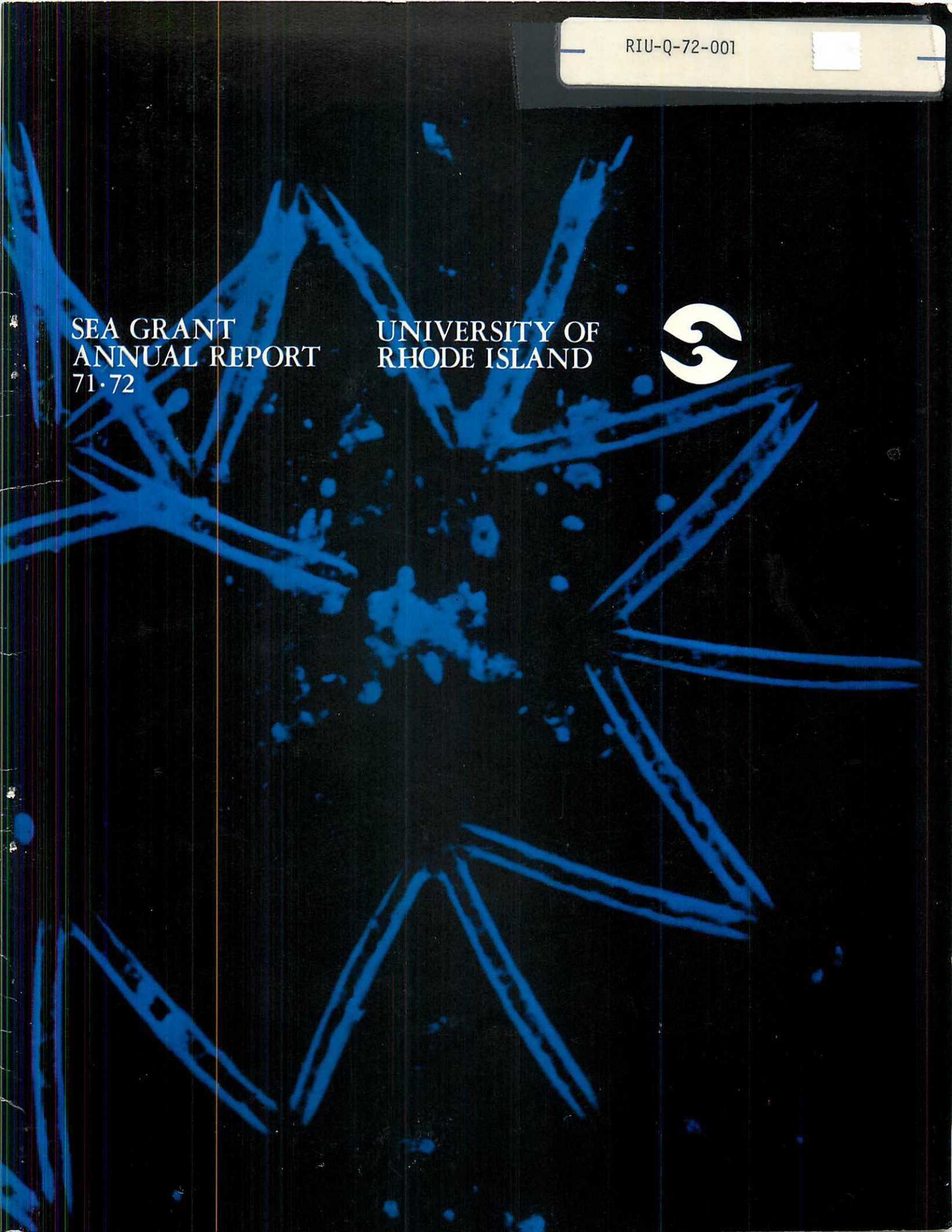


SEA GRANT ANNUAL REPORT 71·72

UNIVERSITY OF RHODE ISLAND

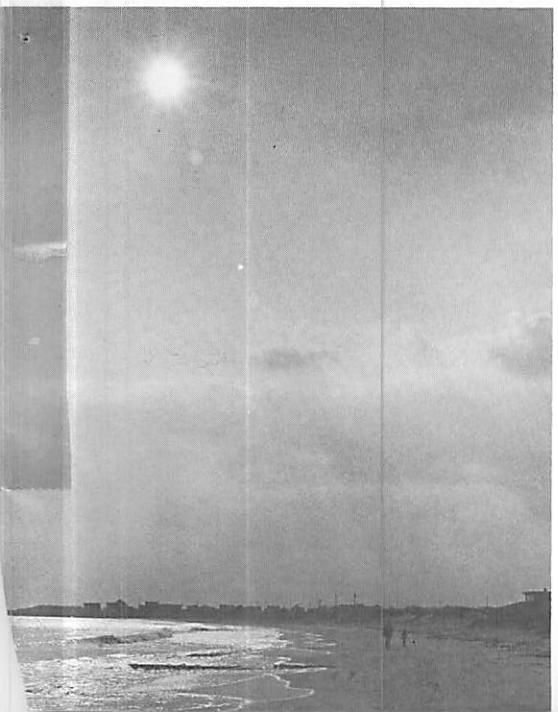
In September, 1971, the U.S. Secretary of Commerce announced the designation of the University of Rhode Island (URI) as one of the first four Sea Grant colleges in the nation. The designation was the culmination of a relationship between Sea Grant and URI that dates back to 1965, when URI co-sponsored the first Sea Grant national conference in Newport. Senator Claiborne Pell of Rhode Island was the co-sponsor of the Sea Grant College Act, creating the program in 1966, and URI was among the first three universities to receive institutional support from Sea Grant in 1968.

Since the 1965 conference, four new marine degree programs have been established at URI. Sea Grant has spurred research in fisheries, coastal resources, marine foods and drugs, marine economics, and other areas. And it has provided an apparatus at the University to communicate the results of marine research to people who can use it in the state and in the region.

During this fiscal year, about 42 faculty members at URI engaged in Sea Grant research, and 19 of them 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 University deans and other administrators, although not funded by Sea Grant, helped to implement Sea Grant education, research and public service programs. Through these programs, Sea Grant has been able to mobilize the considerable resources of the University to meet its pragmatic mission—the benefit of man through utilization of the marine environment.

With this annual report, and with others to follow, we hope to keep the reader informed of progress in the URI Sea Grant Program. It is worth noting, however, that most research, education, and public service achievements do not fit neatly into one-year time capsules. That is particularly true of a Sea Grant College Program that is apt to attack problems that do not yield immediate solutions. Thus, not all of our efforts are reported here, and the choice of which achievements to include in a particular annual report is, to some extent, arbitrary. Therefore, rather than considering this report as a complete summation of one year's work, consider it a report of work in progress.

Dr. Niels Rorholm.



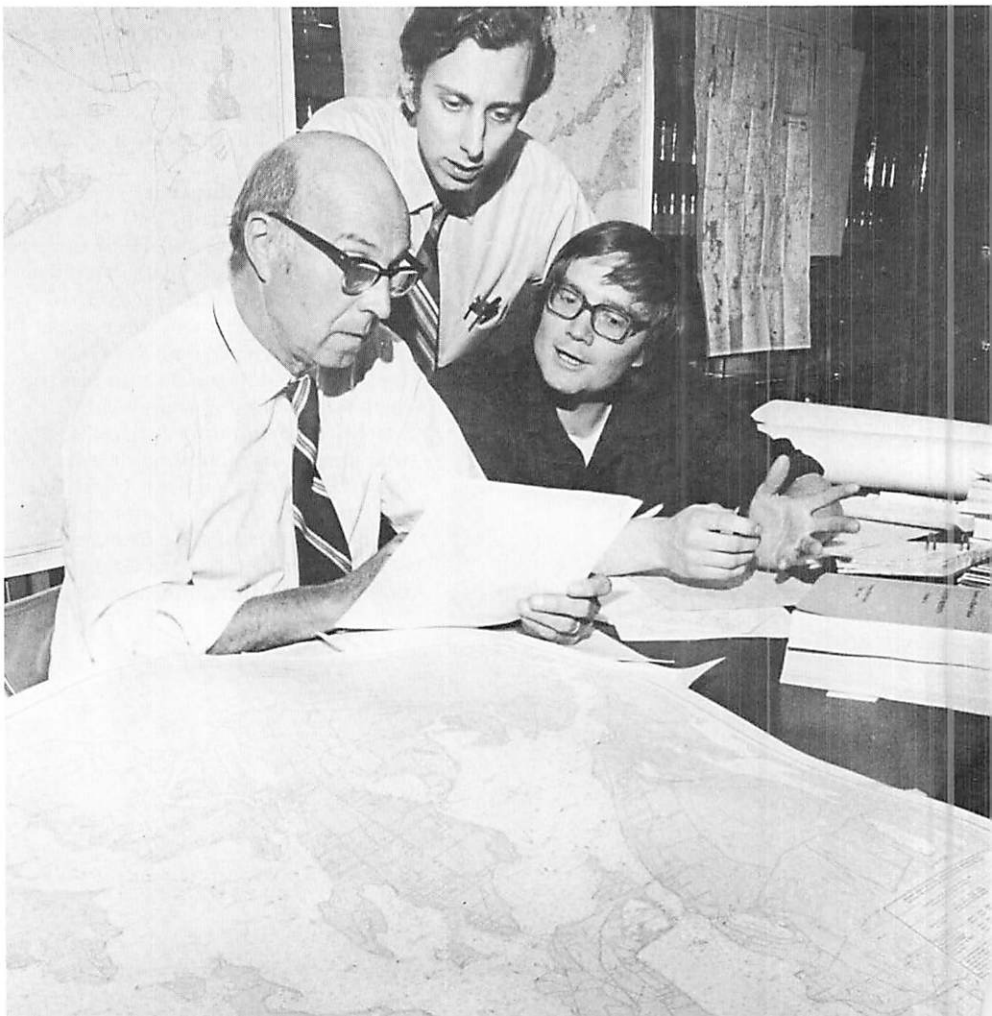
Dr. Rorholm is coordinator of the University of Rhode Island Sea Grant Program. Micro-photo of plankton courtesy of Jan C. Prager, adjunct associate professor of microbiology at the University, *(cover)*. October, 1972, Kingston, Rhode Island.

Cataloging Our Coastal Resources

Rhode Island is the smallest state in the union in land area, and it is the second most densely populated. It has only about 1,038 square miles of land for nearly a million people. But it also has 419 miles of shoreline in bays, harbors and oceanfront. Over 50 million people live within one day's drive of the state's coastline.

Activities oriented toward the sea are worth about $470 million a year in personal income for Rhode Islanders. Narragansett Bay has commercial ports, oil terminals, ship and boat building facilities, marinas and other recreational industries, fishing ports and, most important, the U.S. Navy. It absorbs and transports sewage from the state. It is the natural habitat for about 22,000 registered motor boats and several thousand sailing craft, and provides beaches for many thousands of people in the summer. The bay suffuses the entire state and its history.

Effective use of the state's coastal resources has become an area of prime concern for Rhode Island and, thus, for the Sea Grant Program at URI. This year, Sea Grant helped to start a Coastal Resources Center at the University at the request of Governor Frank Licht. The center is, in effect, the state's coastal zone laboratory, providing the Rhode Island Coastal Resources Management Council—



formed by the state's General Assembly in 1971—with the information it needs for both short-term and long-term planning and regulation of the coastal area. From its inception, the center has been engaged in work for the management council. A marine resource inventory is being compiled. The initial work is devoted to problem areas expected to require immediate attention by the coastal council. In addition, an experimental spoil disposal project is being designed through the efforts of the URI Marine Experiment Station to solve a pressing problem involving disposal at sea of toxic material dredged from a polluted section of the Providence River.

Much of the coastal zone research at URI is given form by the effort under Sea Grant to develop a systems analysis of Narragansett Bay. Researchers from different University departments are constructing models of the physical, economic and ecological systems of the bay that can be expressed mathematically, computerized and integrated. When completed, the systems model will be able to systematically predict—for the coastal council or anyone else—effects of any proposed changes upon the bay. An immediate use of a physical model might be to help predict the probable effects of growth in Rhode Island industry or population in certain areas upon fisheries and other bay uses. The physical factors being considered in the systems analysis are tidal heights, currents, salinity, temperature and concentrations of certain chemicals, such as dissolved oxygen; biological factors include plankton metabolism, bottom respiration, sediment organic content, and fauna in and above the sediment; socio-economic inputs involve factors like types of industry and concentrations of population along the coast. The ultimate goal is to provide an effective tool to guide decision-making for the bay.

The entire project has been underway for three years, and this year the first "installment" of the payoff was made. Ocean engineers working on the physical systems of the bay report that they can now determine tidal height and tidal currents in any part of the bay at any time in history, either past or future. The analysis has been tested for accuracy by actual observations of tidal rise and tidal currents at various points in the bay and

also by "predicting" the surges from the hurricanes of 1938, 1944 and 1954. The model is available for use now. As an example of its possible uses, if the wind direction, velocity and time of a hurricane were fed into the computer, the tidal height at specific points along the shore could be determined. From this, it would be possible to predict flooding and perhaps to avert loss of life or property damage.

With the model developed this year, the ocean engineers have also found ways to compute how long it would take a given particle of water to be flushed out to the open ocean from any given point of entry in the bay—an application particularly useful for pollution studies. Models of temperature, salinity and chemical concentrations are still being refined.

Last year, marine ecologists at URI finished a simulation model of the daily dissolved oxygen patterns of a small tidal marsh in North Kingstown, Rhode Island. This year, they have turned the skills they gained from their work on the tidal marsh to the bay itself. During the summer, they measured plankton photosynthesis and respiration in the surface and bottom water at locations throughout the bay, surveyed fauna in and above the sediment and measured the sediment's organic content and oxygen consumption.

A major factor regulating the seasonal cycles of plankton in Narragansett Bay are the large pulses of grazing animals that develop within or migrate into the system each summer. For north temperate bays, such as Narragansett Bay, dominant grazing populations include the comb jelly, Mnemiopsis, and schools of menhaden. Exploratory studies this year have documented an abundance of these animals, suggesting they have an impact on the bay system as consumers of zooplankton and phytoplankton and as nutrient recyclers. For the first time, scientists have been able to get quantitative estimates of Mnemiopsis populations and to measure the effect of menhaden schools on plankton and water chemistry.

Attempts have been initiated to design an interface between the ecological model and the physical model this year. When successful, it will be possible to do such things as take the change in temperature of a point in the bay and estimate associated changes in the phytoplankton population, or determine how increased nutrients from a proposed sewage outfall would affect the concentration of phytoplankton.

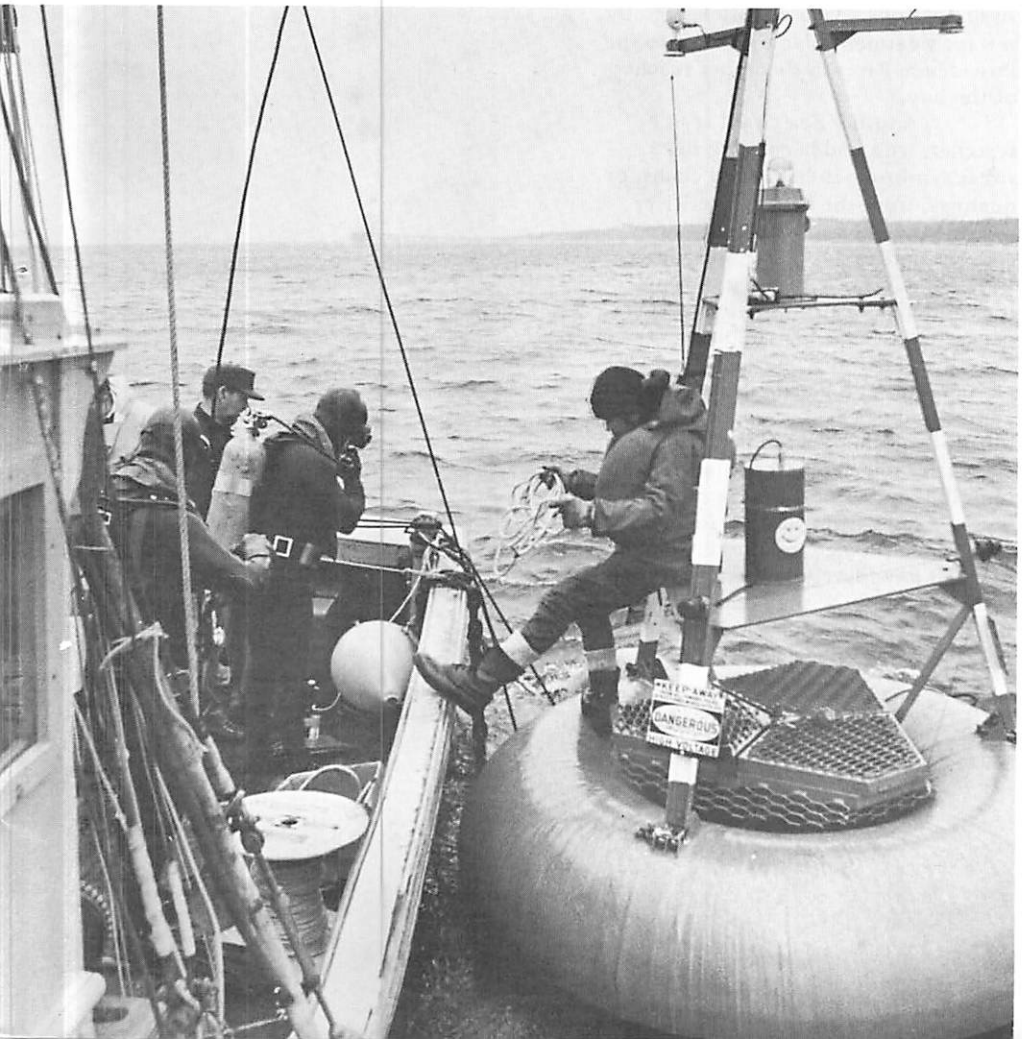
Integrating the socio-economic analysis with the other models is somewhat more complex. This year, the state's economy was divided into 57 sectors to develop a model of the flow of goods and money among these sectors. This economic model, in turn, is being integrated with selected ecological coefficients, such as biochemical oxygen demand (B.O.D.), coliform count and chemicals involved in the operation of each type of industry in the model. It is hoped that as changes in the economy are projected, it will

be possible to also project what will be dumped into the bay, or will no longer be dumped into the bay, and the effect. The model would also work like a two-way street. It would be possible to predict the influence on the economy if the decision were made to reduce an ecological coefficient, such as the coliform count, in a section of the bay.

Some of the data being fed into the computer for the models, particularly for the physical model, are being obtained by ocean engineering faculty and staff members working under another Sea Grant project called "Bay Watch." These people work on the bay, obtaining the measurements needed for the development of the models and, once they are developed, make sure the models accurately represent what happens in the bay.

Most of the work has been done by engineers aboard the department's research vessel, which continually traverses the bay taking the measurements needed for the models. To test a method for monitoring the bay for long periods of time in a single location, the ocean engineers this year fabricated a buoy containing multiple sensors to relay a constant stream of information to a receiving station at URI's Narragansett Bay Campus. The buoy was officially launched in January, and was anchored at a location off Casey Point in North Kingstown. Valued at about $300,000, the buoy and its equipment were nearly all acquired by URI without charge from government and industry surplus stocks. Financial assistance needed came from the National Science Foundation and Sea Grant.

Coded information from the buoy is being sent by radiotelemetry to the receiving station. A device there "unscrambles" the data and feeds it into a computer, which puts it on magnetic tape. Information is being stored on current speed and direction, temperature, quantity of dissolved oxygen, salinity, light intensity, the

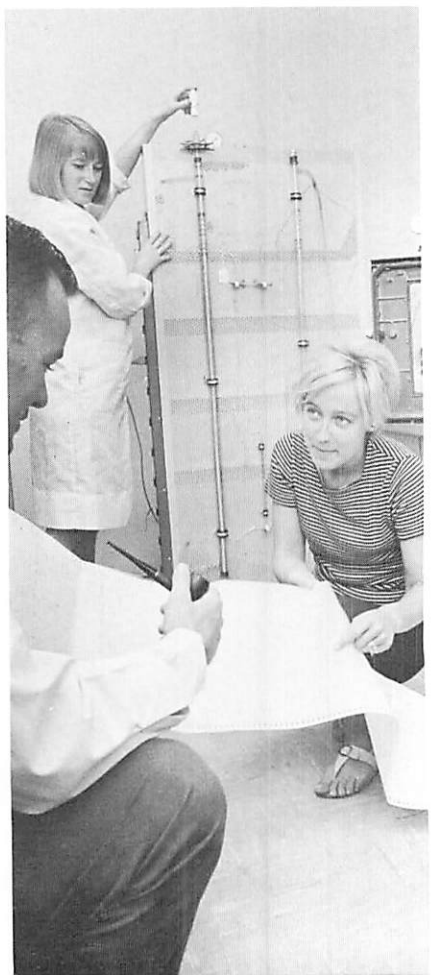


rate of solar radiation, heat transfer to the water, as well as wind speed and direction.

Besides the buoy, an underwater habitat, which will provide URI scientists and engineers a safe base platform and a dry, heated air-filled refuge from which to conduct underwater research, was prepared for launching in the West Passage of Narragansett Bay. The habitat, which is about 7 feet high with an 8 by 6 foot base, will be used for Sea Grant scuba safety studies, among other things. The habitat is to be placed offshore at the end of South Ferry Road in Narragansett, where the pier at the URI Graduate School of Oceanography is located. Called *Portalab,* it is an ambient habitat—that is, the air pressure inside is equalized with the outside water pressure. It can be lowered to virtually any depth, but is being dropped to 36 feet so a diver can come up at any time without getting the bends or having to use a decompression chamber. The two-man habitat will be connected by a hose to compressors and a life support system at the pier. Besides scuba safety, the habitat will be used for such projects as a study of paint corrosion, pollution monitoring and an evaluation of life support systems.

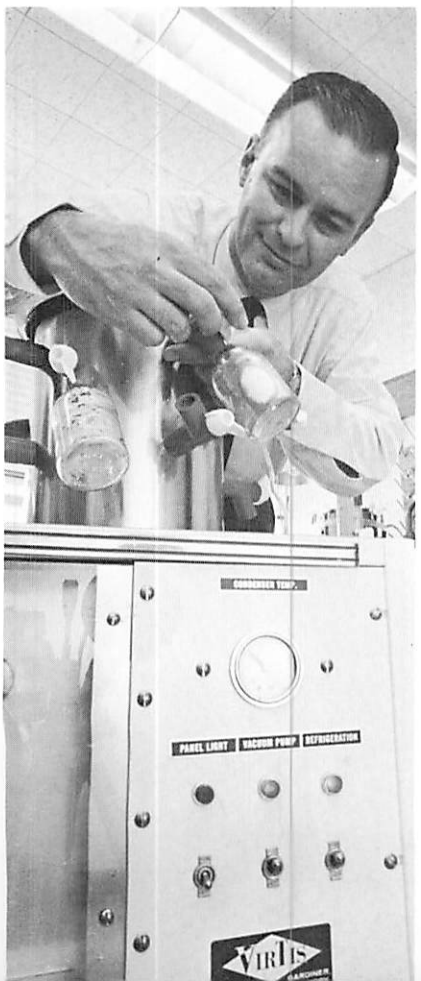
Another ten projects related to the development and understanding of the state's coastal resources are funded at URI by Sea Grant, and all are providing data for the previously mentioned systems analysis of the bay. Developments in several of the projects this year have provided new insights into the nature and extent of the pollution problem in Narragansett Bay. For example, Sea Grant scientists studying estuarine biogeochemistry reported this year that they have found hydrocarbons, derived from petroleum products, in sediments and clams in parts of Narragansett Bay considered unpolluted up to now. The sediments in some areas of the bay, including areas in the West Passage where the waters are designated as unpolluted and shellfishing is not restricted, may be chronically polluted with oil, the researchers found. Sources of the oil include sewage treatment plants, storm sewers, repeated small spills from tankers and Naval vessels, and motor oil from small craft. On the basis of analyses of the effluents, the scientists estimated that about 79,450 gallons of hydrocarbons a year are discharged by sewage treatment plants alone into the Providence River in the upper reaches of the bay.

Another Sea Grant researcher, who had been studying a stress syndrome in hard-shell clams, or quahogs, from the Providence River for six years, found that the hydrocarbons detected by his colleagues were a likely cause of the abnormalities and high death rate of the Providence River clams he had been examining. Stress from the hydrocarbons causes behavioral, structural and physiological changes in the clams. Most of the changes did not disappear even after the clams were placed in an unpolluted environment for more than a year. Clams from the Providence River were smaller and darker than normal; they developed a ridge on the inside of the shell; they had a mud blister infestation; their kidneys were plugged with a black substance that is a residue of organic compounds; and there were marked changes in the biochemistry of the animal—all apparently the result of irritation from hydrocarbons. These findings do not give reason to believe that clams transplanted from the river to cleaner areas of the bay for self-purification are a health hazard. But they do constitute a reason for the state Department of Natural Resources to examine alternative ways to benefit the quahog industry. One way, a scientist suggested, might be to just leave



the clams to spawn in the Providence River. Most of the larvae from the spawning quahogs would eventually be carried downstream to clean areas of the bay, he asserted.

The total pollution picture in Rhode Island's coastal areas is being filled out with other studies of heavy metals and pesticides in the bay. Sea Grant researchers have already determined that the pesticide problem in the bay is not yet a serious one, primarily because the estuaries emptying into the bay do not run through heavily agricultural areas; the heavy metals, particularly zinc and copper, are more serious problems because of their widespread use in Rhode Island industry. The researchers this year are concentrating on the role of sedimentary organic matter—which is so essential in the food cycle of benthic shellfish—in the absorption, migration and degradation of pesticides carried into the marine environment. They have also begun to examine the interactions between heavy metals and organic matter in the bay sediments.



Besides making ecological inputs into the systems analyses, Sea Grant researchers are providing vital economic data, which can be used not only for the theoretical models, but also for direct, immediate insertion into the process of making decisions about coastal zone uses. One researcher found, for example, that the average Rhode Island marina of 126 boats uses 473 feet of shore and 3.6 acres of land, and from gross business of approximately $120,000, generates an additional $91,773 in spending. Of this total of $211,773 of spending, $101,445 accrues to the personal incomes of people in the area. Also of direct use is the study begun this year on the institutional aspects of waste disposal in Narragansett Bay, part of a general program examining the economic aspects of multiple-use coastal zone planning. An economist is examining the possible economic impact of a proposed nuclear power plant on the town of North Kingstown, Rhode Island, and on users of adjacent coastal waters. Another project of great potential importance that continued this year is a Sea Grant study of the institutional setting for and ecomomic impact of petroleum exploitation in New England. This year's work provided information on the physical and institutional framework within which regional impacts of offshore petroleum exploitation can be estimated.

Food and Drugs from the Sea

Food scientists face the staggering problem of developing products to feed a world population that could double in the next 30 years, a population that is already starving or subsisting on a nutritionally inadequate diet in many areas. An additional problem is the concentration of the world population in cities far from the points of food production. In some countries, up to 50 percent of food production is wasted because of inefficient processing. At URI this year, food scientists from four different departments joined to offer a University-wide program in food science for more efficient use of educational resources. Faculty in the new program—from the Departments of Animal Science, Food and Resource Chemistry, Food and Nutritional Science and Bacteriology—are also those funded by Sea Grant to do research on ways of applying science and engineering to the development, processing, preservation and distribution of marine foods.

A new process developed this year could sharply increase the price fishermen receive for "trash" and industrial fish. The process is for the commercial production of fish protein concentrate (FPC) at a price competitive in the "milk-replacer" market. (A milk replacer is a substance used in human food and animal feed to supply the same protein as milk.) Although existing commecial methods for the production of FPC from trash and in-

dustrial fish are workable, the product is too expensive to compete with protein supplements already on the market, particularly soy protein. Because there is so little demand, fishermen are getting an unsatisfactory price for trash fish—about $18 a ton.

The method developed by Sea Grant researchers in the Department of Animal Science could cut the cost of producing high-grade FPC in half. The process entails reduction and extraction techniques to transform the fish into a floury, white substance that is 90 percent protein; patents for the process are pending.

In the United States, the most promising commercial use for FPC is as a milk-replacer supplement for feeding livestock. This is partly because there are fewer legal complications in entering the feed market than the human food market, and partly because there are more essential amino acids (building blocks of protein) in fish protein than in other proteins. The amount of supplement needed can be exactly determined—making it less expensive—by giving the livestock only the amount they need to meet amino acid requirements rather than total protein requirement.

While the process was being developed, the product was constantly evaluated on poultry by Sea Grant researchers from the URI Department of Animal Science. Feed grade products evaluated biologically gave consistently good results. Similar FPC products are now being tested on calves.

Although the FPC may be most economically used as feed for animals in the United States, the method developed at URI could also be used to reduce the cost of producing FPC as a protein supplement for humans in other countries—particularly in countries that have large fisheries but grow little if any soy, such as Peru.

Tests run by Sea Grant researchers in the Department of Food and Nutritional Science showed that most people cannot detect a difference in the taste of bread fortified with the FPC from bread without it. Tests on rats showed the superior nutritive quality of the FPC over other commercially produced FPC products. A pilot plant is now being established at URI to produce the FPC to continue feeding tests on calves grown for veal.

URI Sea Grant was one of five sponsors of an International Conference on FPC held at Massachusetts Institute of Technology in June. The purpose of the conference was to review the state of the art and assess the future potential of FPC as a significant source of human dietary protein. At the conference, experts—including two

from URI—discussed the extent of fisheries resources, processing methods, nutritional evaluations, application in foods, economic aspects and marketing.

This year, research also continued on the preservation and evaluation of marine foods. One Sea Grant scientist has found that by partially drying fish and using glycols and alcohols, it is possible to preserve them indefinitely. The fish he has preserved by this method have retained their original texture and other desirable characteristics lost in other methods of preservation. Another scientist is studying the proteolytic enzymes of finfish and marine invertebrates with special emphasis on those responsible for spoilage and loss of quality in important northern species. Particularly interesting is research done on enzymatic blackening of shrimps, crabs and lobsters. Dozens of methods have been tried to control blackening; if the research is successful, it will be possible to treat the shellfish to retain their color and freeze them to last indefinitely. Such methods would be useful not only to local processors, but also to developing countries where the high perishability of fish can prevent its utilization as an important source of protein. In addition, economic studies of aquaculture have shown the greatest potential in the production of highly pigmented species, and since little is known about carotenoid pigmentation of marine animals, a project in this area continued this year.

Because of the highly specific nature of research on drugs from the sea, results for any one year may appear unspectacular. But the project is potentially of immense benefit to man. In the Department of Pharmacognosy, Sea Grant research this year has concentrated on isolating and identifying compounds from marine sources, both plant and animal, of potential importance as drugs or diagnostic agents. These agents can be useful in determining metabolic pathways or processes relevant to the health of man and other animals. They are also studying marine sterols—unsaturated alcohols occurring widely in plants and animals—with a view to converting them into various therapeutically useful steroid agents. A study of algal steroids could open a route to using these agents for the manufacture of steroidal hormones whose sources are now primarily land plants. In addition, a study of starfish toxins has been initiated to establish the nature of these compounds, 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 starfish, 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 examined this year 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.

The other aspect of the drugs-from-the-sea project is conducted by the Department of Pharmacology and Toxicology. One objective of the pharmacologists is to investigate marine drugs supplied by the Department of Pharmacognosy for possible biological activity on organisms. Another objective 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.

Sea Grant researchers in the College of Pharmacy were also engaged this year in planning the third conference on Food-Drugs from the Sea, sponsored by the Marine Biological Resources Committee of the Marine Technology Society and the college, and held at URI in August. The two previous conferences were held at the University in 1967 and 1969, and each drew more than 200 people from universities, government and industry.

Fishing and Farming the Sea

Research on problems of natural fisheries at URI has essentially three components: research aimed at improving gear, primarily for finfish and lobster trawling; study of fishery population dynamics, which produces information useful in gear research as well as in policy considerations; and finally, several economic and social projects, which produce information important to individual fishermen, as well as to persons determining policy for fisheries management.

The most striking achievement of the Sea Grant gear research program this year was the development of an electric trawl system that has increased the catch of lobsters and crabs up to 50 percent in controlled experiments. The system literally shocks lobsters and crabs into lifting their bodies off the bottom sediment just before the mouth of a bottom-dragging net reaches them, thereby increasing the likelihood they will be caught. An array of electrodes, which are about three feet long and two feet apart, are towed in front of the mouth of the net. A heavy-duty automobile battery connected to the electrodes can emit about 45 electrical pulses a minute. If the trawler is moving at about two-and-a-half knots, each lobster is subjected to two of the pulses before the net reaches it.

Lobsters resting on the bottom rise on the tip of their claws when they are shocked, and present a bigger target for the net. Similarly, crabs rise off the bottom onto the tips of their walking legs when shocked. Besides increasing the catch of the animals, the system should also increase the quality. Conventional trawling requires the use of heavy rollers in order to stay as close to the bottom as possible. As a result, silt and rocks are also trapped in the net, sometimes injuring the animals. With the electric trawl, lighter equipment can be used since it is not necessary for the net to hug the bottom to reach the lobsters and crabs.

So far, the system has been tested only in shallow waters, about 120 feet deep, in Rhode Island Sound. An attempt is also being made this year to develop a pulse duration and frequency that will induce flatfish into the nets. The present electric trawl apparently repels the fast-swimming flatfish, which are a staple of the Point Judith fishery.

No detailed cost analysis has as yet been done on the electric trawl system, but one estimate is that it could be built for about $3,000. Each of the batteries used in the operation can work effectively for about eight hours before being re-charged. Since the announcement of the development of the system, a number of lobster fishermen have expressed interest in it. The system may help make trawling more competitive with lobster potting operations, which have been on the ascendancy on the East Coast recently. Were this to happen, a side benefit would be the lessening of conflicts between draggers and fixed-gear fishermen offshore.

Other Sea Grant gear research at URI this year is aimed at increasing the catch of commercial fishermen by developing gear that will speed up their vessels or permit them to tow larger nets. A URI resource economist who specializes in fisheries has found that a greater correlation exists between size of catch and horsepower of the fishing vessel than between size of catch and any other factor, including the length or tonnage of the boat.

Horsepower, he explained, is important for two reasons: first, the greater the speed, the more ground the fishing vessel is able to cover on a trip; second, many fast-swimming fish, which are particularly prevalent in the Atlantic, can swim in and out of the trawl of slow vessels, or avoid the trawls altogether.

As part of the research effort in the hydrodynamics of fishing gear and towing power of bottom trawls, an attempt is being made to determine and improve the drag characteristics of common fish-net sections. Much of this work is being conducted in the laboratory in a 30-foot channel that allows for an even flow of recirculating water. The pressure in front of the net sections is measured, since there is most probably a "pressure threshold" at which the fish could be scared away from the net. Related to this are the researchers' attempts to determine net permeability and to produce a design that will minimize the pressure envelope in front of the net, as well as to decrease the drag of fishing gear netting by changing the shape or arrangement of its components.

Another researcher is concentrating on the effects on the towing power and net geometry of bottom trawls of such factors as otter board size and weight, twine and mesh size, warp scope, floats and bottom gear. These findings can be of great use to gear technologists designing nets, to net makers in making and rigging nets, and to commercial fishermen themselves in rigging and adjusting fishing gear for maximum effectiveness.

These gear studies will be supplemented by another project seeking to develop and test new conceptual approaches to natural fisheries management, and to apply existing techniques that could contribute to the rational management of natural fisheries. A simulation model of the population and vital statistics of the northern lobster, *Homarus americanus*, has already been completed for the region. Information gained from these studies will be applied in the form of specific recommendations to the state Department of Natural Resources and the National Marine Fisheries Service for the management of New England fisheries.

URI sociologists and anthropologists, in their inquiries into the social and cultural factors associated with work at sea, are examining the occupational subculture of commercial fishing as it contrasts with that of land occupations. Information gained here will make it more feasible to design realistic programs for recruitment, retention and retraining of a labor force for commercial fishing. Alternatively, if the need for commercial fishermen is reduced, such understanding will make it easier to design retraining programs or to recommend other vocations for fishermen.

The scope of the sociological research ranges from a study of the significance of fishing superstitutions and taboos, to a study of the probable consequences on fishing families of any schemes to restrict entry into the commercial fishery in order to prevent depletion of fish stocks. The same researchers this year are conducting a survey intended to provide an empirical basis for designing measures to assist fishermen whose earnings are marginal and who wish to leave the fishing industry.

Aquaculture—the culture of marine organisms under controlled conditions—continued as an area of research this year, but some of Sea Grant's goals were reordered. The research now aims specifically at determining the feasibility of growing market-size lobsters and salmonids in closed recirculating systems. A pilot system is being constructed to grow lobsters from the time they are hatched until they reach marketable size of one pound, a process that takes about two years. Although other researchers have established that it is possible to raise a few marketable lobsters under controlled conditions, no one has as yet established how to cut the cost of culturing lobsters to a commercially practical level. The pilot system should indicate how to minimize the loss of lobsters from biological factors, thus giving a preliminary idea of both economic and engineering aspects of lobster production. Earlier attempts under Sea Grant to evaluate the economic feasibility of the methods used have been put aside for the present. This work will be reactivated when additional scientific and technical information becomes available. The four continuing projects in aquaculture cover aspects of growing and feeding, the microbiology of filters, and diseases and their control.

The University's fish histopathology laboratory, established in 1970 with Sea Grant funds, has become an integral part of URI aquaculture and state hatchery projects. Among the problems being examined at the laboratory are fin rot in salmon, protozoal disease in ocean pout and fungus in trout. Over the past year the diagnostic laboratory has developed both bacterial and clinical pathological capabilities. In addition to diagnosing disease outbreaks in aquaculture pro-

jects, the researchers at the laboratory have helped to provide means to prevent disease spread, for example, in a closed environmental salmonid system.

A significant finding of the laboratory this year was the identification of Vibriosis, a bacterial disease, afflicting marine fish in Rhode Island waters. Specifically, the disease has been found in New England winter flounder; the condition had previously been undescribed. The prevalence of the disease could affect the culture of anadromous fish raised in a controlled environment and released to the open ocean. When the fish return to spawn, they could carry the disease with them. Thus, the researchers are now attempting to determine how the disease develops and spreads, and possible methods to immunize the fish being raised in aquacultural projects.

Formal Education Programs

In education, two programs are supported in part by Sea Grant funds: the Master of Marine Affairs (MMA) Program, and the doctoral program in economics with a marine resource option. Sea Grant funds are used mainly for salaries of faculty teaching necessary marine-oriented courses. This was the third year for the MMA program which is aimed at training people already engaged in a professional career in the complex problems involved in making decisions about the marine environment. It was the first program of its type in the nation. Another 20 students were graduated from the nine-month course of study in June. The students, many of whom already have advanced degrees in a subject related to the oceans, or have had equivalent experience, applied themselves to particular problems during the year. These included regimes for the deep seas, decision inputs for coastal zone regulation, juris-

dictional requirements for pollution controls, criteria for deciding among competing uses for the continental shelf, arms control in the oceans and others. Graduates of the program have returned to positions in the U.S. Navy, or have gone to work in state planning offices, coastal zone management agencies, regional commissions, oceanographic instrumentation corporations, and an aquacultural firm.

The graduate program in economics with a marine resource option, which was initiated in 1969, awarded its first Ph.D. this year. The program now has about 15 students, compared to a first-year enrollment of five. Eight students have already completed their course work and comprehensive examinations, and are working full-time on dissertations. The final course offered to students in the program is a seminar in marine resource policy and, as part of that course, six students spent a week in Washington, D. C., for a series of seminars sponsored by the National Oceanic and Atmospheric Administration, the Environmental Protection Agency, the Council on Environmental Quality, the National Water Commission, the Water Resources Council, the Office of Management and Budget, the Army Corps of Engineers and the President's Council of Economic Advisors. The purpose of the trip was to give the students, who had already gone

through the necessary theoretical and quantitative studies, a direct view of how the government actually arrives at marine resource policies. Many of these students will one day be working for the agencies, running the seminars or conducting university research under their auspices. The trip was funded by Sea Grant and may become an annual one. Among the topics being studied by the people in the program are the economics of fisheries, petroleum exploitation, minerals from the sea, waste disposal and coastal management in general.

Sea Grant has also played a significant role in other marine education programs at URI. The graduate program in ocean engineering this year graduated 12 people, three with Ph.D.s and the rest with master's degrees; the entire program has about 88 students, two-thirds of whom are at the master's level. Until this year, however, it was necessary for students to obtain a bachelor's degree before studying ocean engineering at URI. But this year, Sea Grant played a seminal role in starting an ocean engineering option for undergraduates majoring in mechanical engineering. A review of in-

dustries in the southern New England area showed a great interest in hiring engineers who have bachelor of science degrees and who also have ocean-related skills. A graduate of this program will still be able to practice as a mechanical engineer, since he will have taken all the core mechanical engineering courses. But the graduate will also be prepared to enter an ocean-related technical career by being exposed to an intensive series of courses introducing him to the design of ocean systems, estuarine pollution and water quality, theories of underwater acoustics, and the operation of instruments and gear from research vessels. In addition, a non-credit course in scientific scuba diving will be available to those electing the joint program and able to meet the physical requirements. A similar option, not funded by Sea Grant, was also made available to the University's chemical engineering undergraduates.

Another marine degree program at URI that received some Sea Grant support this year was the two-year, associate degree program in commercial fisheries. The program prepares young men for eventual command of fishing vessels, as well as employment in other aspects of the marine industry. All the graduates of the program, which began in 1967, have entered the fishing industry or are continuing their education; those working receive salaries ranging from $12,000 to $20,000 a year, depending on the vessel and the fishery.

Advisory Services and Law of the Sea

An integral part of the Sea Grant program is to communicate the results of marine research to the people who can use them. Linking the sources of marine information with its potential users are two public service programs conducted by the University of Rhode Island through Sea Grant. The first, the New England Marine Resources Information Program (NEMRIP), was established at URI to provide information services to individuals and organizations in the six-state New England region. The second, the URI Marine Advisory Service (MAS), provides field services to Rhode Island's marine community, along with other programs in the tradition of the agricultural extension service. The two programs are administered jointly and, in effect, are staffed by the same people.

This year, for the first time, NEMRIP had a full-time marine education specialist to help science teachers throughout New England do a better job in marine education by providing them with information and resources for use in the classroom. His first task, which was completed this year, was to update a bibliography of research done on Rhode Island's Narragansett Bay. This year he also co-sponsored various workshops and conferences for marine science and education, produced a marine education series for television, and laid the groundwork for the establishment of a marine curriculum materials resource center at the University. A long-term goal, toward which some progress was made this year, is to establish a marine science center—a teaching center with classrooms, laboratories, field equipment and other resources to be used by every school in Rhode Island, and to be a model for schools in other states. It could serve in addition as a workshop for preservice and in-service training of teachers and for evening, weekend and summer continuing education programs.

NEMRIP is being increasingly utilized by the general public, as shown by the 2,044 requests for information received this year, up 755 over the previous year. About one-fourth of all information requests come from business and industry, largely from service and consulting companies and small enterprises, such as marinas and commercial fisheries

operations. A large proportion of the requests comes from students and teachers, and the rest are from government agencies, unions, associations and individuals. There are also 11,444 publication requests, up 469; and the readership of the NEMRIP monthly newsletter, *INFORMATION*, grew by 2,493 to a total of 14,000.

Of more immediate and direct economic benefit to the marine community is some of the work being done by the commercial fisheries extension specialists in the Marine Advisory Service. This year the advisory service helped introduce mid-water pair trawling for herring at Point Judith, Rhode Island. Two Point Judith vessels teamed up during the first week of February and have been successfully catching herring in Rhode Island Sound and adjacent waters since then. The method is commonly used in Ireland, and the advisory service brought an Irish fishing captain to Point Judith for two weeks to assist the local fishermen in learning the method. This type of fishing has distinct advantages over single-boat mid-water trawling in that

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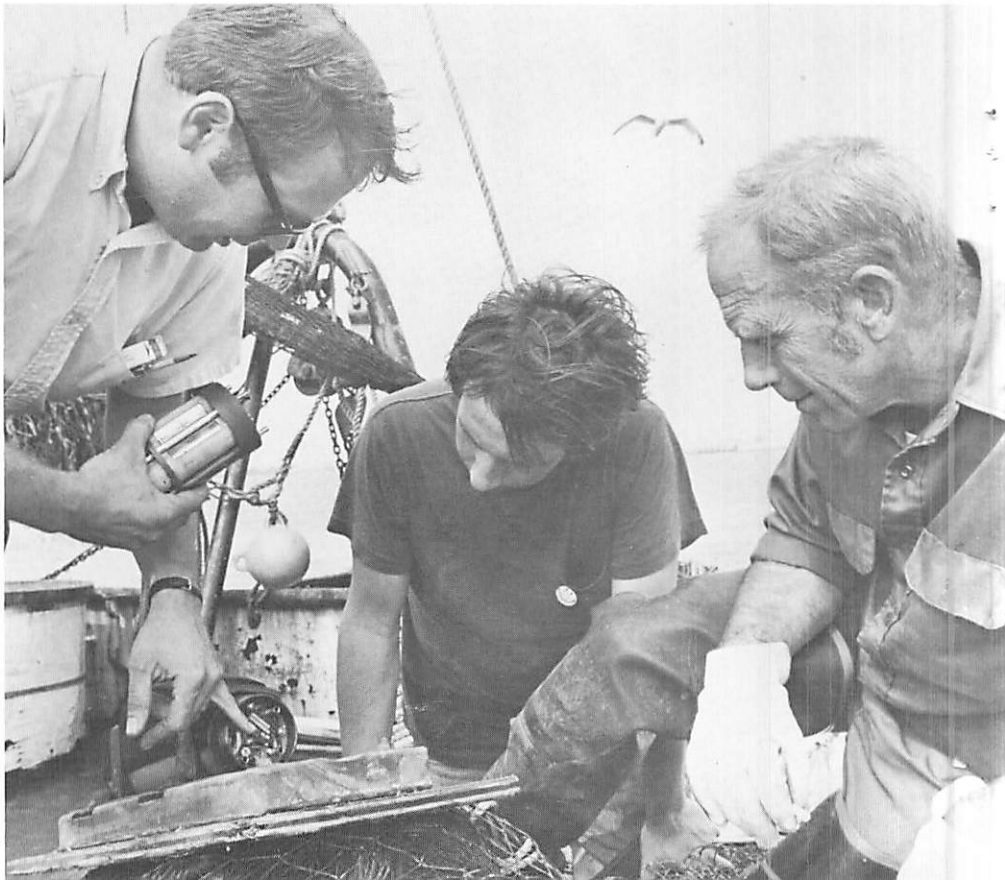
a) the drag due to the doors is eliminated, hence the power can be utilized more effectively in towing a larger trawl; b) there is a herding effect toward the path of the trawl due to the noise from the two vessels, and c) two vessels are more effective in locating the herring prior to shooting the trawl. The potential of the method is great; catches of 30,000 pounds in tow are quite common. In fact, caution must be exercised to avoid catching too many herring in one tow. Gear loss is possible if the herring drown and become extremely heavy. A second pair of vessels has been geared up for pair trawling at Point Judith. Fishermen in Maine have also shown interest, and the method may be applied to the herring fishery in the Gulf of Maine during the summer of 1972. For about six weeks this year, the advisory service also tested the efficacy of single-boat mid-water trawling. For the type of vessel and gear used locally, the method was shown to be uneconomical—information, supported by data, that could prove invaluable to fishermen considering the use of that method. The advisory service this year also assisted fishermen trying to establish the feasibility of gill-netting for codfish in the off-season.

The Marine Advisory Service, along with the Point Judith Fishermen's Cooperative Association, this year sponsored one of the most productive of the annual Fishermen's Forums ever held. An offshoot of the forum was the formation by the fishermen of an offshore fisheries association. The new group, called the Atlantic Offshore Fish and Lobster Association, intends to provide the apparatus to assist individual fishermen in filing with the State Department, claims of loss or damage of gear by foreign vessels.

In response to an increasing number of requests from fishermen for information on organizing and operating fisheries cooperatives, the advisory service also sponsored a workshop on fisheries cooperatives, held in June at Galilee, Rhode Island.



The Marine Advisory Service, along with NEMRIP, played an active role in the field of marine recreation this year. NEMRIP's most conspicuous activity was the marine recreation conference on boating in New England, sponsored by it and four other organizations in Newport, in December. The function of the invitational conference was to catalyze communications between those in the boating industry and legislators and others involved with coastal zone planning. About 80 people attended the conference, which included such topics as a socio-economic profile of the New England boatman, projections for recreational boating for the next ten years and discussions of such questions as coastal zone planning, boating safety and education, ecology, taxation, boating services, financing, and boat thefts.

In addition, the Marine Advisory Service sponsored a series of business management workshops for people in the boating industry. They involved such practical considerations as managing money and employees, and services and salesmanship in boating. NEMRIP has also sponsored, or co-sponsored, several workshops to increase the cooperation and effectiveness of marine extension workers. The first national Sea Grant publications conference also was held at the University in May. The meeting drew advisory services' directors, publications people, and representatives from some agencies of NOAA, which administers Sea Grant. The purpose of the meeting was to encourage people involved with publications to examine more critically the relevance of their productions. Topics of two panels were "Did

the Publication Hit the Target?" and "Is it Worth Printing?" Panel members were professionals in publishing, printing and design.

Another marine communications link with Sea Grant support at URI is the Law of the Sea Institute, which provides for the exchange of information and ideas on the use and control of the sea. Media used by the institute are conferences, seminars, workshops and publications. This year, it published and distributed the proceedings of the conference of the 1971 Law of the Sea Institute, which was attended by some 200 persons. With the heightened interest in ocean law at both the national and international levels because of the United Nations Law of the Sea Conference, tentatively set for Geneva, Switzerland, in 1973, this year's conference was on the needs and interests of developing nations. Held at the University between June 26 and 29, the conference was the seventh to be sponsored by the institute and had speakers and discussion groups dealing with the relationship between the law of the sea and interest of developing nations in minerals from the sea bed, in fisheries, and in other ocean resources. This year's topic was especially relevant insofar as developing countries are expected to play a major role in the impending U.N. conference. There have been indications of some basic differences between the interests of the major, developed nations and the more numerous developing nations in the law of the sea, particularly in regard to proposals for setting the width of territorial seas. This year, the institute also published studies in its Occasional Papers Series; topics of the papers included factors influencing the U.S. position on the law of the sea; the operation of the Japanese fishery management system; a convention for an international environmental protection agency; and fisheries and the law of the sea. Several programs were also sponsored by the institute's Fisheries Incentive Management Program in New Bedford, Massachusetts, on proposals for national fisheries management legislation and the management of fish resources for optimum returns.