SEA GRANT ANNUAL REPORT • UNIVERSITY OF RHODE ISLAND • JUNE 1974-JULY 1975

INTRODUCTION

Rhode Islanders always have been tied inextricably to the sea. To the colonists, 30-mile-long Narragansett Bay was a lifeline, connecting the harbors of Newport, Providence and Wickford to the Atlantic. When the British threatened to curtail use of that lifeline in the 1760s by enforcing anti-smuggling laws, they found Rhode Islanders (or "Rogue Islanders," as they came to be called by some) ardent revolutionaries. Two British customs schooners, *Liberty* and *Gaspee*, were burned by angry colonists, and not long after those incidents, Rhode Islanders created the first colonial navy. When the first Continental Congress was held at Philadelphia, it was the Rhode Islanders who led the support for establishment of the Continental Navy. After delegates agreed to a navy, Rhode Island supplied one of its first vessels.

No longer are Narragansett Bay and the Atlantic heavily depended upon as lifelines. Nevertheless, Rhode Islanders remain just as dependent upon the sea for economic and recreational reasons as the colonists once were. All industries which use the Bay in one way or another add an estimated $375 million boost to Rhode Island's gross state product. Commercial fishermen at Galilee and Newport rely upon renewable fish stocks for their livelihood. Industries along the state's more than 400 miles of shoreline depend upon coastal tidal currents to dilute and remove some of their waste products. Sailboats and power cruisers ply the state's waters. They visit such sites as Newport, Watch Hill, and Block Island, which lies about 12 miles off the state's south coast. To Rhode Island's beaches and vacation homes come tens of thousands of summer visitors from Connecticut, New York, Massachusetts, and elsewhere around the country.

The value of the Bay is more than economic; it is also aesthetic. Rhode Islanders value their Bay highly for its untamed beauty. Rhode Islanders are aware that the sea is there, waiting, only a few minutes' drive from their homes. Many of the state's one million citizens participate in boating, fishing, swimming, or other salt water sports.

Gone are the days when cannon and musket could protect Rhode Island's ocean interests. Today, our interests lie in making certain that our ocean resources are used wisely for the benefit of all Rhode Islanders and for future generations. What is needed now is sophisticated research of the sea and its embayments, done by trained technical, scientific, and advisory personnel.

Here is where the Sea Grant Program of the University of Rhode Island enters the picture. Sea Grant is a federal-state program, begun in 1966 to ensure the wise use of marine resources. In 1971, the University of Rhode Island was designated one of the first four Sea Grant Colleges. Over the past year, six of URI's eight schools and colleges have been involved in a comprehensive effort aimed at generating the kind of knowledge needed to develop, manage, and protect our valuable coastal and marine resources. One hundred and forty-six teachers, researchers, professional staff members, and graduate students were involved in teaching, research, and advisory-service projects in such areas as marine environmental problems, commercial fisheries, marine recreation, aquaculture, foods from the sea, and exploitation of minerals on the continental shelf. What follows are accomplishments of the University of Rhode Island Sea Grant Program during the period July 1, 1974, through June 30, 1975.

COASTAL RESOURCES

Researchers at URI's Department of Ocean Engineering have developed a way to use a virtually indestructible waste product—worn out auto tires—to build an inexpensive but effective alternative to rock jetties.

The scrap tires are being used to construct rafts of moored, floating breakwaters for use in protecting small boat marinas that cannot afford the astronomical cost of building breakwaters made of concrete, steel, or rock. The scrap tire breakwaters also show promise for protecting shoreline vulnerable to erosion.

The engineers say that floating tire breakwaters could become an important way of recycling the more than 200 million tires discarded each year. Only about ten percent of the discards can be recapped; the rest are non-biodegradable and must be dumped at landfill sites, which are becoming scarce.

With the help of the URI Sea Grant Program, several New England small-boat marinas have already built and installed floating breakwaters. Interest in them is continuing to grow.

The floating scrap tire breakwater project is a good example of how Sea Grant works to identify problems, search for solutions, and introduce those solutions to the people who need them. In this case, the need for inexpensive breakwater protection for small boat marinas was learned of two years ago by the Sea Grant Marine Advisory Service's marine recreation specialist. He brought the problem back to the ocean engineers at URI. The Sea Grant Program and Goodyear Tire and Rubber Company, which had done preliminary studies, funded research on the new concept at URI.

Recently, the ocean researchers developed an "optimum" breakwater—the third design built and evaluated in Narragansett Bay—and MAS specialists have worked to introduce the idea into the marine community through demonstrations, boat show exhibits, the news media, and personal communications. Their efforts have paid off.

This spring, the Edgewood Yacht Club at Cranston, Rhode Island, called upon Sea Grant breakwater experts to assist in designing, building, and installing a 500-foot-long scrap tire breakwater. The total cost to the club was $2,500 not counting labor (which was donated by club members) or the tires (which tire-replacement centers gladly provided for free). Boston Harbor Marina has built and installed a 500-foot-long tire breakwater. A 100-foot-long scrap tire breakwater was so effective in helping to protect $3 million worth of new boats at the fall 1974 Newport International Sailboat Show that show promoters were planning to construct a 500-foot-long breakwater for the 1975 show. One of the experimental URI breakwaters has been given to Parent's Marina at Providence for boat protection there. Several towns contemplating scrap tire breakwaters for shoreline protection have contacted the URI ocean engineers.

The "optimum" URI design consists of 18-tire units, which are tied on shore (in about ten minutes) and pushed into the water. The diamond-shaped units—each a small, floating raft—are strapped together in the water and moored to complete the breakwater. The final product can be a 500-foot-long by 22-foot-wide breakwater which will reduce a three-foot wave to less than a foot.

The latest design positions tires vertically, and only the tops of the tires float above water. The vertical design captures air in the tires' crowns, eliminating the need for expensive flotation materials.

Floating scrap tire breakwaters are ecologically sound. They do not impede tides or natural currents. The URI team found that after a few months seaweed and barnacles grow on the breakwater, providing food for small fish—which soon attract larger fish. Also encouraging are the results of Environmental Protection Agency experiments that show that pollutants do not leech from tires.

Three Sea Grant studies have been concerned with the opportunities and problems facing New England with regard to offshore oil development and oil pollution.

A major study of potential onshore impact of New England offshore oil development was completed this year by a researcher in the Department of Resource Eco-

nomics. The report, *Offshore Petroleum and New England*, is a significant document that local, state, and federal planners can use to anticipate the significance of oil development.

The resource economist concluded that development of a large oil find in the Georges Bank area is not going to be a panacea for New England's severe unemployment or energy problems. However, in selected locations where related onshore developments are situated (including refineries and support operations), substantial employment opportunities may be created. The economist also concluded that there is a possibility of discovering a natural gas deposit which would make the region self-sufficient. New England uses such large quantities of oil, however, that it is unlikely that even a large oil find would make the region self-sufficient.

Georges Bank is a historically rich fishing ground, larger than any of the New England states except Maine. It is located about 100 miles east of Cape Cod. Until exploratory drilling is tried on Georges Bank, no one can be certain of possible gas and oil reserves there. However, the U.S. Geological Survey has estimated that the Bank may contain 900 million barrels of recoverable oil and four and one-half trillion cubic feet of recoverable natural gas.

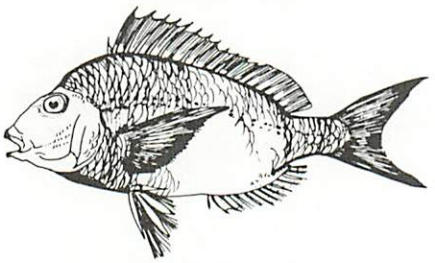
The resource economist made estimates of impacts from scenarios of high and low offshore finds, high and low prices for oil and gas, and one and three regional refineries. A large oil find of three billion barrels would result in a maximum production of 219 million barrels yearly, only about half of the region's 1972 oil consump-

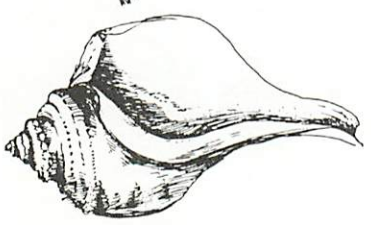
tion. If only a small find of oil and natural gas were made, oil production would be only a fraction of the regional consumption rate. However, natural gas production would still supply a significant amount of New England's needs.

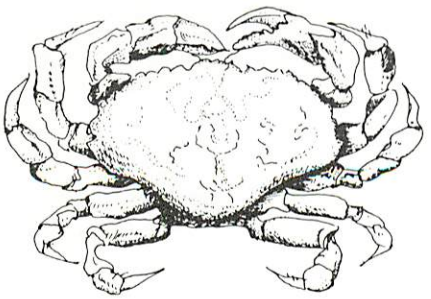
While the economic impact of oil development would not be great for New England, the impact on selected coastal areas could be considerable. Exploitation of a large find, if accompanied by construction of three petroleum refineries in the region, could mean about 14,515 new jobs and a boost in income to the region of $205 million from 1977 to 1979. New jobs would open up primarily in coastal areas where support operations and refineries would be located. However, the economist believes that a substantial number of these jobs might be filled by skilled workers from outside the region.

Exploitation of a small find of 400 million barrels of crude oil and two trillion cubic feet of natural gas—and construction of one refinery—would mean creation of 5,913 new jobs and an additional $81.7 million for the region's annual income.

The Sea Grant researcher said a planning strategy needs to be worked out to meet the impacts of onshore development. Oil development can result in an influx of people to selected coastal areas, causing land and housing costs to soar and putting pressure on public services.







Last year's *Annual Report* noted that chemists, supported in part by Sea Grant, had developed a spectroscopic method for "fingerprinting" oil spills and tracing them to their sources. This method can be a valuable tool for monitoring oil pollution and for finding those responsible for spills.

This year, the chemists have expanded their research to find background levels of oil on Rhode Island beaches and in state waters, to identify components of oil that dissolve in water, and to improve their "fingerprinting" method.

Their research comes at a highly appropriate time. The background levels they are finding, for example, will provide a yardstick with which to judge the impact of offshore oil development and accidental spills in the future.

Analyzing beach sands from nine locations, the chemists found that sands within the Bay had been contaminated by fuel oil. Sands from south coastal locations, however, were found to be clean. The Sea Grant researchers are now determining the absolute amounts of petroleum contamination in Bay sands.

At the same time that these beach samples were taken, nearshore water samples were obtained and later found to be free of oil contamination. Samples taken in Wickford Harbor, however, were contaminated. More than 60 subsurface water samples collected there contained hydrocarbon pollution, indicating the possible role of pleasure boats in polluting Bay waters.

In other studies, components of petroleum are being separated and

fingerprinted. The ultimate goal is to find which of the components dissolve in seawater and which remain on the surface where they may be removed. First indications are that the aromatics—some of which may be cancer-causing substances—are among the faster-dissolving components.

The fingerprinting technique currently in use by the chemists is a modified and more effective version of the infrared spectroscopic method used last year. The original technique involved shining light through an oil sample to obtain an infrared spectrum that could be depicted on a graph. Using the graphs, different oil samples were identified and oil samples from a spill and a spill source frequently could be matched.

For the new fingerprinting technique, the chemists freeze the sample with liquid nitrogen to a temperature of —187°C and then obtain the spectrum. The result is a considerably more sensitive identification. They evaluated the new method in a blind test on eight simulated oil spills and on an actual spill that occurred in New Haven, Connecticut. Using the room-temperature technique, there was some doubt as to the source of the real spill. With the low temperature method, there was unequivocal evidence pointing out the source.

Most people are accustomed to thinking that the major sources of oil pollution are catastrophic oil tanker spills.

Another important, but obscure, source of oil pollution, however, is the flow of petroleum hydrocarbons added daily to our estuaries from the discharge of treated sewage effluent.

URI Sea Grant researchers at the Graduate School of Oceanography have completed the first year of a two-year study to find the amount of petroleum hydrocarbons discharged from a large treatment plant into the Providence River and eventually into Narragansett Bay. During the second year they will analyze water samples and sediment cores to find how far different fractions of hydrocarbons are transported, and their ultimate fate. Results of the study will help define the pollution problem of sewage treatment plants.

Previous studies have shown higher concentrations of hydrocarbons in water and sediments in upper Narragansett Bay. This research gives scientists the first opportunity to study hydrocarbons at a source of discharge and trace their movement. In this case, the source is the Field's Point sewage treatment plant, which is capable of secondary treatment and chlorination. Located on the Providence River, the Field's Point plant is the largest in the state, discharging approximately 50 million gallons daily: about 40 percent of the sewage that enters Narragansett Bay.

Thus far, 15 samples of effluent from the treatment plant have been analyzed. Each sample contained, on the average, about 2.5 milligrams of hydrocarbons per liter of effluent, meaning that the annual output of hydrocarbons from the plant is in the range of 150 to 200 metric tons.

Only a small percentage of the hydrocarbons was associated with humic substances in the effluent. Humic substances increase solubility of hydrocarbons, and it has been theorized that they may suspend them in the water column long enough to be flushed with the tides out of Narragansett Bay. About 50 to 75 percent of the hydrocarbons contained in the effluent, however, are in the form of rather insoluble residuals, which may be deposited in sediments much more quickly.

In the second phase of the study, the scientists will trace the paths of the different fractions of petroleum hydrocarbons from the treatment plant. Analyses of petroleum suspended in water and sediment core samples will be completed.

With considerable help from the URI Coastal Resources Center (CRC) this year, Rhode Island passed the half-way mark in creation of an integrated plan to guide development in the state's coastal zone.

Established in 1971 with Sea Grant funding, the center now receives most of its support from NOAA's Office of Coastal Zone Management. However, Sea Grant still provides support for CRC staff.

The CRC assists the state Coastal Resources Management Council, which is empowered to develop and implement coastal planning, by inventorying and studying state coastal resources, and by making management recommendations. After each segment of the Rhode Island coastal environment is eval-

uated, the Coastal Council reviews the recommended management policy, submits it to public hearing, and adds it to the integrated plan. Once the policy and regulations are added to the state plan, they become law. Rhode Island is believed to be the only state taking this step-at-a-time approach, made necessary by the severe pressures of development on coastal areas.

The CRC this year completed a two-year study documenting a century of Rhode Island commercial fishing and examining possibilities for future expansion of the industry anticipated by possible extended federal jurisdiction over fisheries resources. An important spinoff of the study has been the creation of a task force, co-sponsored by the Coastal Council and Governor Philip W. Noel, to work on recommendations contained in the report, *Commercial Marine Fish and Fisheries of Rhode Island.*

The task force, created in June, is expected to examine and make recommendations on fishery management policy, encourage aquaculture in Rhode Island, study the state's needs for expanded and improved port facilities, and develop a line of communication between the Coastal Council and fishermen.

Inventorying and mapping of all Rhode Island salt marshes, including areas containing fringe marsh, were completed this year. The maps are much more accurate than those previously available. Regulations for protection of state salt marshes have been developed and adopted by the Coastal Council. Under study are techniques to rate marshes by their environmental and other values. An inventory and report on unique natural features of the Rhode Island coast have been completed. In other work, the CRC co-sponsored, with the URI Sea Grant Program, a seminar on the possibilities of using remote sensing techniques for studying and managing coastal resources.

With expertise gained during several years of coastal zone studies, the CRC is branching out into other areas unrelated to development of the state coastal management plan. In the summer of 1974, the CRC coordinated, at the request of the governor, an environmental evaluation of a south coast area proposed for the site of a 2,400-megawatt nuclear power plant installation. Their findings were reported in the publication *An Environmental Study of a Nuclear Power Plant at Charlestown, RI.* In June, 1975, the governor's office contracted with the CRC to continue evaluation of the project as it develops. The CRC has a proposal before the governor's office to coordinate a program of energy studies, to furnish the state with plans for development of new energy sources, and for energy management and utilization. Other work for the governor has included completion of a report examining the possibility of creation of a Narragansett Bay islands park system.

As a spinoff of the study of Rhode Island's fishing industry, the CRC has been able to inform the American Telephone and Telegraph Company where it should lay a transatlantic telephone cable to France to avoid fishing grounds and potential breaks of the cable, costly both to fishermen and ATT. The maps of Rhode Island commercial fishing grounds developed by the CRC are the most accurate to date. The value of this assistance is clear once past experience with a nearby ATT cable to Spain is considered. That cable, which crosses valuable fishing grounds off Rhode Island's coast, has been broken by trawlers at least three times at a cost of $2 million to $5 million each time. ATT now must patrol the cable 24 hours a day to warn trawlers away.

Several other Sea Grant studies are helping state planners measure recreational use of Rhode Island's beaches by residents and out-of-state visitors, forecast recreational demand, and measure benefits of recreational beach use.

Resource economists have been working cooperatively with the Department of Natural Resources and the Statewide Planning Program, both of which need results of the studies for long-term planning. Although the Sea Grant surveys are still in progress, much of the survey data has been analyzed and supplied to state officials. Many social science studies of these types require years to complete. These surveys, however, will be completed, and *all* information will be supplied to state departments less than a year after the data gathering stage.

In one study, 1,000 Rhode Island households are maintaining five-month diaries of their recreational activities. This study, carried out with funding from Sea Grant and the state Department of Natural Resources, is yielding exceptional information on recreational activity of Rhode Islanders and on numbers and characteristics of residents

who use state beaches. Results of this study, forecasts of population changes and distribution, changes in family size and education, and other information will help in predicting recreational demand for our beaches for the next 20 years.

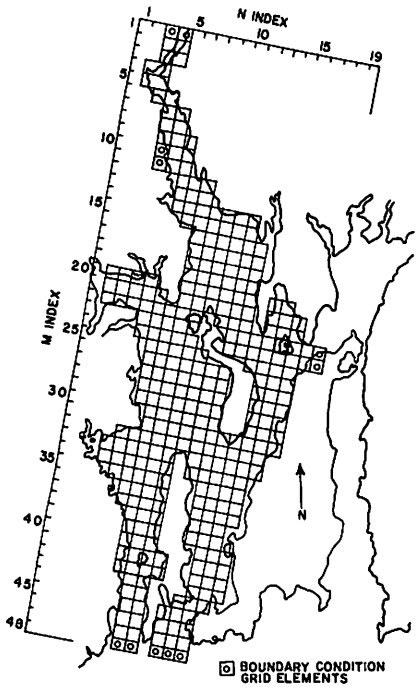
Nine hundred beach-goers were interviewed at south coast beaches to find out what they think detracts from the quality of their beach experience and to determine out-of-state use of Rhode Island beaches. Results of this study are helping state planners determine whether they must be concerned with overcrowding, inadequate public facilities, or other problems.

Campers and beach-goers have been interviewed for an evaluation of the economic importance of recreational areas. Resource economists have also used the surveys as a means of determining whether beach-goers would be willing to pay for the recreational experience.

A Sea Grant sociological study is investigating ways to quantify non-economic benefits of beach use by studying changes in tension levels of people who go to the beach. A manuscript has been completed in which an analysis is made of changes in tension levels—from work to beach activity—in various occupations. Comparison was also made among occupations. The relevance of this study to recreational beach management is in its implications for the design and equipping of beach space to serve varieties of populations and still retain a recreational function as a natural or developed area.

In January, 1975, at a conference center in Warwick, Rhode Island, more than 50 officials from engineering firms, the state departments of Health and Natural Resources, the Environmental Protection Agency, local governments, and other state and federal agencies gathered. They met to hear Sea Grant scientists and engineers explain, in general fashion, about the simulated models of Narragansett Bay they have developed. The models are mathematical, computerized, and they simulate physical and biological processes going on in the Bay, as well as some of man's interaction with the Bay.

When Sea Grant ocean engineers, resource economists, and ecologists began working on the models several years ago, they were uncertain whether models could be useful in management of Bay resources or, more specifically, in predicting man's impact on the Bay and the Bay's impact on Rhode Islanders. As explained at the January meeting, four models *had* been successfully developed to the point of usefulness to resource managers. The models included two physical ones capable of predicting tide heights, currents, temperature, salinity, dissolved oxygen, and biochemical oxygen demand in each of 320 compartments of the Bay. An economic model could be used to alert coastal planners to increases in various waterborne wastes that might occur with economic growth in any one of a number of industrial sectors as well as in the residential sector. Conversely, it could tell planners whether a reduction of certain waterborne wastes would have a severe economic impact on industry.



The ecological model, Sea Grant scientists explained, could be used to help predict effects on marine life of sewage waste loadings and of coastal-sited power generating stations.

In addition to the general interest in the models that the meeting stirred, there have been at least two spinoffs: One firm has obtained a copy of the physical model for use in a study of water circulation patterns near Quonset Point, where an effluent discharge pipe may be installed. A New England university plans to use the URI physical model to study a coastal pond near a proposed oil-refinery site.

There have been other recent uses of the models. For example, sailing on Narragansett Bay has been made easier this year, thanks to the physical model of the bay.

Using the two-dimensional circulation model, ocean engineers formulated the publication *Tides and Tidal Currents of Narragansett Bay* entirely by computer. Drawings of the bay and tide tables were also constructed and printed by computer.

The new tide charts give tide height and current at each of 600 locations throughout the bay on an hourly basis, compared to older charts that give that information for only about 80 locations. In addition, the charts are believed to offer great accuracy, because they are based on calculations done at the same time for all points. The charts are good from 1975 through 1984.

Tides and Tidal Currents of Narragansett Bay has been in high demand by Rhode Island sailors and boatmen. The first printing of 2,000 was sold out in several months. The publication was revised to make it easier to use, and a second printing was completed. The usefulness of the charts is under evaluation now that thousands of Rhode Islanders have tried them out during summer of 1975.

Sea Grant ocean engineers are continuing to improve and extend their modeling techniques and are presently working on a three-dimensional hydrodynamic and salinity model designed to permit analysis of surface and bottom currents separately.

A computerized bibliography of modeling literature concerning circulation, mass movement, and temperature changes for estuarine, coastal, and tidal rivers has been completed and published by Sea Grant. The bibliography is useful to both the professional in the field and the novice studying environmental modeling.

If population growth and industrialization around Narragansett Bay continue, what will happen to the bay's water quality? What level of waste treatment will be required to maintain or improve the quality of bay water?

A study by Sea Grant resource economists is helping answer those questions.

With different projections for population growth, industrial growth, and waste water treatment facilities, the resource economists are using a computerized "water quality model" developed by ocean engineers to predict levels of dissolved oxygen and biochemical oxygen demand in the bay for years to come. (Biochemical oxygen

demand is a measure of the oxygen-depleting substances in the bay.) With the same economic projections, another computer model is used to predict levels of a variety of waste products—including oil and grease, ammonia, nutrients, and a number of metals—discharged into the bay by industry and residential areas.

The results of this study help define the waste management problem for Narragansett Bay.

This study is helping identify future pollution problems resulting from additional wastes flowing into the bay, and it should help determine whether planned expansion of treatment facilities will keep pace with increased amounts of residential and industrial wastes or whether such expansion really may be more than is required to maintain the bay environment.

Ecologists at URI are using findings of this study to predict impacts of expected population and industrial growth on marine life.

For the past several years, Sea Grant ecologists at URI have been developing a computerized, mathematical model of the Narragansett Bay ecosystem.

The model is now capable of indicating which environmental factors would limit numbers of bay plankton, basis of the food chain. The model also can show, for example, what would happen to the bay ecosystem if a toxicant were spilled into the East Passage.

Considered in this simplified version of the bay are phytoplankton, small carnivores (comb-jellies and larval fish), benthic organisms, and the nutrients nitrogen, phosphorus, and silicon. Also simulated are temperature, sunlight, and the mixing effect of tidal currents. The water temperature in the model bay varies seasonally and by the eight areas of the bay simulation. Light patterns vary by season and day-to-day cloudiness. Temperature, light, and nutrient availability control the growth of microscopic plants or phytoplankton.

The model is not meant to simulate all the rich diversity of the bay. For example, it does not yet include large fish such as striped bass or flounder. The model has been structured to study the dynamics of the plankton system which is the base of productivity in Narragansett Bay.

This year the model has been verified with field data taken at 13 sampling stations. Although the model does not show exact agreement, it does reflect the general observed patterns of greater abundance of plankton in the upper bay. Seasonal patterns also emerge: A spring bloom of phytoplankton is followed by a summer period of rapid oscillations. However, field measurements and the model do not agree in fall. The model predicts plankton blooms, but actual measurements in the field show that there is a marked suppression of phytoplankton in fall during some years. This disagreement illustrates a strength of the modeling technique. It is the modeling which has pointed out to the ecologists a gap in their understanding of the bay's ecosystem—a gap which they are now trying to fill.

Sea Grant ecologists are using the model to complete a nutrient budget for Narragansett Bay, a potentially valuable tool for management. We must know what levels of nutrients—such as ammonia, nitrates, and phosphorus—discharged into the bay from residential areas and industry the bay can assimilate without damage to important marine life. This ecosystems model furnishes the information on the pelagic phase of the nutrient cycle. To complete their understanding of the cycle, ecologists will combine with this other data on the bottom phase of the nutrient cycle and information on levels of nutrients entering Narragansett Bay. The nutrient budget will forecast the level of nutrients the bay can withstand before it is damaged or its dissolved oxygen is dangerously depleted.

Applying lessons learned from the ecological systems work in the bay, the Sea Grant ecologists are midway through a systems analysis of the coastal towns of Narragansett and South Kingstown, Rhode Island. The study is being carried out in cooperation with the South Kingstown town planner and with a number of state agencies involved in planning and management.

So far, historical and current information has been gathered on land use patterns, energy use, waste production and disposal, water consumption, water table levels, natural ecology, population changes, agricultural use of land area, roads, fishing industry, and a number of other variables which must be considered. The information will be organized into a mathematical model of the Narragansett-South Kingstown area to test the application of ecological systems analysis to coastal areas.

FISHERIES

New fishing nets, ways to utilize reject species and waste products of currently processed seafoods, and new techniques to ensure that fish stocks are harvested fully but not depleted were among the accomplishments of 13 fisheries-related Sea Grant research projects this year. In addition, the Marine Advisory Service (MAS) continued assisting fishermen in adopting mid-water pair trawling for herring, and 12 additional vessels began using the method this year. Accomplishments of the MAS are explained in the section on advisory services and education.

Pioneering net design studies by Sea Grant researchers in the Department of Fisheries and Marine Technology have provided urgently needed improvements in American net technology and have boosted catches of fishermen using the nets developed at URI.

Success of the URI 340, a high-opening bottom trawl developed two years ago, has led to a modified version of the net for use as a squid trawl. A high-opening bottom trawl is required to catch squid because they swim up to 16 feet off the sea floor, much too high to be taken by trawls commonly used by New England fishermen. Two squid trawls have been designed and constructed based on towing tank evaluations carried out at the University of Florida. One has been tested and found to achieve a headline height of 14 to 15 feet. The other trawl has a much larger mesh size that should enable the net to attain greater headline height. The squid trawls, which also fish the sea bottom well, were to be evaluated by a New Bedford trawler.

A dozen of the many fishermen who have obtained plans for the URI 340 net from the Sea Grant Program and constructed their own were questioned to see whether the net had boosted their catches. Nine of them praised the net, saying it catches 25 percent more fish than the nets they previously used. Helping to spread the word about the URI 340, the Sea Grant Program published a leaflet, *Bottom Trawl Manual, URI High Rise Series,* which provides fishermen with the basic plan of the net as well as information on adapting its rigging to different vessels.

Rhode Island fishermen soon will be able to have their net designs evaluated with a new towing tank at the URI Narragansett Bay Campus. Although researchers in the Department of Fisheries and Marine Technology will use the testing tank primarily for evaluating the performance of trawl doors, they will also evaluate net designs of local commercial fishermen. Two local fishermen have given designs of their nets to the Sea Grant team which will evaluate scaled-down versions. Information provided by tests in the 100-foot-long towing tank may also prove useful to fishing gear designers, manufacturers and vessel designers who want to make the most efficient match of vessel and trawl.

In another Sea Grant project, oceanographers tested underwater light-attraction techniques for squid fishing in Rhode Island waters. The project was designed to evaluate the effectiveness of various light sources, intensities, and durations for squid attraction. The experiment was successful in attracting squid, but not in commercially useful quantities.

Much of the contents of the nets swung onboard by American trawlers is wasted. Up to two-thirds of a catch may be thrown back to the sea simply because no markets exist for the species, or because market prices are so low that it is not worth the efforts of fishermen to haul these species to port. Once the catch is brought to port and processed, substantial quantities of highly-nutritional viscera, shell, and unextracted meat end up as waste.

Three Sea Grant projects have attempted to find ways to use those rejected species—such as ocean pout, hake, dogfish and crab—and to recover and utilize the "waste" from the processing of seafood.

For example, researchers in the Department of Food and Resource Economics found that those feisty rock and Jonah crabs that lobster fishermen find in their pots and usually throw back could be bringing them a significant amount of supplemental income.

A full-time inshore lobster fisherman who lifts 100 pots per fishing trip and makes 100 trips a year could bring in crabs worth $800 to $4,000. Larger offshore lobster fishing vessels, which average 40 trips during the season and lift about 400 pots each trip, could catch enough crabs to mean $4,000 to $16,000 over and above their present income from lobster.

Results of the study, based on a mail survey of 43 holders of com-

mercial lobster fishing licenses in Rhode Island and interviews with fishermen, were reported in the publication titled *Harvesting Rock and Jonah Crabs in Rhode Island: Some Technical and Economic Aspects.*

The analysis showed that fishermen could not make as much money fishing for crabs alone as they could for lobster, but that the one to five crabs frequently found in each lobster pot could provide a good supplemental income. The economists wrote in their report that "it is surprising to hear several dealers state that they cannot obtain a sufficient supply of Cancer (Jonah and rock) crabs, while fishermen state that they cannot find a market." Since the marketing system for crabs is not well developed in southern New England, the economists advised lobstermen to set up marketing agreements with specific dealers.

Another underutilized species, the deep-water red crab, also may support a small seafood industry if economic problems are solved. The red crab is a bottom dweller that prefers the cold waters off the continental shelf from Maine to Cape Hatteras at depths of down to about 2,500 feet.

A URI resource economist and a shellfish consultant from the state of Washington studied red crab for its economic potential. The results of their study look promising. Fisheries experts say five million pounds of red crab could be harvested yearly without damaging the stock—and the technology exists for harvesting and processing. The red crab fishery could support an estimated seven to eight vessels supplying three processing plants. The total output would be about 1.2 million pounds of meat per year.

A small red crab industry has been established, but it is contending with economic problems. Large inventories of king crab—a major competitor of the deep-sea red crab—and declining consumer buying power make the red crab market future unclear. Nevertheless, people are taking risks to break into the business. Groundbreaking for the first full-scale commercial red crab processing plant took place in New Bedford, Massachusetts, in fall of 1974. Fishermen supplied red crab in 1974 to a temporary pilot plant at Point Judith, Rhode Island, at prices they considered favorable.

The report on the Sea Grant red crab study, *Technological and Economic Aspects of Red Crab Harvesting and Processing,* examines not only the economic aspects of red crab harvesting and processing but also provides detailed specifications on the construction of crab pots, the equipment and layout necessary for a processing plant, and the types of vessels suitable for the industry.

These are some of the findings by Department of Food and Nutritional Science researchers who completed studies of utilization of crab waste and minced fish products:

Rejected fish species can be used in minced fish products. Crab and shrimp waste could be extracted with deboning machines currently in use, dried, and used as flavorings or food fortifiers.

They found that viscera and meat still on crab shells after picking could be extracted and incorporated into seafood products as flavoring or fortifier. After extraction, the highly nutritious crab "waste" may be dried and added to such products as soups and potato chip dips. With this technique, an additional 20 percent of nutritional material could be utilized. Small crabs now rejected also could be used with this technique, and it could be adapted for utilization of shrimp waste.

Minced fish products with desirable taste and texture were developed using various proportions of the frequently discarded species such as hake, pout, and dogfish. In another study, a commercial minced fish product was tested to see whether there was a problem with loss of water soluble nutrients as a result of the numerous washings used in minced fish processing. Indeed, great losses of nutrients were found. The scientists tested a Japanese minced fish product, made from Alaskan pollack and marketed in the U.S., and found it contained 30 percent less protein, 46 percent less riboflavin and 66 percent less niacin than the fresh product. The results of this work were presented in the fall of 1974 before the Annual Atlantic Technology Conference at Quebec, Canada.

A new waste is being produced by plants which process the red crab. The plants have a problem of disposing of waste that includes shells, viscera, and unextracted meat. At the same time, several salmon growing concerns have consulted URI about the problem with the color of their product. Fish raised on commercial fish meal lack the characteristic color and flavor of natural fish, partly because the meal contains no carotenoid pigments, substances which cause the pink coloration of fish flesh.

Scientists, working under partial support of Sea Grant, have demonstrated that the crab plant's trash can be a salmon farm's treasure. The ground-up waste, or an extract from the waste, can supply the missing pigmentation when fed as a diet supplement.

URI scientists in the Department of Food and Resource Chemistry have been studying the chemical basis of fish coloration and ways to make these color sources available in fish diets for more than eight years.

Carotenoid pigments are not the only ones found in fish, but they are the most important commercially and nutritionally, since they also are the ultimate sources of vitamin A. One of the pigments, which fish must be supplied in their food, accounts for the red color in salmon, trout, and crustaceans, the gold in goldfish and the blue of other crustaceans.

For their studies, the URI team used tanks of salmon and rainbow trout. They have found that a pigment extract from crab waste mixed with the meal brought the pink back to the pale trout. Their rainbows reappeared and their meat became almost as red as a salmon's after a little over a month on the diet. The scientists have fed crab waste to salmon with equally successful results. This should be good news for salmon hatcheries, since in some areas pale salmon meat fetches 25 cents less a pound.

Since the initial research has been completed, Sea Grant scientists have been bringing together salmon farmers who have the pigmentation problem and firms which process shrimp and crab wastes. A Texas firm processes shrimp waste to obtain a chitinous material and a high protein meat-waste which contains the carotenoid pigments. However, no reliable market exists for its products. Two other firms, which market pan-sized salmon from their culturing operations in the Pacific Northwest, need a steady supply of fish feed which would provide the pigments salmon need for the characteristically pink flesh. Sea Grant scientists have brought to the attention of these firms the common interest they have and also are evaluating the shrimp waste product to see whether it can solve the salmon farmers' problem. Arrangements have also been made to evaluate orange peel wastes for possible use as fish food supplement. In New England, a red crab processing plant at New Bedford is being advised on the capital improvements which would enable it to utilize crab wastes.

Wise management of fish stocks is of vital concern to the fishing industry and to consumers who depend on a steady supply of high quality seafood products. Techniques of fish stock management may soon undergo radical changes, hopefully for the better, if predictions of a United States 200-mile resource limit prove true.

In any case, Sea Grant research completed this year should help in the improvement of fisheries management. As an example, mathematical techniques have been developed that show promise in helping maintain fishing effort at optimum levels without overfishing the resource.

The URI technique allows year-by-year predictions of changes in populations of commercially important marine species and enables calculations of the level of fishing effort which will insure the largest catch without depleting or otherwise damaging the resource.

Fisheries decisions frequently are based on the assumption that populations of valuable marine species remain static year after year. The problem with this assumption is that changing fishing effort, landings and environmental influences alter the population size from year to year and change the number of adult fish or shellfish available for harvest. The URI model is a dynamic one that takes into consideration the major factors influencing population, and takes into account the time delay between spawning and recruitment.

The new mathematical techniques have been tested on two fisheries—Rhode Island inshore

lobster and Pacific yellowfin tuna—with excellent results. Rhode Island lobster landings statistics for 1930 to 1967 were used to test the technique. The researchers found that the method is capable of making good predictions of lobster landings based on past lobster fishing effort and landings. They are now finishing the study, using "optimization techniques" to determine the maximum number of lobster pots that could be used in Rhode Island waters without overfishing the resource. With the URI mathematical technique, the annual population of marketable-size lobsters can be predicted, and the level of fishing effort—the number of pots—can be adjusted to maintain fishing effort at a maximum without overfishing lobster. The technique could be applied to management of many other fisheries.

Marine biologists at the Graduate School of Oceanography have continued monitoring the environmental effects of dredge spoil dumped in Rhode Island Sound at a site about five miles south of Newport, Rhode Island. With samples of marine organisms taken over a number of years, they are determining rates of recolonization.

In the summer of 1974, an additional 50 samples were obtained from the spoil and from adjacent natural sea floor. One objective of the collections is to follow the life histories of important species. Among the variables for the study are the length-frequency and brood size of amphipod crustaceans, and numbers of growth rings of the commercially important ocean quahog.

Benthic animals in 99 samples have been identified and counted for statistical tests. The number of potential recolonizers has been reduced in shallower parts of the spoil. The deeper silty spoil has been recolonized, the biologists found, but densities remained low four and one-half years after the dumping was completed.

A Sea Grant sociologist and an anthropologist have completed studies of the occupational subculture and mobility of fishermen of several New England ports. Their studies come at a highly appropriate time because the drastic overfishing by foreign fleets threatens to continue depletion of fish stocks and aggravate problems plaguing New England's fishing industry.

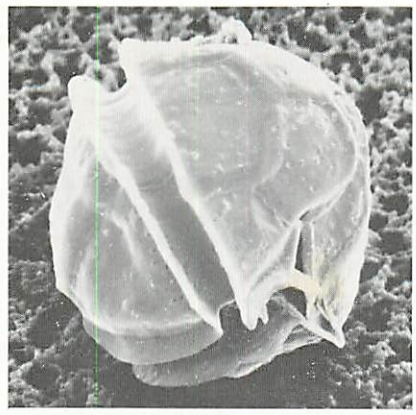
Their studies indicate two lines of approach to help the fishing industry. One is to prevent the further depletion of fish stocks both by means of a 200-mile fisheries zone and by controlling the catch of those who have access to that zone. The second is to foster programs in behalf of fishermen displaced from the industry because of further decline of stocks or because of imposed limited access.

Some steps to assist fishermen might be improved pensions and a maritime placement program. For example, if the pension share of the New Bedford fishermen's lag, or distribution of profits, were to

be raised from its present one percent, a policy of early retirement could assist those fishermen whose mobility potential is most restricted because of advancing age. An employment placement program with shipping companies and maritime unions could facilitate placement of fishermen who seek alternatives.

A draft of safety standards for fishing vessels has been prepared in another study. Current general regulations of the Occupational Safety and Health Administration cover the fishing industry, but there have been no regulations prepared specifically for the industry. The draft standards, prepared by a researcher in the Department of Industrial Engineering, could help the industry in adopting voluntary standards which would give it an advantage in case specific standards are eventually prepared by OSHA. Rather than have new standards imposed by OSHA, it would be to the industry's advantage to have ready for OSHA's consideration standards which would be fair and reasonable.

The draft standards have been prepared using the current OSHA regulations, Coast Guard regulations, and a set of preliminary standards of the Inter-Governmental Maritime Consultative Organization. The draft report was to be submitted to the Safety Committee of the New England Fisheries Steering Committee for its consideration and use.



The dinoflagellate which causes red tide. Enlargement 2050X.

In September 1972, New Englanders were suddenly alarmed by newspaper, radio, and television reports of the "red tide," and many frightened people abstained from eating any seafood, even though commercial seafood was continuously monitored and safe to eat. Markets for New England's famous seafood all but disappeared for a short time.

The red tide consists of unicellular algae called dinoflagellates. When environmental conditions are right, these organisms multiply to astronomical numbers and give a reddish appearance to coastal waters.

Since 1972, Sea Grant researchers in the Department of Pharmacognosy have been carrying out research to purify and identify the red tide poison and find antidotes. This year, they made major breakthroughs.

The red tide poison of New England has been assumed to be the same as the poison, called saxitoxin, found in West Coast red tide. URI researchers have purified the New England red tide poison and found that it really consists of at least four poisons, including saxitoxin. Sophisticated analytical techniques have been developed to purify the toxin from red tide infested clams and from the red tide organisms cultured at URI.

The Sea Grant scientists have found the persistence of each of the four toxins. Sanitary measures for New England seafood products, based on knowledge of the West Coast saxitoxin, can now be based on knowledge of New England's variety of red tide. The researchers are continuing to characterize the poisons and are beginning tests of a number of potential antidotes.

AQUACULTURE

The world's oceans, scientists say, do not contain the limitless reservoirs of food that, only a few years ago, they were believed to contain. Up to 90 percent of the sea is relatively unproductive. In the other 10 percent, which includes the richly productive estuaries and continental shelf areas, the fish harvests in many areas are at a maximum, or stocks have been severely depleted by years of overfishing.

Aquaculture could supplement the harvest from the sea. Sea Grant scientists at URI are looking for economically feasible ways of culturing finfish and the American lobster. Much of the required technology has been perfected, and, in the case of finfish aquaculture, it now looks economically possible to use the non-polluting system developed at URI.

This year, an economic feasibility study of the finfish culture system developed at URI indicated that the possibilities are encouraging, although rapidly rising capital cost is a factor which must be taken into consideration. The temperamental lobster would appear to present more of a challenge to scientists who are developing the technology to culture it. Nevertheless, aquaculturists at URI have a much more complete understanding, after this year's studies, of the lobster's life cycle and its behavior —information that will be necessary when commercial operations begin. The URI scientists are also pursuing their search for ways to reduce mortality among lobster raised in the communal situations that will most likely be required for a commercial undertaking.

The URI aquaculture system for raising salmon and other species, as reported last year, has now been perfected and has raised thousands of Chinook salmon to market size. The scientist estimates that a commercial version of his pilot plant could raise salmon for close to half the $1.70 that salmon frequently costs at the market. Technical aspects of the URI fish farm were reported this year in the publication entitled *The Technology of Closed System Culture of Salmonids.*

The URI system, a maze of tanks, pipes, filters, and pumps, is closed and recirculates water through highly effective biological filters. This prevents the discharge of waste water with high levels of nutrients, and eliminates the need for the culture operation to be located near reliable sources of fresh or salt water. The URI fish farm, in fact, is located at the URI Kingston Campus, about five miles from the Atlantic and six miles from Narragansett Bay.

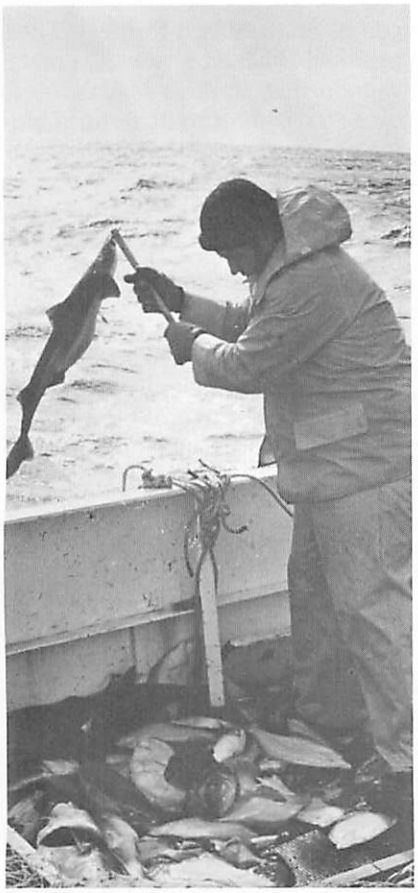
A large version of the URI fish farm, initially costing about $175,000, could produce Chinook salmon smolts for about $1 a pound. This is considerably less than the cost at state and federal hatcheries, an economist found in another Sea Grant study. The price of materials needed to build such a plant, however, is rapidly increasing.

This year, URI aquaculturists have begun experiments in an attempt to reduce the cost of farm-raised salmon for the table and solve a problem that has plagued commercial salmon farmers. The problem is called a "jack," a male salmon that matures sexually and dies—according to its natural biological rhythms—after little more than a year and frequently before it is ready for market. Farmers must market Chinook and Coho salmon at pan size (about one pound) to keep mortality losses of precocious males to a minimum.

The answer may be sterile hybrids that would eliminate the jack. Plans are afoot to cross the Chinook and Atlantic salmon, or the Atlantic salmon and the Arctic char; either combination would produce sterile offspring, which grow quickly.

Lobster aquaculture research at URI is providing understanding and information of the culture technology and of the behavior of the temperamental lobster. It is hoped that some day entrepreneurs will be able to use this understanding in designing and operating successful commercial operations.

Sea Grant aquaculturists at the Graduate School of Oceanography have 30 months of data on egg hatching, culture of larvae and juveniles, molt frequency, weight gain per molt, and survival rates. They have found optimum hatching conditions and optimum water quality conditions for raising lobster. Ammonia excretion rates of lobster at various stages of growth have been determined, as has the ability of lobster to tolerate ammonia, important considerations in any culture operation. Lobsters have been maintained both in flow-through and flow-through heated systems. In the most recent experiments, the fastest growing lobsters are being selected and cultured.



Because of lower capital requirements, communal growing conditions probably will be necessary to make lobster aquaculture commercially feasible. The URI researchers, located at the URI Narragansett Bay Campus, are looking for ways to improve survival rates of lobster under communal conditions. In other experiments, they have found effects of eye stalk removal on weight gain and molting. Eye stalk removal caused high mortalities in early juveniles maintained in the recirculating sea water system. However, it had the beneficial effect of cutting intermolt time by about half in some juvenile stages, synchronizing molting and enhancing growth. Recent experiments have been conducted to see whether eye stalk removal affects the lobster's ability to acclimate to temperature change.

In studies of behavior, the Sea Grant aquaculturists have found that both the type of culture system and the culturing conditions affected the behavior of lobster. Lobsters reared under communal conditions, for example, maintained lower levels of activity than those reared within individual compartments. That may be an indication that the feed conversion ratio of lobsters raised in compartments may be lower than the ratio for lobsters raised communally. Lobster raised without shelters have been found to remain more active than those raised with shelters. Even the culture system affects behavior; lobster raised in recirculating systems were found to be more aggressive than those raised in flow-through systems.

Other behavioral research of lobster has been carried out by scientists in the Department of Zoology. They have found, for example, that many lobsters raised under communal conditions can delay molting. Searching for a reason, they observed lobsters raised under four conditions: (1) isolated, (2) visual communication with other lobsters, (3) chemical communication, but no visual communication, and (4) both chemical and visual communication. None of these growing conditions appeared to cause molt delay, which has led the researchers to believe that it must be a combination of these factors and tactile communication that cause molt delay. These experiments have also led them to think that chemical manipulation of lobster environment probably will not be the way to synchronize molting conditions and reduce cannibalism.

In related work, they have found that lobsters seldom molt at night and that it is always the dominant animal that molts first. Experiments were under way in the spring of 1975 to see whether agonistic behavior may be hormonally controlled, and to see whether behavior is altered by high levels of metabolic wastes in the water of the culturing system.

A study of the diseases of striped bass, *Morone saxatilis*, a fish of economic and sport value and a po-

tential candidate for aquaculture, was begun this year by the Marine Pathology Laboratory. The goals are to find what disease problems might occur if striped bass are tried in aquaculture, how to diagnose disease in this species, and what are the incidence and impact of diseases. This new project is being carried out in cooperation with the URI Marine Field Station at Jerusalem, which is currently raising young bass. Thus far, the laboratory's animal pathologist has completed autopsies on more than 50 bass collected from New England and mid-Atlantic coastal waters, collected serum, and recorded diseases. The laboratory has what is believed to be the largest collection of diseased tissue from striped bass.

The Marine Pathology Laboratory continues assisting commercial firms and state and federal agencies in the diagnosis of disease and mass mortalities of fish. Fresh and saltwater Coho, Chinook and Atlantic salmon, raised in university aquaculture projects, are routinely monitored for disease.

A study of gas bubble disease, a serious problem near power plants, has been completed by the pathologist and another scientist. They found that embolism—and not heated effluent water—is the cause of fish kills near power plants. Diseases of gray seals is the subject of other research by the laboratory, which, for this project, worked with the Mystic Marine Aquarium. These marine mammals were found to have a high incidence of heart worms, which frequently cause death due to pulmonary embolism. In other studies, Papilloma, a skin tumor, has been identified in shark, and kidney tumors have been found in the striped bass.

ADVISORY SERVICES AND EDUCATION

Conducting a national conference for marine educators, assisting fishermen in trying new nets and gear, helping a Rhode Island seafood processing plant—these are a few of the advisory services provided by the URI Sea Grant Program.

Begun in 1970, the Marine Advisory Service focuses on Rhode Island marine problems and opportunities to develop new resources. Marine advisory specialists in areas of commercial fishing, seafood technology, marine recreation and marine education work directly with interested groups, introducing new techniques and practices, identifying research needs, and helping expand opportunities for wise management and development of our marine resources.

Thanks to efforts of the MAS commercial fisheries specialist, New England fishermen are adding to their trade some new tricks learned from European coastal fishermen. New fishing techniques, European style nets, and a power-assisted block, introduced by the fishing specialist, have boosted catches and improved fishing efficiency.

Pelagic pair trawling was introduced three years ago by the commercial fisheries specialist to Point Judith, Rhode Island, fishermen. Efforts continued this year to demonstrate the method at other ports. The result: 12 additional vessels from ports of New Bedford and Gloucester, Massachusetts, and Cape May, New Jersey, have adopted pair trawling for seasonal herring fishing. The fishing specialist assisted in installing and evaluating a power-assisted block on a Point Judith trawler. The power block, which costs about $7,000, makes possible faster net handling and a 25 percent increase in fishing time.

Because European fishing techniques have proved so useful to New England fishermen, the MAS organized a 25-day fall tour of some of Europe's largest ports for eight New England skippers from Maine, Massachusetts, and Rhode Island. The purpose of the trip was to give the New England skippers a chance to go on board European coastal trawlers to observe the equipment and methods used. The trip was paid for almost entirely by European manufacturers of nets, gear, and electronic equipment.

The skippers reported their findings at the Fishermen's Forum, organized by the commercial fisheries specialist and held last winter at Galilee, Rhode Island. The forum, an annual event, was attended by about 150 fishermen, federal and state officials, researchers, and others involved in the industry. Among other forum topics were possible impacts on the fishing industry of oil development on New England's continental shelf and the New England fisheries development program. A Scottish fishing expert, brought over to participate in the forum and consult with local fishermen, built a European-style bottom trawl which has been tested by local fishermen who have since built a number of nets along the same design. The forum was sponsored by the MAS and Point Judith Fishermen's Cooperative.

The MAS seafood specialist is assisting Blount Seafood Corporation at Warren, Rhode Island, in its efforts to construct and operate the first commercial Rhode Island salmon aquaculture operation. Blount, which prepares a chopped clam product from the ocean quahaug and the surf clam for Campbell's soups, has had a waste disposal problem for some time. An aquaculture operation may be the solution. The nutritious waste from clams, which is now discarded, will become salmon feed if the project is successful. The utilization of the waste should prove economical because feed constitutes a high percentage of the cost of raising fish.

So far, Blount has set up a flow-through system with two 1,500-gallon tanks, based in part on the salmon aquaculture technology developed by Sea Grant at URI. Permission has been obtained from the Environmental Protection Agency to discharge water which has flowed through the system back into Narragansett Bay. In addition, Sea Grant is providing 2,000 Coho salmon for initial stocking.

The seafood specialist was successful this year in organizing a meeting of Rhode Island seafood processors—the first such meeting in 15 years—to discuss whether cooperative approaches to problems could assist the industry.

Yankee Seafood, Inc., a new Galilee, Rhode Island, firm which processes the underutilized ocean quahaug, was assisted by the seafood specialist in product formulation, new product development, and quality control. Yankee produces stuffed clams, Manhattan-style chowder, and clams casino for retail and wholesale markets. Private industry also has been assisted in plans for a depuration plant which would permit the harvest of quahaugs from about 9,500 acres of marginally polluted area in Narragansett Bay. The seafood specialist is also assisting on projects to develop a quick, easy way of measuring seafood freshness and to evaluate possibilities for utilization of ocean pout, currently sold as industrial fish or discarded by fishermen.

The MAS marine recreation specialist worked intensively with the boating industry this past year, conducting a major regional conference, holding workshops for shipyard personnel, and demonstrating floating breakwaters to New England marina owners.

The theme of the fourth annual Marine Recreation Conference, held in December 1974, was the national economy and its effect on the boating industry. More than 80 boating businessmen, educators, and others attended the conference to hear predictions of economists and to participate in small-group sessions. A report on the conference, *The Economy and the Business of Marine Recreation*, was prepared by the MAS and published.

Three winter workshops on marine diesel engine repair and trouble shooting, wire and rope splicing, and electrolysis were attended by 50 marina and shipyard personnel from Rhode Island, Connecticut, and Massachusetts.

Demonstrations of the floating scrap tire breakwater, developed at URI, were conducted by the MAS at the Narragansett Bay Campus. MAS specialists also used a wave tank and scale model breakwater to demonstrate the floating breakwater concept at the Winter Boat Show held at the Providence Civic Center.

The marine recreation specialist is coordinating efforts to put together a bicentennial cruising guide for Rhode Island waters. The guide, which will be ready for early 1976 publication, will be useful to Rhode Islanders and may help generate extra tourist dollars. The guide is to include nautical charts, historical maps, aerial photographs, shore-street maps, walking tours, and marina and dock services.

The MAS continued working through the general news media and the marine-oriented media. Seventy-five news articles covering topics such as aquaculture, oceanographic research, the fishing industry, and coastal zone management and development were prepared and distributed. Articles were prepared for the *Marine Technology Society Journal* and *National Fisherman*, and published. A morning radio program, "Southern New England Marine Report," was completed in cooperation with the Providence-based AM station, WPRO. "Southern New England Marine Report" was a five-minute public service program aired six times a week for 13 weeks to a daily audience estimated at 32,000. The programs covered work of the

URI Sea Grant Program as well as general topics such as ocean pollution problems, seafood cookery, and marine life.

The MAS marine education specialist held two conferences this year, promoted environmental education at state and national levels, and worked with teachers interested in developing environmental curricula. One hundred and fifty marine educators representing 23 states, France, and Mexico met for the four-day National Marine Education Conference at the URI Kingston Campus. One spinoff of the conference was the formation of a national association of marine educators to foster improved communications among educators and cooperative efforts in developing and improving environmental education.

In the spring of 1975, 80 southern New England guidance counselors, elementary, and secondary school teachers attended a conference on employment opportunities and training programs in marine career fields at Newport, Rhode Island. The conference, which was sponsored by the MAS, the New England Aquarium, and the U.S. Office of Education, acquainted them with marine vocational training and employment opportunities in recreation fisheries, aquaculture, technology, science, and maritime operations. The marine education specialist also consulted for the Olympus Research Corporation on a marine occupation cluster project, a survey of methods and materials used to teach school children about some of the career options open to them. The study was conducted for the U.S. Office of Education.

The MAS resource economist's work with fishermen this year included the following items:

(1) In responding to a request by Point Judith, Rhode Island, fishermen, the resource economist and the seafood specialist of the MAS completed a study which showed that freshwater ice is more economical for fishermen to use than salt-water ice.

(2) The resource economist worked with a number of fishermen, helping answer their questions concerning taxes and vessel financing. Local banks were assisted with questions concerning taxes and the Capital Construction Fund, which is a means of paying for a vessel with tax-exempt income. An advisory publication titled *Payroll Taxes and Tax Withholdings for Rhode Island Fishermen* was completed in time for Rhode Island fishermen to use in 1975.

(3) Northeast fishermen frequently find themselves in trouble when they fish in waters outside of their home state and violate fisheries regulations (such as size limits), which vary from state to state. The problem frequently occurs because of the difficulty of finding out each state's regulations. A publication was completed which explains the state laws affecting non-resident fishermen from New Jersey to Maine.

A second advisory service organization, the New England Marine Resources Information Program (NEMRIP), continued this year in

its role of information clearinghouse, distributing reports and periodicals, and answering thousands of information requests. More than 4,000 individual inquiries for information were received this year. Many of those inquiries were from fishermen (one-fourth of all the requests), from marine business (one-third), and from teachers and students (one-third).

Newsletters distributed by NEMRIP include the *New England Marine Resources Information,* with a monthly circulation of 16,000; the monthly *MAS Newsletter,* with a circulation of 900; and the bimonthly *URI Commercial Fisheries Newsletter,* with a circulation of 1,200.

This past year, 50,000 publications, excluding periodicals, were distributed to individuals upon request. One Sea Grant researcher was presented a special award by the New England Marine Trade Association for his efforts in producing the publication, *Tides and Tidal Currents of Narragansett Bay.*

A new regional advisory service was begun in New England during the year, partially due to the efforts of the director of the URI Marine Advisory Service, who initially chaired the new service's advisory board. With a grant from the National Oceanic and Atmospheric Administration, the New England Marine Advisory Service (NEMAS) was established at the New England Center at Durham, New Hampshire. NEMAS will allow the marine advisory programs within the region to rely on the services and organizational efforts of a central coordinator. The result is expected to be more sharing of existing talents among the states, less duplication of effort and more joint programs, with resulting cost savings and a regionalized approach to the common marine-related problems and opportunities. Two regional conferences have already been sponsored by NEMAS at the New England Center. The first, held in the spring of 1974, dealt with perspectives on oil refineries and offshore unloading facilities. The second, held in the fall of 1974, concerned the use of recent developments in research to foster commercial aquaculture in the region.

The Law of the Sea Institute at URI held its ninth annual Law of the Sea Conference this year and continued to use other media, such as workshops and publications, for addressing a wide range of issues dealing with management, control, and utilization of the marine environment. The purpose of the institute is to create forums open to divergent viewpoints, both national and international. In so doing, policy positions are clarified and the chances for consensus and accommodation on sea law are improved.

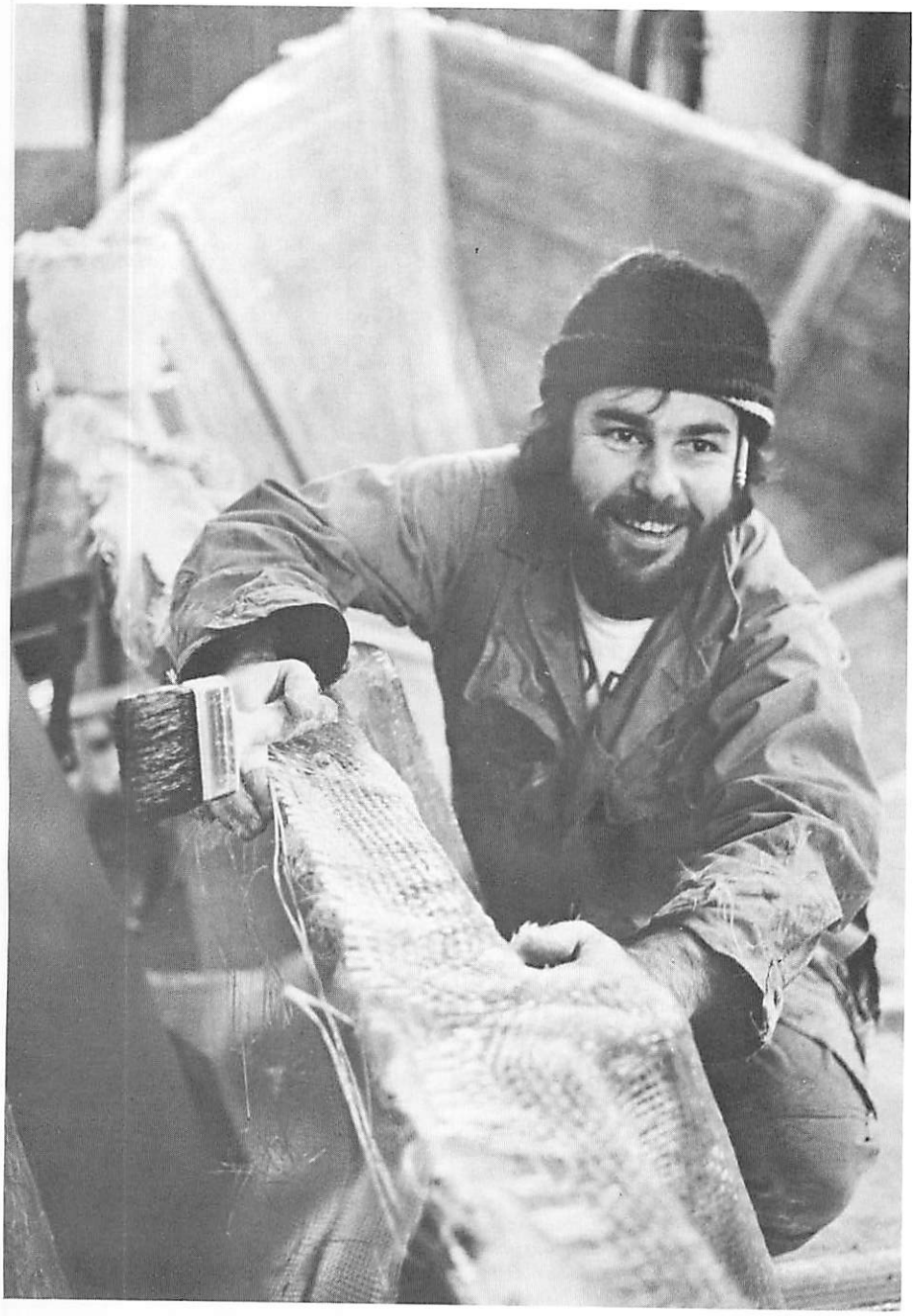
The recent sea law conference was conducted by the institute in January. More than 400 people representing federal and state governments, the military, commercial interests, and about 50 foreign countries attended. Recent conferences have focused on prospects for a new United Nations' Law of the Sea treaty. It is anticipated that at least one more conference will address that same topic. The institute continued its publications program, distributing several thousand reports around the globe. At present, 36 institute publications are available.

Four educational programs at URI, supported by Sea Grant, continued providing students with the breadth of training and experience necessary to successfully enter a very competitive job market.

A recent survey of graduates of the Master of Marine Affairs Program indicates, for example, that they believe the program to be a success. Surveyed were 102 graduates who are currently employed in state and national government organizations concerned with the marine environment, maritime industries, and universities. All graduates are working in a marine-related field, and all felt that the Marine Affairs Program had prepared them well for their respective jobs.

The one-year Master of Marine Affairs Program generally accepts only applicants who are in mid-career and who desire to broaden their knowledge of marine policy problems. The program may help a graduate to be more effective in his current job, or it may enable him to make a change of course in mid-career. This year's graduates are somewhat representative of those in past years, and included nine senior naval officers from the Naval War College, one senior U.S. Coast Guard officer, one employee of the Department of State, six students from industry (including the fishing and oil industries), six students from academia, and international students from Argentina and Uruguay.

Beginning with the fall semester of 1975, students in the program may specialize in fisheries, coastal



zone management, or international management. The potential for research by students has been enhanced with a unique collection of government and private publications pertinent to ocean management in the recently established Marine Affairs Library.

Success has marked the past year of the Commercial Fisheries Program, offered through the URI Department of Fisheries and Marine Technology at Wickford, Rhode Island. The program trains students for employment on fishing vessels and for other jobs in the marine industry. Those who complete the program receive a two-year associate degree in commercial fisheries, or they may opt to continue course work toward a four-year bachelor of science degree in natural resources.

Seven of the eight 1974 graduates entered the fishing industry, and one continued his education in the Master of Marine Affairs Program. More than 20 graduated this year, and the second-year class for the fall semester of 1975 was expected to number close to 50. Typically, about two-thirds of the enrollment is from New England.

The commercial fisheries curriculum includes navigation, twine work, meteorology, marine insurance, maritime transportation, seamanship, safety at sea, diesel engineering and hydraulics, and fish processing and marketing. However, a number of courses have been modified to acquaint students with the latest changes in equipment and operations. The marine electronics course, for example,

has been altered to reflect availability of a new autotrack Loran A receiver and the anticipated use of Loran C equipment by the industry. Because the 47-foot training trawler, *Gail Ann*, is unusable for offshore fishing during severe spring weather, the fishing operations course has been changed to allow students to combine trips on commercial trawlers of the Point Judith fishing fleet with experience gained from fishing onboard *Gail Ann*. Two senior-year, special-problems courses, recently added to the curriculum, permit students to undertake study of specific problems relating to commercial fisheries. Recent projects have included a study of trawl design changes to correct chafe in the bottom wings, a study of the composition of underutilized fish species caught by representative New England vessels, and an investigation of the feasibility of using a towed sled for underwater observation of nets.

The Department of Ocean Engineering, which offers both the master's and the doctorate degrees, graduated 19 last year, and all found employment in their chosen field. The department has moved into the new South Laboratory at the Narragansett Bay Campus. The building houses an underwater acoustic tank and extensive ocean data processing equipment. The research vessel, *Crowsnest VI*, has been modified to carry more research equipment, including new radar, and provides improved facilities for teaching and research.

The doctoral program in economics with the marine resource option graduated three students in 1974, all of whom are employed by academic institutions and involved in teaching and research in marine-related areas.

SEA GRANT PUBLICATIONS AND PAPERS JULY 1, 1974 TO JUNE 30, 1975

Marine Resources Development

Aquaculture

Ammonia Removal by Selective Ion Exchange. A Backup System for Microbiological Filters in Closed-System Aquaculture. *Aquaculture*, 4:61-68 (1974). P. W. Johnson and J. M. Sieburth, Graduate School of Oceanography, URI. 1975.

Aquaculture in New England. J. M. Gates, G. C. Matthiessen and C. A. Griscom, Coastal Resources Center, URI. 1974.

Social Conditions Increase Intermolt Period in Juvenile Lobsters, *Homarus americanus*. *J. Fish. Res. Board Can.*, 32:1941-1943 (1974). J. S. Cobb and G. R. Tamm, Zoology, URI. 1975.

Living Resources, other than Aquaculture

Azoreductase Activity in the Hard Clam, *Mercenaria mercenaria*. *J. Exp. Mar. Biol. Ecol.*, 14:225-229 (1974). M. E. Hanzel and G. P. Carlson, Pharmacology and Toxicology, URI. 1975.

A Bibliography of the Biology of the Striped Bass, *Morone saxatilis*. B. A. Rogers and D. T. Westin, Graduate School of Oceanography, URI. 1975.

The Biosynthesis of Astaxanthin XVIII. The Incorporation and Transformation of Carotenoids in the Goldfish. *Int. Journal Biochemistry*, 5:157-166 (1974). D. B. Rodriguez, K. L. Simpson and C. O. Chichester, Food and Resource Chemistry, URI. 1974.

Biosynthesis of Carotenoids in Brevibacterium s.p. KY-4313[1]. *Journal of Bacteriology*, 118:385-393 (1974). L. K. Hsieh, T. Lee, C. O. Chichester and K. L. Simpson, Food and Resource Chemistry, URI. 1974.

Commercial Marine Fish and Fisheries of Rhode Island 1880-1973. S. B. Olsen and D. K. Stevenson, Coastal Resources Center, URI. 1975.

The Demersal Fish of Narragansett Bay: An Analysis of Community Structure, Distribution and Abundance. *Estuarine and Coastal Marine Science*, 1:361-378 (1973). C. A. Oviatt and S. W. Nixon, Graduate School of Oceanography, URI. 1974.

Nocardiosis in Chinook Salmon. *Journal of Wild Diseases*, 10:149-154 (1974). R. E. Wolke and T. L. Meade, Animal Pathology, URI. 1974.

Ocean Pout Parasites. *Marine Fisheries Review*, 36:29-33 (1974). D. J. Sheehy, M. P. Sissenwine and S. B. Saila, Graduate School of Oceanography, URI. 1974.

Seasonal Distribution of Bottom Fishes in the Narragansett Bay Area: Seven-Year Variation in the Abundance of Winter Flounder. *Journal Fish. Res. Board Can.*, 31:1057-1066. H. P. Jeffries and W. C. Johnson, Graduate School of Oceanography, URI. 1974.

Variability in Recruitment and Equilibrium Catch of the Southern New England Yellowtail Flounder Fishery. *J. Cons. Int. Explor. Mer.*, 36(1):15-26 (1974). M. P. Sissenwine, Graduate School of Oceanography, URI. 1975.

Marine Biomedicinals and Extracts

Pharmacological Evaluation of an Extract from *Eisenia bicyclis*. *Marine Technology Food-Drugs from the Sea Proceedings*, 97-103 (1972). D. M. Whitaker and G. P. Carlson, Pharmacology and Toxicology, URI. 1974.

Two Biologically Active Polymers from *Eisenia bicyclis* (Kjellman) Setchell. *Botanica Marina*, 17:191-194 (1974). S. F. Zelenski and L. R. Worthen, Pharmacognosy, URI. 1975.

Socio-Economic and Legal Studies

Marine Economics

An Analysis of the Rhode Island Marina Industry. R. Kelley and N. Rorholm, Resource Economics, URI. 1974.

Economic Impact: 1973 Newport International Sailboat Show. A. J. Della Bitta and D. L. Loudon, Marketing Management, URI. 1974.

Offshore Petroleum and New England. T. A. Grigalunas, Resource Economics, URI. 1975.

User Manual for Recon 4: A Bio-Economic Simulator of a Fishery. J. M. Gates, Resource Economics, URI. 1974.

Socio-Political Studies

Fishermen of Galilee. J. J. Poggie, Jr. and C. Gersuny, Sociology and Anthropology, URI. 1974.

A Fishermen's Cooperative: Open System Theory Applied. C. Gersuny and J. J. Poggie, Jr., Sociology and Anthropology, URI. 1974.

Luddites and Fishermen: A Note on Response to Technological Change. C. Gersuny and J. J. Poggie, Jr., Sociology and Anthropology, URI. 1975.

Marine Technology Research and Development

Resources Recovery and Utilization

Calculation of Fishing Net Drag. T. Kowalski and J. Giannotti, Ocean Engineering, URI. 1974.

Calculation of Trawling Gear Drag. T. Kowalski and J. Giannotti, Ocean Engineering, URI. 1974.

Calculation of Trawling Gear-Trawler Interaction. T. Kowalski and J. Giannotti, Ocean Engineering, URI. 1974.

Harvesting Rock and Jonah Crabs in Rhode Island: Some Technical and Economic Aspects. A. Marchant and A. Holmsen, Resource Economics, URI. 1975.

Technological and Economic Aspects of Red Crab Harvesting and Processing. A. A. Holmsen and H. McAllister, Resource Economics, URI. 1974. First and second printing.

URI High Rise Series Bottom Trawl Manual. A. J. Hillier, Fisheries and Marine Technology, URI. 1974.

Marine Environmental Research

Research and Studies in Direct Support of Coastal Management Decisions

An Environmental Study of a Nuclear Power Plant at Charlestown, Rhode Island. Coastal Resources Center, URI. 1974.

Perspectives on Coastal Management. Marine Trades and the Coastal Crisis. M. J. Grant, Coastal Resources Center, URI. 1974. Second printing.

Ecosystems Research

Analysis of Local Variation in the Standing Crop of *Spartina alterniflora Botanica Marina*, 16:103-109 (1973). S. W. Nixon and C. A. Oviatt, Graduate School of Oceanography, URI. 1974. Second printing.

Ecology of a New England Salt Marsh. *Ecological Monographs*, 43(2):463-498 (1973). S. W. Nixon and C. A. Oviatt, Graduate School of Oceanography, URI. 1974. Second printing.

Pollution Studies

Measurements of Phytol in Estuarine Suspended Organic Matter. *Marine Biology*, 27:143-146 (1974). D. M. Schultz and J. F. Quinn, Graduate School of Oceanography, URI. 1975.

Organic Matter on Clay Minerals and Marine Sediments—Effect on Adsorption of Dissolved Copper, Phosphate and Lipids from Saline Solutions. *Chemical Geology*, 13:63-68 (1974). P. A. Meyers and J. G. Quinn, Graduate School of Oceanography, URI. 1974.

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Rhode Island Sound Dredge Spoil Disposal and Trends in the Floating Trap Fishery. *Transactions of the American Fisheries Society*, 103(3):498-506 (1974). M. P. Sissenwine and S. B. Saila, Graduate School of Oceanography, URI. 1975.

The Solubility Behavior of No. 2 Fuel Oil in Sea Water. *Marine Pollution Bulletin*, 5(7):101-105 (1974). P. D. Boehm and J. F. Quinn, Graduate School of Oceanography, URI. 1975.

Environmental Models

Applying a Water Quality Model to Pollution Management. M. L. Spaulding, G. A. Brown and F. M. White, Ocean and Mechanical Engineering, URI. 1974.

A Bibliography of Numerical Models for Tidal Rivers, Estuaries and Coastal Waters. R. Gordon and M. S. Spaulding, Ocean Engineering, URI. 1974.

Laterally Integrated Numerical Water Quality Model for an Estuary. *Journal of Fluids Engineering*, 103-110 (1974). M. L. Spaulding, Ocean Engineering, URI. 1974.

Tides and Tidal Currents of Narragansett Bay. M. Spaulding and C. Swanson, Ocean Engineering. 1974 and 1975. First and second printing.

Marine Education and Training

College Level

Marine Affairs Journal #2. P. R. Latham and E. J. Linky, eds., Master of Marine Affairs Program, URI. 1974.

Advisory Services

Extension Programs

Commercial Marine Insurance Guide. S. Snow (Medway Marine Corp.) assisted by Norman F. Wahl (American Universal Insurance Co.). Marine Advisory Service, URI. 1974. Third printing.

Payroll Taxes and Tax Withholdings for Rhode Island Fishermen. A. A. Holmsen, Resource Economics, URI. 1975. Second printing.

Sea Grant Annual Report, University of Rhode Island. B. J. Cole, Marine Advisory Service, URI. 1975.

Other Advisory Services

Marine Recreation Conference: The Economy and the Business of Marine Recreation. B. J. Cole, Marine Advisory Service, URI. 1975.

1974 Floating Breakwater Conference Papers. T. Kowalski, ed., Ocean Engineering, URI. 1974.

Marine Recreation Conference: Planning for Shoreline and Water Uses. B. J. Cole, ed., Marine Advisory Service, URI. 1974.

PROJECT STATUS
FISCAL YEAR 1975

Project Number and Title		Planned Termination Date	Date Initiated
Advisory Services			
A/AS-1	New England Marine Resources Information Program	none	1968
A/AS-2	URI Marine Advisory Service	none	1970
A/L-1	Law of the Sea Institute	1976	1969
Education			
E/FT-1	Fisheries & Marine Technology	none	1968
E/M-1	Master of Marine Affairs	none	1969
E/ME-1	Marine Resources Economic Option	none	1971
E/OE-1	Graduate Program in Ocean Engineering	none	1971
Coastal Resources			
R/CR-5	Coastal Resources Center	none	1971
R/E-4	Ecosystem Analysis—Application in a Coastal Town	1976	1974
R/E-5	Effect of Dredge Spoil on Benthic Animals	1976	1974
R/E-8	Identifying and Monitoring Oil Spills	1977E2	1974
R/ES-1	Analytical Physical Model	1975C	1970
R/ES-2	Systems Ecology Studies of Narragansett Bay	1976	1970
R/ES-3	Economic-Ecological Model of Narragansett Bay Basin	1975C	1970
R/ES-6	Development of an Integrated Three-Dimensional Hydrodynamic, Salinity & Temperature Model	1977	1974
R/FB-1	Floating Breakwaters	1976	1973
R/MR-1	Non-Economic Benefits from Marine Recreation	1975C	1972
R/MR-2	An Economic Evaluation of Marine Recreation in Rhode Island	1976	1974
R/OM-1	The Economics of the Ocean Mining of Sand & Gravel off the Coast of Rhode Island	1975T	1974
R/WP-1	Economics of Waste Disposal in the Marine Environment	1975C	1972
R/WP-2	Source, Transport and Fate of Petroleum Hydrocarbons in Marine Effluent	1976	1974
Fisheries			
R/F-7	Socio-Economic Study of Fishing Occupations	1975C	1971
R/F-11	Bottom Trawl and Otterboard Performance Study	1976	1973
R/F-13	Economics of Utilizing Latent Fish Resources in Southern New England	1975T	1974
R/F-14	Development of a New Squid Trawl	1975C	1974
R/F-15	Work Methods in Fishing	1975C	1974
R/F-16	Regional Fisheries Population Management	1977	1974
R/F-18	Optimization for Fisheries Management Models with Time Delays	1975C	1974
(R/OM-1 & R/F-13 terminated because of changing market conditions)			
Aquaculture			
R/A-1	Management of Salmonids in a Closed Circulating Controlled Environment System	1976	1974
R/A-2	Aquaculture of American Lobster	1976	1968
R/A-4	Marine Pathology	1978	1970
R/A-8	Economics of Salmonid Aquaculture in New England	1976	1974
Food and Drugs			
R/D-3	Study of East Coast Paralytic Shellfish Poison	1976	1968
R/T-3	Preservation and Evaluation of Marine Foods II	1975C	1969
R/T-5	Utilization of Red Crab Waste in Trout Aquaculture	1977	1974
Management and Development			
M/PM-1	Program Management	none	1971
M/PD-1	Program Development	none	1973

C—indicates project was completed at the end of Fiscal Year 1975
T—indicates that the project was terminated due to changing market conditions
E2—indicates that the project was extended for 2 years.

ACTIVITIES
FISCAL YEAR 1975

	NOAA Grant Funds	University Matching Funds
Marine Resources Development		
Aquaculture	$118,909	$19,998
Living Resources, other than aquaculture	66,846	6,468
Marine Biomedicinals and Extracts	10,232	2,775
Socio-Economic and Legal Studies		
Marine Economics	96,152	30,672
Ocean Law	31,959	65,652
Marine Recreation	36,639	—
Socio-Political Studies	7,274	8,931
Marine Technology Research & Development		
Ocean Engineering	33,410	4,512
Resources Recovery and Utilization	76,082	42,929
Marine Environmental Research		
Research and Studies in Direct Support of Coastal Management Decisions	33,954	97,014
Ecosystems Research	85,946	10,201
Pollution Studies	33,337	6,011
Environmental Models	37,989	—
Marine Education and Training		
College Level	29,044	179,367
Vocational Marine Technician Training	25,511	96,880
Advisory Services		
Extension Programs	196,679	30,000
Other Advisory Services	70,642	7,500
Program Management and Development		
Program Administration	51,892	—
Program Development	59,503	3,008
TOTAL —	$1,102,000	$611,918