonstration of the Production of Salmonids under Intensive Rearing Conditions (N.E. Regional Commission)
Management of Salmonids in a Closed Circulating Controlled Environment System (SG)
Process Development for Industrial Fishery Products (SG, AES)
Engineering Evaluation and Scale-up of Commercial Processes in the Production of FPC from Heat Transfer Medium (HTM)
Centrifuge Cake (NMFS)

Dr. John C. Sainsbury, associate professor of fisheries and marine technology
Research area: fishing vessel engineering, fisheries and marine education
Funded projects: A Vocational Technical Institute Development Program for Commercial Fisheries (HEW)
Hydrodynamics of Fishing Gear and Towing Power for Bottom Trawls (SG)

Food and Resource Chemistry

Dr. Clinton 0. Chichester, professor of food and resource chemistry
Research area: carotenoids, fish protein concentrate
Funded projects: Feasibility of Utilizing Fish Protein Concentrate in World Feeding (U.S. AID)
Development of Low-Cost, High-Protein Foods for Infant Feeding (U.S. AID)
Marine Fish Pigments (AES, SG, NIH)
The Safety of Marine Food Products (FDA)

Dr. George T. Felbeck, Jr., professor of food and resource chemistry
Research area: organic geochemistry of benthic environments
Funded projects: Organic Geochemistry of Shallow and Productive Benthic Environments (AES, SG)

Dr. Charles E. Olney, professor of food and resource chemistry
Research area: pesticide transfer, fish protein concentrate
Funded projects: Transfer of Pesticides Through Soils, Water, Sediments and Aquatic Life (AES, WRC)
Engineering Evaluation and Scale-up of Commercial Processes in the Production of FPC from Heat Transfer Medium (HTM) Centrifuge Cake (NMFS)
Baseline Concentrations of Pesticide Residues and Polychlorinated Biphenyls in Marine Sediments, Marine Organisms, Sea Surface Films and Atmospheric Particulates (NSF)

Dr. Milton Salomon, professor of food and resource chemistry
Research area: pesticide transfer
Funded projects: Transfer of Pesticides Through Soils, Water, Sediments and Aquatic Life (AES, WRC)

Dr. Kenneth L. Simpson, associate professor of food and resource chemistry
Research area: marine pigments
Funded projects: Marine Fish Pigments (AES, SG, NIH)

Forest and Wildlife Management

Dr. John J. Kupa, associate professor of forest and wildlife management
Research area: management of recreational shellfishing, migratory waterfowl

Plant and Soil Science

Dr. Robinson J. Hindle, associate professor of plant and soil science
Research area: ecology, landscape design
Funded projects: Ecological Inventory and Land Use Plan for Rhode Island and Influent Areas (AES, Urban Observatory)

Dr. Richard J. Hull, associate professor of plant and soil science
Research area: physiology of salt marsh vegetation
Funded projects: Requirements and Responses of Salt Marsh Vegetation (SG, AES, URI Marine Resources Committee)

John A. Jagschitz, assistant professor of plant and soil science
Research area: beach grass, sand dune retention

Dr. Eliot C. Roberts, professor of plant and soil science
Research area: ecology, land use
Funded projects: Ecological Inventory and Land Use Plan for Rhode Island and Influent Areas (AES, Urban Observatory)

Dr. Richard J. Shaw, assistant professor of plant and soil science
Research area: ecology, land use
Funded projects: Ecological Inventory and Land Use Plan for Rhode Island and Influent Areas (AES, Urban Observatory)

James E. Sheehan, assistant professor of plant and soil science
Research area: plant nutrients, turfgrass
Funded projects: Yield of Nutrients from Agricultural Land to Water Sources (AES, WRC)

Dr. Irene H. Stuckey, associate professor of plant and soil science
Research area: salt marsh vegetation, wildflowers
Funded projects: Salt Marsh Ecology and Physiology (AES)

Resource Economics

Dr. John M. Gates, assistant professor of resource economics
Research area: economics of fisheries and aquaculture
Funded projects: Aquaculture Potential of Salmonids: An Economic Analysis (AES, SG)
Assessment of Potentials for Development of Commercial Aquaculture in New England (N.E. Regional Commission)
Fisheries Population Dynamics--Economic Phase (AES, SG)
An Evaluation of the Competitive Position of the New England Fishing Industry (NMFS, SG, AES)

Dr. Andreas Holmsen, professor of resource economics
Research area: fisheries economics
Funded projects: Managerial Problems of Commercial Fisheries (AES, GSO)

Harlan C. Lampe, professor of resource economics
Research area: economics of fisheries and shoreline use
Funded projects: Integrative Systems Modeling of Narragansett Bay (SG)
Market Structure of the Commercial Fishing Industry in New England (NMFS, SG, AES)
An Evaluation of the Competitive Position of the New England Fishing Industry (NMFS, SG, AES)

Dr. Bruce W. Mattox, assistant professor of resource economics
Research area: economics of petroleum exploitation
Funded projects: Petroleum in New England: Institutions and Economic Impact (SG)

Paul D. Mlotok, instructor of resource economics
Research area: economics of coastal zone use
Funded projects: Economic Aspects of Multiple Use Coastal Zone Planning (AES, SG)

Dr. Virgil J. Norton, professor of resource economics and economics
Research area: fishery economics, marine environment utilization
Funded projects: Marine Resources Economics Option (SG, AES)
Impact of International Trade Regulations on the Commercial Fishing Industry (SG, GSO, AES)
Legal and Institutional Constraints Affecting the Efficiency of the U.S. Commercial Fishing Industry (NMFS)
The Labor Force at Certain New England Ports (SG, AES)
Market Structure of the Commercial Fishing Industry in New England (NMFS, SG, AES)

Dr. Niels Rorholm, professor of resource economics
Research area: economic aspects of coastal use
Funded projects: Economic Impact of Recreational Boating (SG, AES)

Dr. Irving A. Spaulding, professor of resource economics and rural sociology
Research area: sociology of recreational activities

COLLEGE OF ENGINEERING

Cnemical Engineering

Dr. Stanley M. Barnett, assistant professor of chemical engineering
Research area: production of fish protein concentrate, recycling
Funded projects: Engineering Evaluation and Scale-Up of Commercial Processes in the Production of Fish Protein Concentrate from Heat Transfer Medium Centrifuge Cake (NMFS)

Dr. Harold N. Knickle, assistant professor of chemical engineering
Research area: production of fish protein concentrate
Funded projects: Engineering Evaluation and Scale-Up of Commercial Processes *in the* Production of Fish Protein Concentrate from Heat Transfer Medium Centrifuge Cake (NMFS)

Dr. Niels Madsen, associate professor of chemical engineering
Research area: desalination of sea water

Dr. Gerold C. Soltz, assistant professor of chemical and ocean engineering
SEE OCEAN ENGINEERING

Dr. A. Ralph Thompson, professor of chemical engineering and director of the Rhode Island Water Resources Center
Research area: desalination of sea water
Funded projects: Water Resources Center (Office of Water Resources Research)

Civil and Environmental Engineering

Vito A. Nacci, professor of civil and ocean engineering
SEE OCEAN ENGINEERING

Dr. Calvin P. C. Poon, associate professor of sanitary engineering
Research area: sedimentary pollution, analytical physical modeling
Funded projects: Sediment Pollution in Narragansett Bay (SG)

Dr. Mian-Chang Wang, assistant professor of civil engineering
Research area: marine sediments
Funded projects: In-Situ Electrokinetic and Strength Properties of Marine Sediments (USC)
Groundwater Flow in Partially Saturated Soils (WRC)

Electrical Engineering

Robert S. Haas, associate professor of electrical and ocean engineering
SEE OCEAN ENGINEERING

Dr. Robert B. Kelley, assistant professor of electrical engineering
Research area: digital and wave form communication systems; instrument sonar systems

Dr. Allen G. Lindgren, professor of electrical engineering
Research area: studies of underwater acoustic tracking, measurement, and communications systems, and studies of guidance and control of unmanned submersibles
Funded projects: Stability of Steady Propagating Waveforms on Non-linear Transmission Lines (NSF)
Study of Sonar Angle Tracking Systems (USC)

John E. Spence, associate professor of electrical engineering
Research areas: study of the acoustic field in a randomly varying sound channel

Dr. Donald W. Tufts, professor of electrical engineering
Research area: underwater acoustic data transmission
Funded projects: Acoustic Signal Processing for Communication and Detection (Navy)

Mechanical Engineering and Applied Mechanics

Dr. George A. Brown, professor of mechanical engineering and applied mechanics, and ocean engineering
SEE OCEAN ENGINEERING

Frank DeLuise associate professor of mechanical engineering and applied mechanics
Research area: water quality, water and air pollution
Funded projects: Water Quality in Narragansett Bay (SG)

Dr. Rodger B. Dowdell, professor of mechanical engineering and applied mechanics
Research area: techniques for flow measurement

Warren M. Hagist associate professor of mechanical engineering and applied mechanics
Research area: heated water diffusion in a moving water stream
Funded projects: Diffusion of Thermally Buoyant Water Jets into a Moving Water Stream (WRC)

Hilbert V. Schenck, Jr., professor of mechanical engineering and applied mechanics, and ocean engineering
SEE OCEAN ENGINEERING

Dr. Frederick L. Test, professor of mechanical engineering and applied mechanics
Research area: heated water diffusion in a moving water stream
Funded projects: Diffusion of Thermally Buoyant Water Jets into a Moving Water Stream (WRC)

Dr. Frank M. White, Jr., professor of mechanical and ocean engineering
SEE OCEAN FNGINEERING

Ocean Engineering

Dr. George A. Brown, professor of mechanical engineering and applied mechanics, and ocean engineering
Research area: thermodynamics, energy conversion, underwater power plants
Funded projects: Bay Watch (SG)
Investigation of Undisturbed Sediment Probe and Development of Techniques in Hydrostatic Anchors (USC)

Robert S. Haas, associate professor of electrical and ocean engineering
Research area: design of ocean instrumentation, bottom profiling and data telemetering
Funded projects: Alternate Flow Measurement Techniques (SG)
Telemetry System for the Deep Ocean Sediment Probe (USC)

Dr. Tadeusz Kowalski, associate professor of ocean engineering
Research area: hydrodynamics of floating and submerged bodies, statical and dynamical stability of water-borne bodies, viscous drag reduction methods
Funded projects: Short Course in Ocean Engineering for College Teachers (NSF)
Hydrodynamics of Fishing Gear (SG)
Alternate Flow Measurement Techniques (SG)
Current Measurements with Free Drifting Drogues (SG)

Lester Le Blanc, assistant professor of ocean engineering
Research area: data buoy monitoring systems, data bank
Funded projects: Data Buoy Monitoring in Narragansett Bay (SG)

Dr. Mark B. Moffett, assistant professor of ocean engineering
Research area: experimental acoustics, including impedance measurements, transient effects, nonlinear phenomena and underwater noise

Vito A. Nacci, professor of civil and ocean engineering
Research area: sediments, soil mechanics, coring devices
Funded projects: Extension Static and Cyclic Sediment Strength (USC)
In-Situ Electrokinetics and Strength Properties of Marine Sediments (USC)
Groundwater Flow in Partially Saturated Soils (WRC)
Investigation of Undisturbed Sediment Probe and Development of Techniques in Hydrostatic Anchor (USC)
Telemetry System for the Deep Ocean Sediment Probe (USC)

Dr. Vincent C. Rose, associate professor of nuclear and ocean engineering
Research area: application of nuclear engineering, chemicals from sea water, pollution control
Funded projects: Drag Reduction Studies (Navy)
Design, Test and Fabricate a Nuclear Sediment Probe for URI Deep Ocean Sediment Probe (AEC)
Analytical Physical Model of Narragansett Bay (SG)

Hilbert V. Schenck, Jr., professor of mechanical engineering and applied mechanics, and ocean engineering
Research area: underwater diving systems, instrument systems, underwater tools
Funded projects: Safety Engineering Study of Skin and Scuba Diving (USCG)
Safe Applications of Civilian Scuba Activities (SG)
An Optical Method of Measuring the Form of the Free Surface of a Fluid (NSF)
Emergency Life Support for Small Submersibles (USCG)

Dr. Herman E. Sheets, professor of ocean engineering
Research area: ocean engineering systems, submersibles, noise generation in turbo machines, hydronautics

Dr. Gerold C. Soltz, assistant professor of chemical and ocean engineering
Research area: marine corrosion, sensor development and instrumentation, structural materials in the ocean
Funded projects: Electrochemical Shipboard Water Sampling System (SG)

Dr. Frank M. White, Jr., professor of mechanical and ocean engineering
Research area: fluid mechanics, boundary layers, estuarine dynamics
Funded projects: Theoretical Analysis of Turbulent Wall-Pressure Fluctuations (ONR)
A New Integral Analysis of the Turbulent Compressible Boundary Layer (Air Force Flight Dynamics Laboratory)
Analytical Physical Model of Narragansett Bay (SG)

COLLEGE OF ARTS AND SCIENCES

Biochemistry

Dr. Spiros M. Constantinides, assistant professor of food and nutritional science and biochemistry
SEE FOOD AND NUTRITIONAL SCIENCE, COLLEGE OF HOME ECONOMICS

Botany

Dr. Roger D. Goos, associate professor of botany
Research area: fungi in marsh grasses

Dr. William L. Halvorson, assistant professor of botany
Research area: salt marshes
Funded projects: Factors Influencing Zonation of Salt Marsh Grasses (URI Grant-in-Aid)

Dr. Marilyn Harlin, assistant professor of botany
Research area: physiological ecology of marine macro-algae

Dr. Theodore J. Smayda, professor of oceanography and botany
SEE OCEANOGRAPHY

Dr. Richard D. Wood, professor of botany
Research area: ecology and systematics of marine vegetation, both macroscopic and microscopic
Funded projects: Phytobenthon and Periphyton as Indicators of Pollution (WRC)

Community Planning

Dr. Arthur D. Jeffrey, professor of economic development and regional planning
Research area: land use
Funded projects: Land Use Study, Including Coastal Areas (AES)

Dieter Hammerschlag, associate professor of urban design
Research area: land use, including coastal areas

Geography

Dr. Lewis M. Alexander, professor of geography and director of the Law of the Sea Institute and Master of Marine Affairs Program
Research area: coastal zone regions, international ocean boundaries
Funded projects: Master of Marine Affairs Program (SG)
Law of the Sea Institute (SG, ONR, NMFS, state of R.I.)
Coastal Zone Regions of the United States (SG)

Dr. John Gamble, assistant professor of marine affairs
Research area: international law, marine aspects
Funded projects: Index to Marine Treaties (NSF, SG)

Geology

Dr. John J. Fisher, assistant professor of geology
Research area: coastal geology, aerial remote sensing
Funded projects: Criteria for Recognition of Estuarine Water Pollution by Aerial Remote Sensing (WRC)
Coastal Geology Bibliography of New England (Coastal Engineering Research Center, U.S. Corps of Engineers)
Synoptic Regional Beach Sediment Transport, Cape Cod (Coastal Engineering Research Center, U.S. Corps of Engineers)

Dr. Monty A. Hampton, assistant professor of geology
Research area: marine sediments

Dr. O. Don Hermes, assistant professor of geology
Research area: petrography
Funded projects: Petrography of Rocks Dredged in the North Atlantic from 60^0 N to the SE-most Tip of Iceland Near 63^0 50' N

Dr. Eugene J. Tynan, associate professor of geology
Research area: Antarctic cores, silica-flagellates, archaeomonads, oamaru deposits in New Zealand

History

Jack Conway Crandall, instructor in history
Research area: American maritime history

Physics

Frank W. Cuomo, assistant professor of physics
Research area: ultrasonic and acousto-optical underwater transducers; detection, directivity and frequency response characteristics of same; molecular scattering of laser radiation in seawater

Dr. Frank T. Dietz , professor of physics and oceanography
SEE OCEANOGRAPHY

Dr. Stephen V. Letcher associate professor of physics
Research area: micro-structure of ocean, ultrasonic studies of double diffuse convection (with Dr. Richard B. Lambert, Oceanography)

Dr. Jan A. Northby assistant professor of physics
Research area: techniques, development of tools to study motion of natural waters
Funded projects: Fluorescent Tracer Techniques (WRC)

Jack Willis, assistant professor of physics
Research area: solar radiation spectral distribution changes underwater, underwater ambient noise

Sociology and Anthropology

Michael S. Bassis instructor in sociology
Research area: maritime sociology, especially educational institutions

Dr. Carl Gersuny, assistant professor of sociology
Research area: occupational culture of fishermen
Funded projects: Fisheries Occupational Culture (SG)

Leif C. W. Landberg, instructor in anthropology
Research area: place of fishing in non-industrialized subsistence systems, anthropological-sociological bibliography for study of fishing communities and industries
Funded projects: Development of an Index of Maritime Social Studies (NSF, URI Grant-in-Aid)

Dr. John J. Poggie, Jr., assistant professor of anthropology
Research area: occupational culture of fishermen
Funded projects: The Labor Force at Certain New England Ports (SG)
Fisheries Occupational Culture (SG)

Dr. William R. Rosengren, professor of sociology
Research area: sociology of maritime areas and activities
Funded projects: Development of an Index of Maritime Social Studies (NSF)

Zoology

Dr. J. Stanley Cobb, assistant professor of zoology
Research area: brain structures of deep-sea fishes in relation to their habitat, marine invertebrate behavior
Funded projects: Investigation of Habitat Selection, Territoriality and Spacing Behavior in Estuarine Marine Invertebrates (URI Grant-in-Aid)

Dr. Carl S. Hammen, professor of zoology
Research area: amino acid oxidation in mollusks and brachiopods
Funded projects: Amino Acid Oxidation in Bivalve Mollusks and Brachiopods (URI)

Dr. Robert B. Hill, associate professor of zoology
Research area: comparative physiology of nervous control of rhythmic organs in marine invertebrates
Funded projects: Neural Control of Myocardial Rhythmicity (involving rhythmicity in heart, crop and smooth muscle of marine gastropods) (NIH)
Excitation-Contraction Coupling in Probiscis Muscle of Marine Gastropods (URI)

Dr. William H. Krueger, assistant professor of zoology
Research area: systematics and ecology of midwater fishes
Funded projects: Vertical Distribution, Life History and Swimbladder Structure of Fishes in Ocean Acre, off Bermuda, Correlated with Deep-Scattering Layers (USC)
Review of the Stickleback Fishes (family Gasterosteidae) of the Western North Atlantic (Sears Foundation for Marine Research)
JOAST Fishes--A Study of the Vertical Distribution Assumed by the Structure of Midwater Fishes Collected in Three Stations Across the North Atlantic (USC)

Dr. Saul B. Saila, professor of oceanography and zoology
SEE OCEANOGRAPHY

Dr. C. Robert Shoop, director of Institute of Environmental Biology and associate professor of zoology
Research area: sea turtles
Funded projects: Radiation Effects on Migratory Circulation (Atomic Energy Commission)

Dr. Howard E. Winn, professor of oceanography and zoology
SEE OCEANOGRAPHY

Dr. Donald J. Zinn, professor of zoology
Research area: taxonomy of intertidal and subtidal interstitial (Thallassopsammic) ectoprocts, copepods, tunicates, opisthobranchs and holothurians; taxonomy of New England ascidian; ecology of intertidal interstitial micrometazoa; use of interstitial fauna to detect pollution

COLLEGE OF PHARMACY

Pharmacognosy

Dr. Yuzuru Shimizu, assistant professor of pharmacognosy
Research area: marine pharmacognosy, toxins
Funded projects: Drugs from the Sea (SG)

Dr. Leonard R. Worthen, professor of pharmacognosy
Research area: marine pharmacognosy
Funded projects: Drugs from the Sea (SG)

Dr. Heber W. Youngken, Jr., provost for health science affairs, dean of the College of Pharmacy, and professor of pharmacognosy
Research area: marine pharmacognosy
Funded projects: Drugs from the Sea (SG)

Pharmacology and Toxicology

Dr. Gary P. Carlson, assistant professor of pharmacology
Research area: pharmacological activity and metabolism of marine organisms
Funded projects: Drugs from the Sea (SG)

Dr. David R. DeFanti associate professor of pharmacology
Research area: marine pharmacology
Funded projects: Drugs from the Sea (SG)

Dr. John J. DeFeo, professor of pharmacology
Research area: marine pharmacology
Funded projects: Drugs from the Sea (SG)

Medicinal Chemistry

Dr. Howard W. Bond, professor of medicinal chemistry
Research area: toxicity of chemicals to shellfish; eradication of snails as intermediary hosts in human disease

Dr. Joseph G. Turcotte, assistant professor of medicinal chemistry
Research area: use of shark organs to develop potential anti-hypertensive drugs
Funded projects: Synthesis and Pharmacology of Potential Renin Inhibitors (R. I. Heart Association, National Heart and Lung Institute)

COLLEGE OF HOME ECONOMICS

Food and Nutritional Science

Dr. Spiros M. Constantinides, associate professor of food and nutritional science and biochemistry
Research area: enzymology of marine organisms
Funded projects: Preservation and Evaluation of Marine Foods (SG)
Multiple Forms of Shrimp and Crab Phenoloxidase (SG)
Enzymatic Blackening of Shrimp and Crab (SG)
Acid Phosphatase in Fish Muscle (SG)
Autolytic Enzymes in Fish Muscle (SG)

Dr. Henry A. Dymsza, professor of food and nutritional science
Research area: preservation and development of marine foods
Funded projects: Gnotobiotic and Germfree Marine Food Species (NSF, NMWQL)
Preservation and Evaluation of Marine Foods (SG)

APPENDIX B: A SHORT HISTORY OF SEA GRANT

(The following article was written for national release when the first sea grant colleges were named in 1971.)

Athena may have sprung fully formed from the head of Zeus, but the idea for sea grant did not just spring from the Olympian head of Athelstan Spilhaus.

"I would say, rather, that it resulted from the recognition of a need, a conception, a period of labor, delivery at the right time, gradual acceptance of the young infant and I now hope that its sponsors here may make it have a productive and useful life," said Dr. Spilhaus at the first sea grant conference in Newport, Rhode Island, October 28, 1965. He was then dean of the Institute of Technology at the University of Minnesota, and a prominent inventor, scientist and author.

His brainchild is turning out admirably "productive and useful."

The National Sea Grant Program, now conducted by the Commerce Department's National Oceanic and Atmospheric Administration, was created in 1966. With matching funds from states and other organizations, it makes possible grants to universities and other institutions, public and private, for research and development, education and training, and marine advisory services.

By 1971, the sea grant program had invested more than $40 million in projects in 27 states, the Virgin Islands and the District of Columbia.

During 1971, there were approximately 90 active individual projects, and 14 institutional grants covering a total of 457 projects in fisheries and aquaculture, ocean engineering, coastal zone resources management, marine pharmacology and pharmaceuticals, pollution, ecological studies, mineral resources, marine and coastal zone law and economics, biological oceanography, seafood science and technology, management and preservation of the environment, man in the sea, and physical and chemical oceanography.

Among the program's major accomplishments are identification of Great Lakes mineral deposits valued at more than $300 million, the first commercial harvest of cultured shrimp, new methodology for coastal zone management decisions, innovative fishery technology, acoustic counting of fish populations, and a system to use deep, cold water as an aquacultural nutrient source.

When Secretary of Commerct Maurice H. Stans announced the designation of the first four institutions in the country as sea grant colleges, Dr. Spilhaus' conception reached fruition. "We must have sea-grant universities and colleges that focus with commitment on the sea--that seek to impinge all our intellectual disciplines on the mastery, exploitation and preservation of the sea," he said in 1965.

The designation of the four sea grant colleges--the University of Rhode Island, Texas A&M, the University of Washington and Oregon State University--was given in recognition of "exceptionally high standards of effort, performance, and innovation in their marine programs." Although not accompanied by a specific grant, the designation placed the universities in the forefront of institutions competing for available sea grant money for marine programs.

As intended, the sea grant colleges are in some ways analogous to the land grant colleges created by the Morrill Act of 1862, which contains the pragmatic philosophy that pervades the sea grant enterprise today.

Dr. Spilhaus first began airing his idea for sea grant in 1961, while he was chairman of a panel of the National Academy Committee that was devoted to special engineering devices, vehicles, instruments and the like. Dr. Spilhaus was already opining over the gap he felt existed between "our excellent science and the pitiful state of the U. S. performance in the exploitation of the sea," and he said so at a joint meeting with the governmental Interagency Committee on Oceanography.

In 1963, in a keynote address to a national meeting on fisheries, he again expressed his unhappiness at the state of affairs, this time citing the Morrill Act as a model of "purposeful positive action" by Congress that "contributed mightily, through the mechanic arts, to lead to our national preeminence in the mass production of things that people need--including agricultural products."

"Why not then provide a focus, a commitment and continuing support in the context of sea grant universities today to bring the United States to a position of leadership in ocean engineering and aquaculture?" he asked.

Among the letters of interest received by Dr. Spilhaus as a result of his speech was one from Dr. Saul B. Saila, a professor of oceanography at the University of Rhode Island. In response to Dr. Saila's enthusiasm, Dr. Spilhaus wrote to Dr. Francis H. Horn, then president of URI, and Dr. John A. Knauss, dean of the URI Graduate School of Oceanography, about his idea, and "received inspiring and heartening" replies.

With the encouragement of Dr. Horn, Dr. Knauss proposed that a conference on the sea grant concept be held and plans were eventually made for it to be sponsored by URI and the Southern New England Marine Sciences Association (SNEMSA) in Newport.

Among the members of SNEMSA was an administrative assistant to the state's junior senator, Claiborne Pell.

Senator Pell was quick to grasp both the realities and promise of sea grant. While lending his support to the conference plans, his legislative aides were set to work on a preliminary draft of enabling legislation.

When Dr. Spilhaus delivered his speech on "The Concept of a Sea Grant University" at the Newport conference, there were 237 scientists and governmental officials in the audience, representing each of the 30 states bordering the Great Lakes and the Atlantic and Pacific Oceans.

Dr. Spilhaus' speech was subsequently reprinted in several places. It was a model of clarity and imagination.

"The oceans," he said, "will offer us more space than space itself in which to remain human. The sea. ..beautiful and dangerous, elegant and strong, bountiful and whimsical--not only challenges us, but offers 'every man in the street' the exciting participation of being 'man in the sea.'"

Senator Pell also spoke at the first conference and outlined for the participants the legislation he had by then introduced in the Senate for the establishment of national sea grant colleges and for a program of education aimed at making maximum use of the country's marine resources.

The conference endorsed in principle the proposed legislation and formed a ten-member national committee which played a significant role in obtaining eventual passage.

Co-sponsor of the bill in the house was from a state also connected vitally and inextricably with the oceans, Representative Paul Rogers of Florida.

In less than a year after the conference, on May 2, 1966, U. S. Senate hearings on the proposed National Sea Grant College and Program Act opened at the URI campus in Kingston. The Pell-Rogers act was passed by Congress and signed into law by President Johnson later the same year.

The National Sea Grant Program was given the following major responsibilities:

> To initiate and support programs at colleges and other suitable institutes, laboratories, and public or private agencies for the education of participants in various fields related to the development of marine resources.
>
> To initiate and support necessary research programs in the various fields relating to the development of marine resources, with preference given to research aimed at practices, techniques, and a design of equipment applicable to the development of marine resources.
>
> To encourage and develop programs consisting of instruction, practical demonstrations, publications and otherwise, by colleges and other suitable institutes, laboratories, and public or private agencies through marine advisory programs with the object of imparting useful information to persons currently employed or interested in various fields related to the development of marine resources, the scientific community and the general public.

The administration of the sea grant program was assigned by the bill to the National Science Foundation, which seemed to Senator Pell the "logical and appropriate choice."

The first sea grant awards came almost a year after the establishment of the NSF Sea Grant Program Office, and only 16 months after the enactment of the bill that created the program.

Three types of support were set up by NSF to implement the sea grant program. Institutional support focused on institutions engaged in a broadbased marine resources program including research, education and marine advisory services. Coherent area support is a limited institutional grant made to schools that are outstanding in single areas of science. And sea grant project support is directed toward specific projects in any of three areas of sea grant work: education, advisory services or research.

On February 21, 1968, nine grants totalling nearly $2 million were announced by NSF. The first three universities to receive institutional support were also named at that time: the University of Rhode Island, Oregon State University and the University of Washington. Texas A&M, the fourth university to eventually be named a sea grant college, received an institutional award in June, 1968.

The sea grant budget is modest when compared to other ocean programs, but has been increasing significantly each year. The first year, the program was funded for $5 million; for fiscal year 1970, it was increased to $9.6 million; for fiscal year 1971, it was funded for $13 million; and in the 1972 fiscal year--sea grant's first full year as part of the recently created NOAA--it was funded for $17.6 million.

Early intimations that sea grant should be moved from NSF surfaced at the second sea grant conference, which was also held in Newport, on October 17, 1968. The late Dr. Wilbert McLeod Chapman, former chairman of the California Advisory Commission on Marine and Coastal Resources and director of marine resources for the Ralston-Purina Co., stated in his speech:

> NSF has, and must retain, a strong role in fostering discipline-oriented ocean research. ..but the whole philosophy of the Sea Grant College Act was mission-oriented, to provide a linkage between scholarly endeavor in respect to the ocean and the improved use of the ocean and its resources. It did not, and does not, belong in the National Science Foundation.

Dr. Chapman was the first recipient of the Sea Grant National College Award, which was established that year to honor an individual who had made a significant contribution to mankind's understanding and proper utilization of the world ocean.

In January, 1969, "Our Nation and the Sea," the report of the National Commission on Marine Science, Engineering and Resources, commonly known as the Stratton Commission, was released. The commission recommended the creation of a new civilian agency, which it suggested be called the National Oceanic and Atmospheric Agency, to be the principal instrumentality in the federal government for the administration of the nation's civil marine and atmospheric programs.

The commission also recommended that the sea grant program be transferred from NSF to the new federal agency (NOAA) to enable the agency, in conjunction with its other functions, to sponsor a wide range of highly useful applied marine science and training activities in cooperation with universities and industry.

In October, 1970, sea grant did become a part of a new National Oceanic and Atmospheric Administration, assigned to the Department of Commerce, by executive order of President Nixon.

In making the announcement of the creation of NOAA, Secretary Stans said: "Until now, in spite of sincere efforts, government has failed to organize itself to meet effectively the challenge and opportunities of operating in an ocean environment. Instead of 23 departments and agencies of government competing for various parts of the Federal mission in the ocean and atmosphere, we will now have a single agency providing a unified national thrust in delivering on both the promise and potential of this last great frontier on earth."

Robert B. Abel, the outspoken director of the National Sea Grant Program, and the man most responsible for keeping the program alive and kicking since its inception, retained his position during the administrative change-over to NOAA.

One of his biggest problems had been convincing scientists that sea grant was not just another governmental faucet to be tapped for basic research funds. All proposals had to coincide with the pragmatic goals of sea grant. It took three years, he told a national publication, to discourage the "prima donnas of science" from seeking project support for "wild" basic studies.

The third sea grant conference was sponsored by Oregon State University in March, 1970, at Portland. It was marked by a real and successful attempt to get input from the men actively engaged in wresting a living from the sea. Some of the active participants were leading fishermen--men who take much of the risk and make major capital expenditures as part of the risk.

There was also an attempt to look at sea grant from inside and outside. Sea grant was assessed by those actively engaged in the program. It was also assessed by those who share responsibility for economic development of the sea, but who are not directly involved in the research, education and advisory programs that now make up sea grant.

The participants in the conference voted to establish a new Association of Sea Grant Program Institutions. Its purposes were as follows:

> To further the optimal development, use and conservation of marine and coastal resources (including those of the Great Lakes), and to encourage increased accomplishment and initiative in related areas.
>
> To increase the effectiveness of member institutions in their work on marine and coastal resources (including the Great Lakes).
>
> To stimulate cooperation and unity of effort among members.

Dr. Knauss, who had been instrumental in getting sea grant off the ground six years earlier, was elected president of the association at its organizational meeting November 19, 1970, in Washington.

The association and the University of Wisconsin, one of the sea grant program institutions, were co-sponsors of the fourth national sea grant conference held in Madison, Wisconsin, October 12-13, 1971. A highlight of the conference was the ringing endorsement of the sea grant program by Dr. Robert White, the NOAA administrator.

Dr. Herbert F. Frolander, sea grant director at Oregon State University, took over as the new president of the Association of Sea Grant Program Institutions for 1971-72 at the conference.

The Sea Grant National College Award--the first to be sponsored by the association--was presented to Dr. Lauren R. Donaldson of the College of Fisheries at the University of Washington. He was honored for his lifetime of work in fish breeding and culture, and on the effects of radioactivity in aquatic animals.

Despite the accomplishment of sea grant to date, Secretary Stans maintains that its real impact is yet to be felt. "I know of few other programs which offer as much long-term promise for the nation," he said in announcing the sea grant college designations.

"In the 19th century, the land-grant college concept began to widen our national horizons in agricultural and mechanical arts. The sea grant college concept, working through existing institutions, will help America toward more effective development and conservation of our final unexplored frontier, the oceans."