A Report on the University of Rhode Island Sea Grant Program

July 1979 to June 1981

Marine Memorandum 71

Foreword

This report describes the wide variety of projects undertaken by the University of Rhode Island Sea Grant Program in the years 1979 to 1981. It is a departure from previous reports, which were annual.

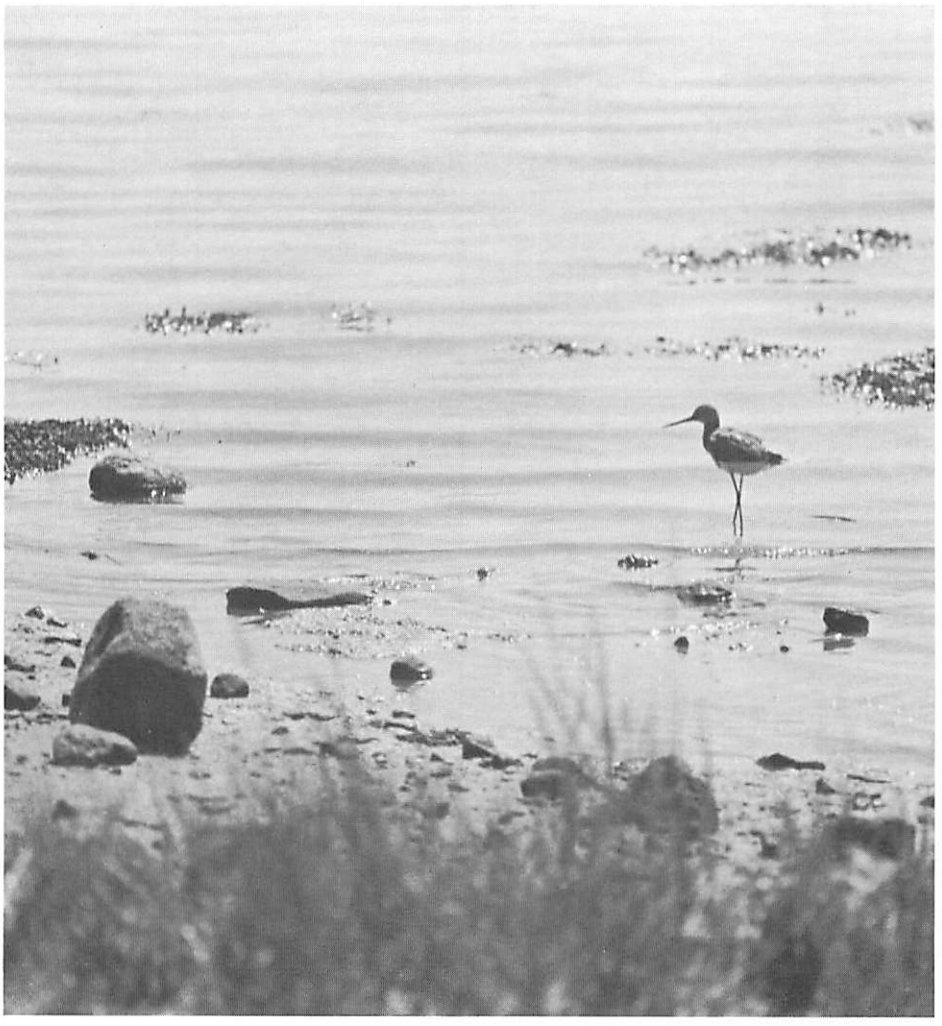
We may boast a little. But that is justified, for the National Sea Grant College Program is a highly efficient network of university-based programs in marine research, education, and technology development. Making sure the new knowledge that results reaches those who need it is a critical component of the national effort. And Rhode Island's program is no less efficient and innovative.

The structure of Sea Grant provides for coordination by the Office of Sea Grant in the U.S. Department of Commerce (NOAA) of work done by universities in the nation's coastal and Great Lakes states. As a result, there is not only healthy competition for support but an opportunity for scientific cooperation in addressing regional and national issues.

Our efforts range from finding ways to improve the efficiency of methods and equipment for industry to providing new perspectives on science and technology for professionals. Over the years we have found we can rely on the assistance and interest of people in industry, in government agencies at all levels, and among the general public in accomplishing our goals. No wonder Sea Grant is successful.

We hope you enjoy our report.

Niels Rorholm
Sea Grant Coordinator



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Marine Advisory and Technical Assistance

URI offers service to the public in the marine area through the Division of Marine Resources. This unit includes both the Marine Advisory Service and the Coastal Resources Center.

Over the past 11 years, the Marine Advisory Service has established a national reputation for its creative and productive programs, which traditionally have had regional and national as well as local benefits. Since understandably there is always some time lag between completion of specific projects and their public adoption, dollar benefits from them cannot be measured immediately. However, there are economic efforts from past work which give an indication of the worth of the projects. For instance:

- Annual savings to marinas nationwide from the use of floating tire breakwaters, developed by URI Sea Grant in cooperation with industry, are estimated at $100,000.
- Continuing training in corrosion prevention offered to marina and boatyard operators saves consumers $625,000 a year.
- Diesel repair workshops over the past five years have benefited marinas and boatyards for a total thus far of $250,000. Additional savings to the public cannot be estimated.
- Adoption of the URI 340 high-rise trawl gear by Rhode Island and Florida fishermen has, the fishermen report, increased individual net income by $5,000 per year.
- Development of the deep-sea red crab fishery along the U.S. East Coast, which URI Sea Grant researchers pioneered, has produced a new product worth about $2,800,000 annually after processing.
- Assistance given to a national fish hatchery has reduced salmonid mortality for an annual saving to the government of $247,500. The information has also been made available to other hatcheries.
- Seminars given in ten states on improving management practices produced immediate savings of $136,000 for 680 firms. Future benefits will be a mixture of savings and greater income.

As time goes on, it will become possible to ascribe similarly impressive benefits to other MAS projects in more than dollars. Stimulating new businesses, saving lives, improving marine products, and protecting coastal areas are only a few of the ways in which the URI Marine Advisory Service has served, and will continue to serve, the American public.

Commercial Fisheries Development

With Rhode Island's port of Point Judith ranking third in New England and thirteenth nationally in terms of landings, it is not surprising that close to a quarter of the total Marine Advisory Service effort was in the area of commercial fishing in 1980-81. By drawing on expertise both within and outside the University, the fisheries development specialist was able to carry out over 20 projects useful to fishermen in a wide range of areas such as fishing methods and gear, manpower training, seafood technology, fisheries management and economics.

Two particularly outstanding accomplishments were the installation on the URI Bay Campus of a towing tank to test model trawls and improve their design and the initiation of a system to improve marine weather forecasting in the New England area.

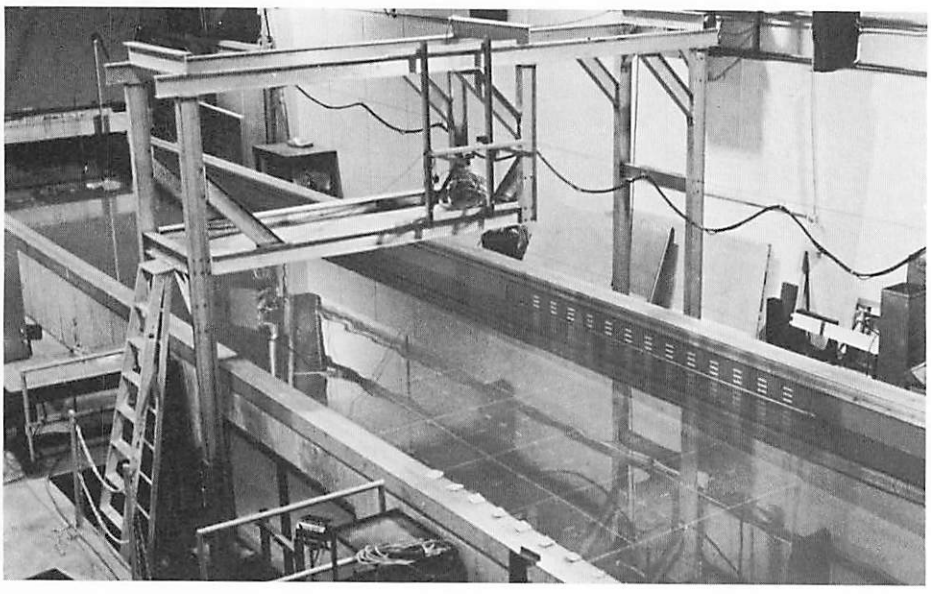
Today fishermen need to know they are going to catch the most possible fish with the least consumption of fuel, and in the URI tank, which photographs a trawl's performance as it moves through the water, it is possible to document its behavior in a way that would be impractical at sea. Tank testing also allows experimentation with a variety of designs without the expense of building a full-scale net. The facility is being made available not only to fishermen, but has attracted the interest of several yacht designers.

For years, local fishermen have complained that weather information available to them was too little and came too late. Consequently, URI became instrumental in setting up a cooperative arrangement in which fishermen at sea keep the Point Judith Fishermen's Cooperative regularly informed of weather conditions in their vicinity, and their reports are promptly relayed to the National Weather Service Forecast Office in Boston to be included in synoptic and prognostic weather charts. The system is expected to expand, and as it does it will improve forecasting reliability for all marine users.

One-day training courses on a wide variety of topics, often with accompanying booklets, were offered frequently. Judging by attendance, fishermen found them extremely useful.

The bimonthly URI *Commercial Fisheries Newsletter*, with over 2,000 readers nationwide, was expanded and broadened in scope, and includes material that one reader described as "invariably interesting and not seen elsewhere." Increasing public awareness of Sea Grant work and fisheries issues was also accomplished through a weekly series of five-minute radio programs which reach audiences in Massachusetts, Rhode Island, and Maine.

Technology transfer was not limited to the state or region. The fisheries development specialist assisted four Southern states in setting up training programs for commercial fishermen and presented programs on gear and fishing techniques to fishermen in South Carolina and Virginia.



Trawl models are tested in URI tow tank.

Marine Recreation and Coastal Utilization

Marine recreation is an important component of the economy of coastal states. In Rhode Island, where tourism and recreation contributes $3 million to the state annually, Marine Advisory Service work focused on areas such as business management, health and safety, economics, coastal planning, and ecology. Considerable time was devoted to workshops and seminars that would be useful to people in marine businesses — marina owners and operators, boatyard workers, mechanics, and sailmakers, to name a few.

Following up on work of previous years, over 20,000 reports, brochures, and posters on subjects such as boat theft, environmental impact of marinas, and red tides were reprinted by request and distributed nationally.

To bring together the various, and sometimes opposing, interest groups involved in saltwater sport fishing, URI organized the first Rhode Island Marine Sports Fishing Forum in 1980 to discuss such topics as rights of way, menhaden fishing, striped bass legislation, and Sea Grant research. The forum was considered so useful by attendees that plans were made to repeat it annually.

Following the first International Hypothermia Conference ever

held, which was organized by URI, over 1,000 requests for information on the subject were received and answered, dramatically increasing national and international communication on what is known and still unknown about hypothermia.

Seafood Technology

Having lost the specialist in this field to a job in industry early in 1980, the Marine Advisory Service moved in the direction of cooperative projects with URI's newly organized Department of Food Science and Technology, Nutrition and Dietetics.

A long-term joint project which got underway in 1979 involved an evaluation of various on-board fish-holding systems for New England fishing vessels. Fishermen in New England have traditionally relied on ice to hold their catch, since markets were close to landing ports, but refrigeration systems have proven to have several advantages over ice. They allow vessels to fish longer without sacrificing the quality of the catch and to deliver high-quality products to distant markets. The question is which system best fits the needs of area fishermen and gives them the most for their money.

With the cooperation of a local fishing captain, four methods were tried out and evaluated over the summers of 1980-81 with locally abundant scup and butterfish. The fish were held either in chilled seawater, boxed in ice, bulk-held in the usual way, or frozen in the food freezer. An analysis of the effects of enzymatic ice was also made. Results of the experiment were published in the URI *Commercial Fisheries Newsletter*, and a subsequent 24-page publication, *Fish Handling and Preservation at Sea*, became available in 1981. A comprehensive annotated bibliography on fish handling and preservation methods was also compiled by the Department of Food Science with MAS assistance.

Marine Education

So great is the influence of the Bay and the sea on life in Rhode Island that MAS educational programs geared to a better understanding of the marine environment have struck an exceptionally responsive chord in this state. Public interest in MAS offerings increases yearly.

The Seascope Program, launched in cooperation with the Greater Providence YMCA in the spring of 1980, has enrolled over 8,000 students and teachers in its day and overnight coastal pond field studies. This first Rhode Island-based marine studies center, tied in with similar centers in Massachusetts and Connecticut, has served groups from New York, Illinois, Vermont, and Michigan, in addition to those from Rhode Island.

As part of URI's summer Elderhostel Program, a series of lectures and field experiences was designed for senior citizens and attracted 250 participants to its first two one-month courses.

A marine awareness speakers' program, presented to over 100 schools and organizations, reached over 5,500 individuals in 1980-81.

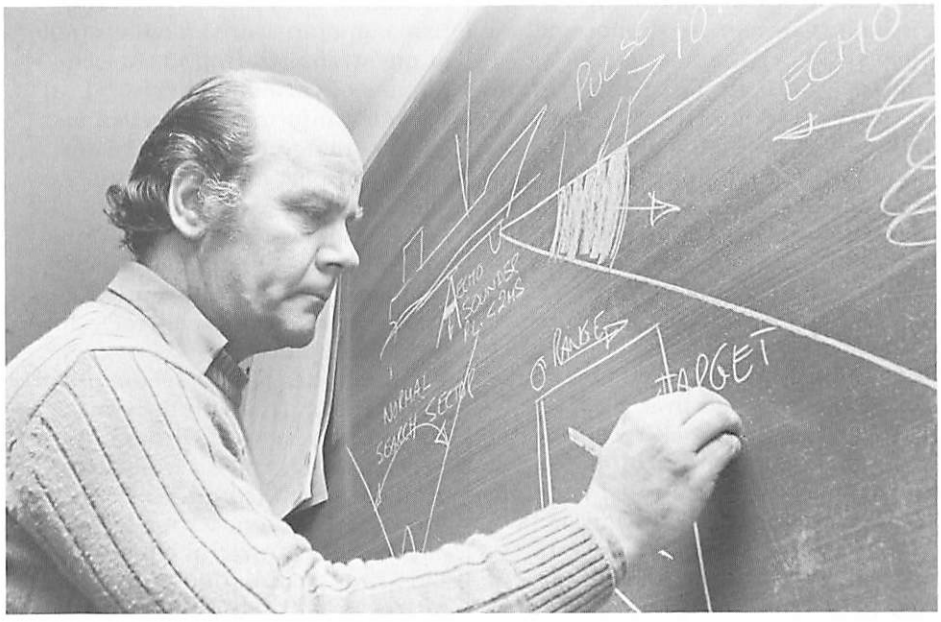
The Marine Awareness Center, established at the Bay Campus in 1979, has grown to house the largest collection of marine-related materials for kindergarten to twelfth grade in the United States and continues to answer a growing number of requests for information from teachers, students, educators, and adult groups nationwide seeking general marine education materials.

A permanent exhibit and resource center located in Providence's Roger Williams Park Museum provides a metropolitan location for learning about the history, habitats, and plants and animals of Narragansett Bay.

Information Transfer

Getting information out to client groups has continued to be a major area of Marine Advisory Service concentration and is accomplished in a number of ways. Under the heading of communications there are newsletters, feature articles, and radio and TV to make Sea Grant results more widely known.

Since its inception in 1969, the bimonthly newsletter now called *New England Information*, which



"Quickie" refresher courses keep commercial fishermen abreast of new technology.

features articles on marine issues of general interest, has attracted a readership around the world of over 11,000. Articles from it are regularly reprinted in newspapers, magazines, and government publications. The Marine Advisory Service newsletter, also bimonthly, continues to inform a readership of over 1,700 of the wide range of MAS activities.

The years 1979-81 saw a considerable increase in the number of articles on URI Sea Grant projects which were placed nationally. *Aquaculture, National Fisherman, Sea Grant Today,* the *Providence Journal, Sea Frontiers, Marina, Science '80s, Soundings,* and *Fishing News International* are some of the publications in which they appeared.

Information was provided regularly to radio and TV reporters concerning marine activities and research projects at URI. This resulted in more rapid and efficient transfer of information to the public.

At the request of the National Weather Service Forecast Office in Boston, a Marine Advisory Service writer collaborated with that office on a booklet, *Weather Information for Boaters, Cape Cod to Watch Hill,* to acquaint the public with weather patterns off the southern New England coast.

The distribution of publications increased dramatically over the past two years, with more of them reaching their targeted audiences, due in part to a program of notices in relevant trade journals and magazines. Many of them were also reprinted by other Sea Grant programs. Emphasis was placed on the distribution of abstracts, and the mailing list for them doubled in size, which also contributed to the increase in orders. Written requests alone for URI publications averaged 500 a month. Because of the extensive public interest in several publications (one book received eight national awards), outside groups took an active role in their advertising and distribution, making it possible to reach an even wider audience at no additional cost to Sea Grant. By charging for publications, the Unit was able to recoup a portion of its postage and handling costs.

The Northeast Regional Coastal Information Center, first of nine such centers proposed, and established at URI in 1977, was closed in June of 1981 due to lack of funding from the Office of Coastal Zone Management and the Environmental Data and Information Service of NOAA. During its years of operation it was recognized for its quality. Since then, the Division of Marine Resources Library has taken on the responsibility of responding to information requests. In many cases, information packages produced by the NERCIC and the library provided quick, appropriate answers to frequently posed questions.

Marine Economics and Business

With the slowing of the national economy and with changing federal policies affecting many marine businesses, an effort was made to reach out to other groups besides commercial fishermen. The URI professor of resource economics who gives one-third time to MAS provided information on fishing vessel investment and financing to a number of organizations, including banks and consulting firms, and answered a wide range of questions relating to the economics of various fisheries. He also provided information needed for preparing development plans for a variety of port facilities. With the expansion of markets for fish around the world, MAS personnel were able to help many industry people investigate alternative markets and secure contracts for their products.

A number of management workshops for marina and boatyard operators were held throughout New England, and an innovative publication, *Marina and Boatyard Financial Structure and Performance,* went into three printings. This first compilation of financial ratios for marinas and boatyards can be used to analyze the financial health and performance of a business firm.

Other

Additional areas in which MAS was involved during the period covered by this report were remote sensing, ocean engineering, and aquaculture.

An existing Satellite Data Distribution Program used on the West Coast was evaluated, and modified to meet the needs of commercial fishermen on the East Coast. Establishing the program in Rhode Island not only improves weather forecasting for commercial fishermen but provides a wealth of useful information on fish location and movement.

A Sea Grant publication on applications of remote sensing was produced to suggest the variety of ways in which remote sensing can be useful in the management of the marine and coastal environment.

Involvement with aquaculture took the form of two publications: a report on the financial feasibility of water reuse systems for salmonid aquaculture and one on the problems existing between aquaculturists and shellfishermen concerning aquaculture development in the state.

A publication by URI engineers, titled *Model-Predicted Tidal Current Charts, Long Island Sound to Buzzards Bay,* was widely distributed by MAS, as was a bibliography on floating tire breakwater research.

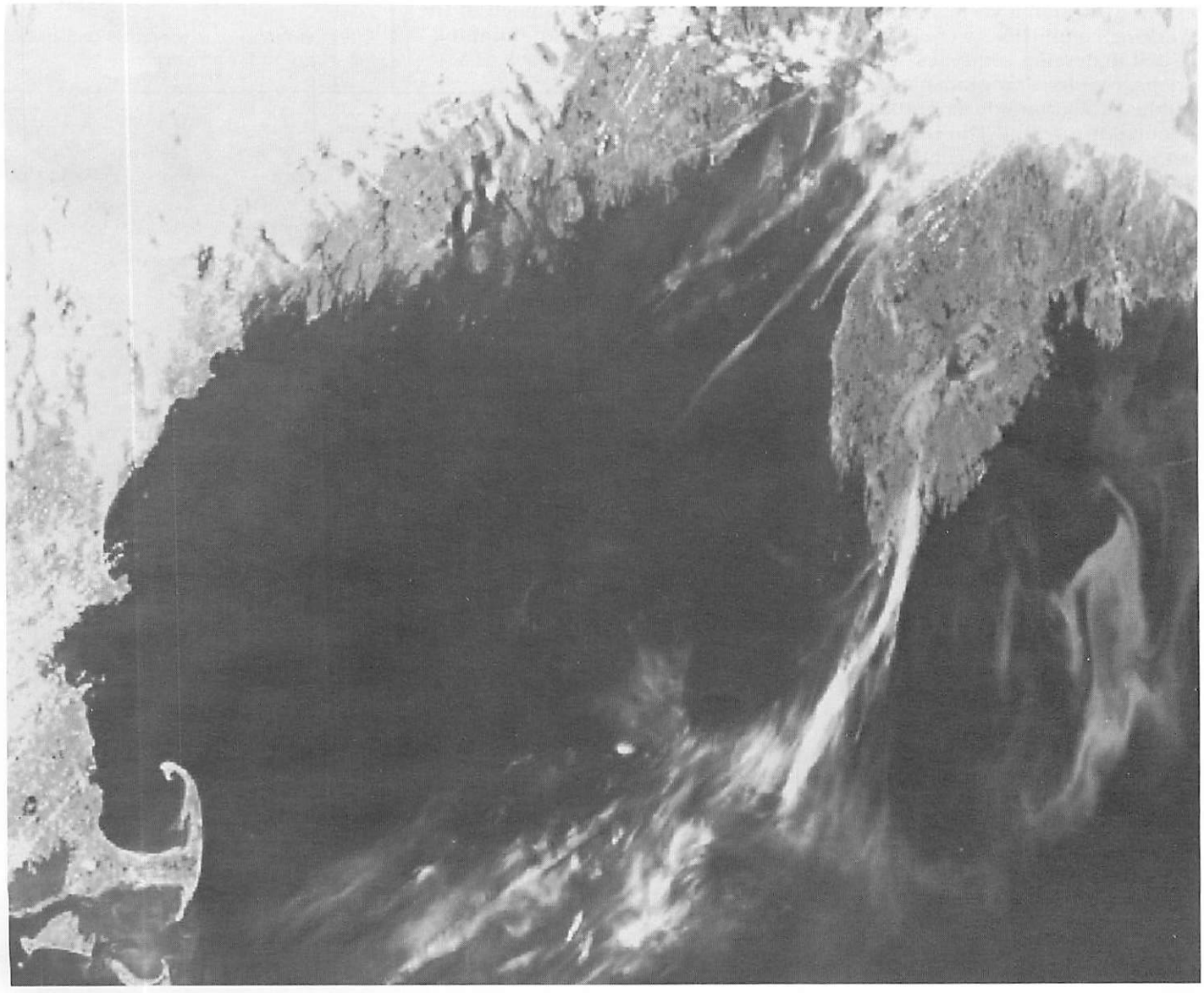
Besides these particular examples, editing and design services were donated to a number of additional research publications.

The Coastal Resources Center

Today all levels of government and, in Rhode Island, the state's Coastal Resources Management Council are required to address a host of concerns to which few people gave serious thought 20 years ago. Consider this awesome yet probably incomplete list:

- the quality of our water and the safe disposal of sewage
- disposal of hazardous wastes
- ports — their expansion and redevelopment, dredging needs, disposal of dredge spoils, decaying waterfronts
- offshore drilling, conflicts between commercial fishing and oil exploration
- barrier beach management, beach erosion, storm damage to developed beaches
- wetlands management and protection
- estuarine ecology, management and possible governmental protection of key resources
- salt pond management, aquaculture potential, fish and shellfish resources, pollution
- marine recreation, boating, marinas, boat registration, economics
- public cooperation with management policies

How can any single group make informed decisions about such a spectrum of marine-related problems, one might ask. In Rhode Island, government agencies and the CRMC depend to a great extent on the skills of the small but highly diversified staff of the Coastal Resources Center, a unit of URI's Division of Marine Resources. In fact, during the period covered by this report, the Center was asked for assistance with every one of the problems listed above. As a crucial liaison between management and the scientific community, it not only supplied technical data and planning scenarios to the CRMC but advised regional councils and state and national government agencies. As marine resource problems intensify, the Center anticipates that the decade of experience



Gulf of Maine region appears on a color scanner image from Nimbus-7 satellite.

it has accumulated will become increasingly useful.

Less than one-third of the funding for the Coastal Resources Center comes from Sea Grant.

The Center for Ocean Management Studies

The Center for Ocean Management Studies, established at URI in 1976 with Sea Grant support to promote more effective ocean and coastal management, has continued to be a useful liaison between marine interests within and outside the University.

In the past two years it has involved a growing community of experts through a variety of means. Working committees were established to develop seminars, workshops, research programs, and public education efforts on issues of current interest. The committees set up in 1980-81 concentrated on surveillance and enforcement, aquaculture, food science, ocean energy, and marine transportation.

A quarterly newsletter, *Coastal Oceanography and Climatology News*, which began publication in 1979, has proved to be an invaluable forum for interdisciplinary communication throughout the United States scientific community. The newsletter is supported by subscriptions and by funding from three divisions of NOAA: the National Marine Fisheries Service, the Environmental Data and Information Service, and the National Marine Pollution Program Office.

A workshop held in the fall of 1979 on managing the resources of Georges Bank led to the formation of an ad hoc committee comprised of representatives from the oil industry, the fishing industry, and environmental groups. Meeting regularly to discuss areas of mutual concern, the group has proposed a monitoring program for Georges Bank and recommended specific actions for the consideration of several government agencies.

The Center's report on a major research activity of 1978-79 — the economic consequences of the 1977 Amoco Cadiz oil spill — was presented to the National Oceanic and Atmospheric Administration in the spring of 1981.

Thomas Scott, director of the Center for Energy Policy and chairman of the New England Energy Committee, began a two-year term as a COMS research associate in June 1980. He is a member of the Georges Bank ad hoc committee and is involved with other COMS efforts related to energy and resource decisions.

Eric Schneider, former director of the Environmental Protection Agency's Narragansett, R.I., laboratory, ended his two-year appointment as a COMS research associate in June 1981. Findings from a credit course he coordinated in the spring of 1980 on ocean dumping will be published as a book.

Captain Charles H. Nixon of NOAA was appointed a COMS research associate for 1981. In addition to being involved in URI Sea Grant activities, Captain Nixon facilitated interaction between NOAA components and URI research interests. In that capacity, he was a valuable liaison on the marine weather project.

Virginia Tippie, executive director of COMS, took a 15-month leave of absence in the spring of 1981 to become a project officer on the EPA-administered Chesapeake Bay Program. Lynne Carter Hanson is acting executive director in her absence.

Electron microtome prepares fish tissue for study under microscope.

Education and Training

There was no expectation that the Sea Grant Program would fund individual education and training programs indefinitely. The purpose of grants in this field is to launch new courses, projects, and programs to meet national marine needs. Employment records and comments of employers soon point to the programs that are producing results, and as these programs begin to attract other support or are included in normal institutional budgets, Sea Grant funding for them winds down. Several programs are in this category at URI.

Marine Affairs Education

Demand for two programs pioneered at URI continues to grow, here and abroad. Both the one-year Master of Marine Affairs Program and the two-year Master of Arts in Marine Affairs turn out specialists in various marine disciplines with a broad perspective on marine management and decision-making. Enrollment in the M.M.A. Program tripled when the degree began to be offered in 1979 on a part-time basis at the Naval Education and Training Center in Newport, R.I., as well as on the Kingston Campus. The Master of Arts in Marine Affairs, initiated in 1977, had space in 1980-81 for only a third of the students who applied. Demand for graduates in the field is expected to remain strong.

The M.M.A. Program, which has four concentrations — coastal zone management, fisheries management, commercial shipping and ports, and international marine affairs — has developed these areas in several new directions. A course in coastal and offshore energy systems was first offered in 1979, and an existing course on environmental impact assessment and analysis focused on an increasingly difficult problem for planners: intensive development of open areas.

Students in marine affairs education are supported by a variety of funding sources. Two fellowships and one scholarship were provided by the Jessie Smith Noyes Foundation for M.M.A. students. The Intergovernmental Oceanographic Commission of UNESCO provides two fellowships yearly for students from developing countries. In 1979, the Food and Agricultural Organization of the United Nations provided a fellowship for a student from the People's Democratic Republic of Yemen. In 1979-80, students from nine countries were enrolled in the program.

The annual *Marine Affairs Journal*, which presents papers written by students and alumni of the program, is subscribed to by over 200 libraries, government organizations, businesses, and individuals.

In the fall of 1979, Dr. Lewis Alexander, director and major architect of the Marine Affairs Program, was awarded the Ninth Annual Sea Grant Award by the Sea Grant Association in recognition of his role in marine resources management. In 1980, Dr. Alexander was appointed interim director of the Office of the Geographer for the U.S. State Department and is on leave from URI until 1982.

Marine Resource Economics

As the national need for informed management of marine resources became obvious some years ago, other needs also became increasingly apparent: the need for trained economists with a grasp of marine issues, the need for more and better data on which to base economic decisions in this area, and the need for interdisciplinary dialogue to relate economic consequences to marine science findings.

URI responded by initiating Ph.D. and Master's programs in marine resource economics and has succeeded in attracting extremely capable students. Two were inducted into Phi Kappa Phi during the past year, and the thesis of a third won honorable mention in the National Sea Grant thesis competition.

During this phase-in period of the program, main emphasis is on curriculum development. By 1982,

all core courses will have been offered at least once and several special courses developed.

Areas in which students are concentrating at present are: fisheries management and the 200-mile limit, international trade issues, marine pollution, and the impact of marine tourism.

Fisheries and Marine Technology

Job opportunities in the marine field are plentiful for those who know their trade. Commercial fishing captains are looking for crew members who understand the increasingly sophisticated fishing gear and methods used today. As a result, this two-year associate degree program has attracted more and more students with previous fishing experience who recognize they lack the technical abilities needed to get ahead.

Graduates of the program now work in all areas of United States fisheries and in countries overseas. Most are skippers, mates, engineers, or deckhands, and several have boats of their own. Other URI-trained men and women have become technicians aboard research vessels, fish plant managers, fisheries instructors, or owner/operators of sportfishing boats. The program's director estimates that in two years an able student can acquire skills it would take as long as seven years to pick up on the job.

Emphasis in course work continued to be on applied practical activities, and students spent much of their time in laboratories, workshops, and at sea aboard the department's training vessel.

To meet the needs of the general public, workshops in gill netting and small trawls were offered through the University's College of Continuing Education.

In September 1980, Conrad W. Recksiek, formerly of Kinnetic Laboratories in Santa Cruz, California, was appointed chairman of the Department of Fisheries and Marine Technology.

Research Projects Completed in 1980-81

Aquaculture

Marine Pathology • The URI Marine Pathology Laboratory continued to play an increasingly important advisory role nationwide. Personnel are regularly called on by government agencies, public aquariums, university aquaculturists, fish retailers, and others to solve problems of disease or diagnose cause of death. The National Marine Fisheries Service, as one example, asked the URI laboratory to develop an autopsy protocol for marine turtles and to suggest how exposure to oil might be diagnosed in Gulf of Mexico turtles. It is expected that this advisory activity will continue to grow and that much of the support for research in the laboratory will be coming from sources other than Sea Grant.

Specific research, much of it co-sponsored, was carried on in a number of areas. A fungal agent isolated from cultured marine fish was identified in 1979-80, and follow-up work the next year investigated its transmission and the immune response to the agent in fish.

During 1979 the laboratory's director, while on sabbatical in Europe, observed that nutritional diseases are causing major mortalities in the developing aquaculture industry. As a result, a research project was begun in 1980 to define the pathological changes and effects of rancid fats, which are common in commercial fish foods, on the growth of fish and shellfish. A method being developed to diagnose liver damage in fish will allow the aquaculture industry to evaluate the cost-effectiveness of improved feeds.

URI Laboratory investigates causes of sudden mortalities in fish populations.

Salmonid Production: A Program in Environmental Physiology • In New England there is a growing interest in salmonid aquaculture. However, if salmonid aquaculture is to be economically attractive, a number of environmental problems must be solved. Recognizing the potential for intensive culture of salmon and trout, scientists at URI have been working since 1975 to improve environmental conditions in closed growing systems.

Among their early accomplishments were the development of a low-cost and efficient diet and the reduction of mortality due to disease and premature sexual development.

In the past two years, researchers have been concentrating on ways to reduce stress during critical periods of the salmonid life cycle. Some stress is inevitable in intensive aquaculture and it is most likely to occur when swim-up fry are being brought on to feed and when fish are adapting for entry into salt water (smoltification). At high levels it can cause retarded growth, shock, and death. Since economic studies at URI have shown that maximum growth and survival are essential for a profitable aquaculture operation, the need for understanding the mechanisms underlying stress is obvious.

Studying the relationship between environment, feeding, and physiological processes thus became the focus for the most recent Sea Grant-funded aquaculture research. Work in this area was coordinated with, and reinforced by, parallel Sea Grant-supported research in fish pathology and in the economics of salmonid production.

Researchers evaluate pesticide levels in brine shrimp on gas chromatograph.

Specifically, research was aimed at learning how toxic wastes enter the bloodstream of salmonids and how they can be removed. Once the biological reactions of trout and salmon to ammonia and nitrite are understood, it will become possible to engineer growing systems to minimize these stressors. Several findings from the study were published in *Progressive Fish Culturist* and the *Journal of Fish Biology*, as well as in master's theses.

During 1980, one of the principal investigators was asked by the Dworshak Federal Hatchery for help in pinpointing causes of high mortalities of steelhead trout which were occurring during smoltification. Finding that the snow-melt water used in the hatchery was abnormally low in ions, URI was able to recommend a mineral enrichment program which resulted in the largest release of steelhead smolts in the hatchery's history.

The Biochemical Composition and Biological Effectiveness of Brine Shrimp in Aquaculture • Brine shrimp (*Artemia*), a primitive crustacean found in lakes and bays with high salinity, is the major source of live food in the aquaculture industry, and hence has considerable economic importance.

As the result of *Artemia* research which had begun at URI in 1975, scientists in the Department of Food Science and Technology, Nutrition and Dietetics became part of an international team formed in 1978 to study commercially used strains of brine shrimp from around the world. It had been recognized that the nutritional quality of different batches of brine shrimp varies enormously, and the University's contribution to the study was to analyze the biochemical and chemical characteristics of five geographically specific strains.

In comparative feeding trials carried out over a two-year period, each of the five strains was fed to four species of fish and crabs. Two, which are sold commercially, proved to be foods that gave poor growth and survival. An analysis of

the results suggests that the causes lie in the food's poor fatty acid profiles combined with high levels of dieldrin and chlordane pollution. The presence of DDT as a primary cause of poor nutritional quality was ruled out.

Five papers reporting on various aspects of this Sea Grant-supported research at URI have been made available here and abroad. Because of the study, it is now possible to identify pollution-free strains of brine shrimp, and the information gained will significantly minimize stock losses by aquaculturists, researchers, and tropical fish dealers.

Salmonid Aquaculture in New England: An Economic Analysis • The salmonids (salmon and trout) are top eating favorites with Americans; commercial aquaculturists have been growing them profitably in other parts of the United States for a long time. Because interest on the Atlantic coast began to build over the past decade, URI researchers in several disciplines have been assessing the potential for culture in New England of various species.

Salmonid culture may use any of several techniques, each carrying different capital and labor requirements. At one extreme is the capital-intensive method, which raises fish from hatchery to market size in a controlled environment, often using a water reuse system. At the other is ocean ranching, in which hatchery-raised smolts are released into the ocean to feed themselves and are harvested when they return to fresh water to spawn. In an intermediate approach, they are kept in floating net pens and supplied with feed.

Of the three, controlled culture promises the greatest possibilities for New England — genetically and geographically — despite being the most expensive and the one possessing the most economic unknowns.

This Sea Grant-supported study concentrated on determining how controlled culture of Coho salmon in a water reuse system can be most profitable. The result is a quantitative economic model that can help an aquaculturist make crucial decisions as to: the water temperature in which he grows his fish, stocking density, the size of his operation, the weight at which he markets his fish, and the kind of product (fresh, frozen, or smoked) he markets.

The model demonstrates, for instance, that it is not economical to grow Coho salmon to maximum size. The best size is one-half to three-quarter pound. It also shows the extent to which increasing stocking density increases profit and suggests, too, that the most economical plant is one of 400,000 cubic feet or over. Before the study ended, similar data were compiled for controlled aquaculture of Atlantic salmon and showed that in this case culturing to larger sizes is more profitable. Many of the figures in the model could also be applied to lobster culture. The economic effects of selected improvements in genetics, nutrition, feed conversion, stocking density, and labor-saving systems were explored via sensitivity analysis and found to be considerable.

Several papers have been published by the researchers, and interest in their findings has been expressed by aquaculturists in Maine and Connecticut as well as in Europe.

Coastal Management

Multidisciplinary Study of Rhode Island Coastal Ponds • In 1978, the University took on a major research effort in response to citizen and management concern for the future of coastal ponds. Besides assessing the changes that the ponds have undergone in the past few decades, the study attempted a better understanding of the nutrient and biological interactions between our coasts and the fishing grounds. These shallow coastal embayments are critical but not well-understood factors in land-sea interaction. Man's attempts to modify them to his liking have often had unexpected and unfortunate results. Increasing development of surrounding acreage and heavy use of the ponds themselves have modified them further. How to stop the ponds from shoaling, keep water quality high, and preserve a healthy environment for fish and shellfish are urgent concerns of residents in Rhode Island and in other states with these lagoon systems.

The three-year project, managed in cooperation with URI's Coastal Resources Center, has examined closely the physical, biological, and ecological processes at work in Rhode Island's ponds. When the last of the studies are completed — in 1983 — the result will be a model, not only for local management efforts but for any coastal state faced with similar problems. By June of 1981, four of the seven investigations, which were supported mainly by Sea Grant but also by EPA, the state's Coastal Resources Management Council, and other state agencies and town governments, had been concluded.

Hydrodynamic models have been developed which accurately represent major circulation patterns in the ponds. Because breachways critically influence circulation by regulating exchange with the ocean, they dramatically affect the ecology of the ponds. These models, which show changes in salinity, flushing velocity, and volume of water exchanged with the ocean, are being used to predict the results of a variety of management options.

To learn the major sources and rates of sedimentation in the ponds, and what effects a breachway has, a geological team studied the sedimentology, erosion patterns on the barrier beach, sand transport through the breachway, rates of storm overwash, and deposition processes on the flood tidal delta. They found that while the breachway is doubling the rate of sedimentation in one pond, it is not a factor in the sedimentation of another, where storm overwash is creating shoals that are annoying to boaters.

Water pollution is a primary

concern of all people who worry about salt ponds. The URI study has approached this from two directions. One group is developing budgets for the major nutrients — carbon, nitrogen, and phosphorus — that enter the ponds (see page 18), while another has completed a series of experiments to establish whether very low levels of nutrients (comparable to amounts that may flow in from residential developments) have a measurable effect on plant life in the salt ponds. Their work has not only provided new information on the response to low-level nutrients of several plant species but has established that blooms of green algae, the early warning sign of eutrophication, are triggered by localized, barely measurable increases in the nitrogen levels of pond waters — the low level of nutrients that increased residential development is likely to produce.

For the past decade it has been widely thought that the fast-growing population of European mute swans (introduced into the ponds in the 1950s) threatened to drive out native waterfowl and decimate the aquatic plant community. As a result, the state Department of Environmental Management began a population control program in certain ponds, to the dismay of some bird lovers.

After two and a half years of observation and experimentation with swan populations in several ponds, URI researchers were able to give the DEM some valuable information. They found that although swan behavior is sometimes aggressive, at the present population level it does not significantly affect the distribution or abundance of native waterfowl. However, when a population becomes dense enough, it can deplete aquatic vegetation. The researchers advise continuing population control measures with the exception of nesting sites, where particularly aggressive swan pairs defend a large water area from fellow swans and thus protect it for other species.

From the beginning of this multidisciplinary project, effort has been made to keep the public informed of findings through meetings, workshops, press releases, news features, and slide shows. Meanwhile, Coastal Resources Center personnel have reviewed the history of the ponds and the impacts of past management policies. When all the research results are in, the CRC will be able to present to the public as well as to state and local governments a number of practical alternatives for achieving various goals. The unique approach of this study and the comprehensive data it has pulled together will also be useful elsewhere in the country.

Circulation Dynamics of Narragansett Bay • A new understanding of the circulation dynamics of Narragansett Bay has resulted from a three-year project completed in 1981.

When extensive data on currents and tides became available from a 1977 National Ocean Survey photographic examination of the Bay, URI ocean engineers seized the opportunity to undertake a detailed analysis of the data in concert with an existing three-dimensional wind-driven numerical model. Once the model had been verified and refined, they began to compile and analyze all existing physical oceanographic data on the Bay to determine its overall circulation dynamics. Both short-term and long-term meteorological events and their significance for important local problems such as pollutant dispersal, storms, and flushing were studied as well.

The results of this work are valuable new insights into how the Bay actually works. It was found that winds play a far greater part in circulation dynamics than had been suspected. A third of the Bay's currents are wind-driven, particularly around the island of Jamestown. Using the model, it is possible to predict the effects of winds up to hurricane force —

Botanists in study of coastal ponds collect samples of aquatic vegetation.

useful knowledge when severe storms are expected. Planners and Bay managers also are now able to estimate how long discharges into the Bay circulate there, and biologists have gained a variety of important data for their studies of the Bay.

Fisheries

Tank Testing of the URI Series 340 Trawl • The original design of the URI Series 340 trawl was developed in 1972 under a contract with the National Marine Fisheries Service. The objective of the design was to modify the long-used Yankee 41 net for greater versatility in size and catch type without major deviations from the standard equipment.

Initial tests of the net carried out jointly by the United States and the U.S.S.R. showed it to be considerably more effective than the corresponding Yankee nets, and it quickly gained popularity with fishermen here and abroad.

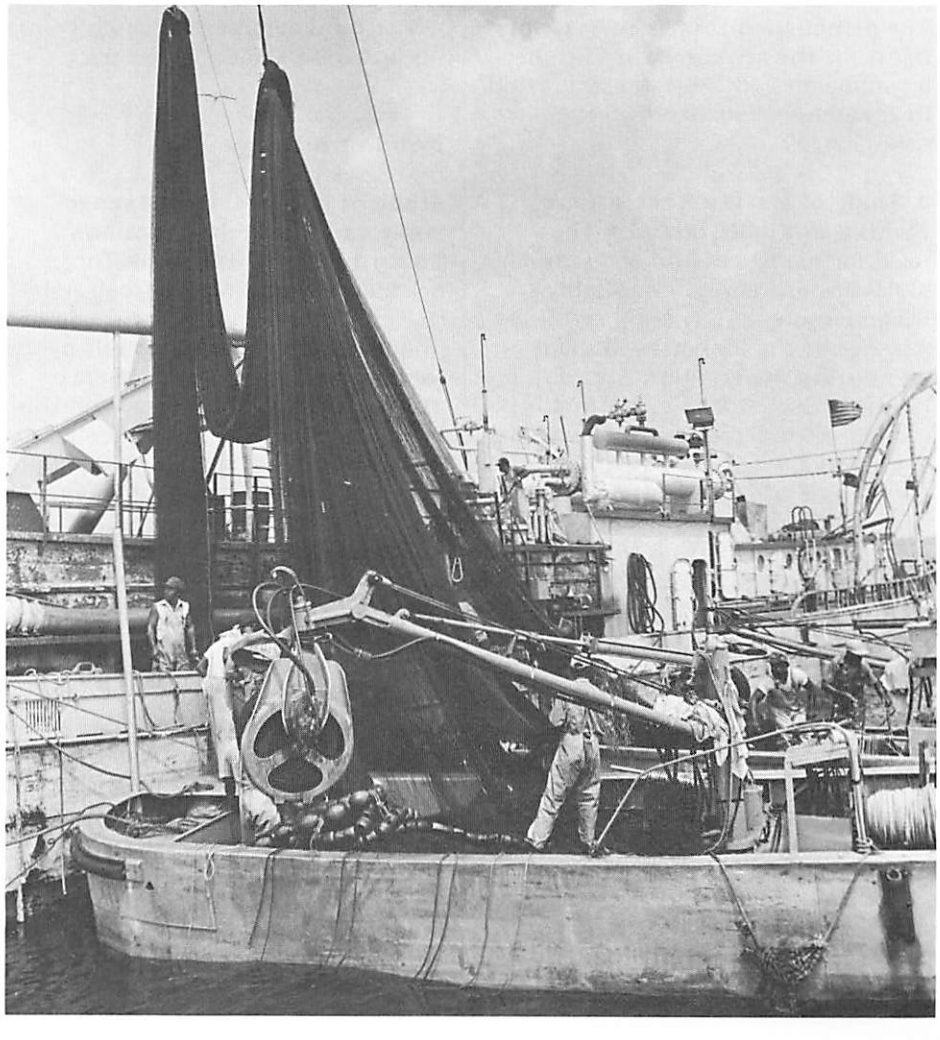
However, as time went on, some users of the nets reported specific problems with its design, and as a result six scale models of the net were constructed in 1978, one of them to the standard design and the other five incorporating a variety of design modifications. These models were then extensively tank-tested. It was found that the most successful model incorporated variations in three design elements — square depth, hanging ratio, and float numbers. To acquaint commercial fishermen with the results of these tests, URI published a booklet, *Suggested Design Modifications to the URI 340 Series Trawl Following Tank Testing*, which had a second printing in 1980.

Analysis of Changes in Capital Stock in New England Fisheries • Management of domestic fisheries became a fact of life in 1976 with passage of the Fisheries Management and Conservation Act, which established the 200-mile fishing limit. How well management succeeds will depend in large part on how accurately regional councils can predict participation in given fisheries in response to changes in economic conditions and regulatory policies.

Answering the New England Council's appeal for economic data, resource economists at URI have developed a model to analyze the phenomenon of entry, exit, and switches among fisheries as a result of management measures. Economists in this country and Canada have praised its "behavioral" approach as an important new direction in fisheries economics.

The sequential logit model, developed and refined with Sea Grant support over a two-year period, was applied to investment decision-making in the New England fisheries in 1976-77, using a maximum-likelihood procedure. The sample included over 90 percent of vessels over five gross tons on record with the National Marine Fisheries Service as landing fish in New England ports. A discrete model of investment decisions by fishing firms was then modified to reflect fishermen's response to risk.

The model provides some important new insights. Certain management policies, it suggests, may unexpectedly have just the opposite of the desired effect. Vessel catch quotas without limited entry, for example, attract rather than discourage fishermen because the quotas increase stability; other kinds of controls may be needed as



Purse seiners off Quonset Point, Rhode Island.

well. The model also suggests that large incentives will have to be provided to overcome fishermen's hesitancy to enter underutilized and hence uncertain fisheries. Recently, a system of incentives/disincentives has been discussed for New England fishery management. The aim is to divert effort from overfished species to less heavily exploited ones by using price incentives. The model can be used to estimate just how large a price change will be necessary, since it relates entry with prices, yields, and costs. Forms of incentive other than those of price, or direct means of reducing uncertainty in underdeveloped fisheries, might be more effective.

In its current form, the model is intended for economists, and it has been presented to a number of them at symposia and in papers published both here and abroad. The principal author is now adapting it for the layman so that fisheries managers without a background in economics will also find it useful.

A Study of Marine Recreational Fishing in Rhode Island • The need for biological and economic statistics on recreational fishing became increasingly apparent after passage of the Fisheries Management and Conservation Act, which requires that stocks be optimally managed for recreational as well as commercial yield. Meanwhile, competition between commercial and sport fishermen for the same species continues to grow.

As a result, URI and the National Marine Fisheries Service began a survey in 1977 of Rhode Island sportfishing. Information was obtained through a telephone survey of 9,000 households and field interviews with 5,000 sport fishermen.

A final report, *Marine Sportfishing in Rhode Island, 1978*, was published in 1981 and offers a variety of information to fisheries management personnel and others. A forthcoming technical paper will describe the sampling methodology developed for the survey and will provide a number of economic analyses.

The report presents basic findings from the study, including numbers and weight of fish caught by species, time, and type of fishing. It also characterizes Rhode Island resident and non-resident saltwater sport fishermen as to fishing effort, catch, and seasonal catch variation, and it estimates cost of transportation to and from the fishing grounds as well as out-of-pocket expenses.

The biological data in the report provides information critical to effective fisheries management. Because it gives some evidence of the biomass of fish, it is an indicator of the productivity of the state's estuarine areas and the biological effect on them of sportfishing. This appears to be surprisingly great: the catch of only nine species of sport fish proved to be nearly equal to the total commercial catch coming into one Rhode Island port.

Food and Drugs

Study of Food Service Management and Clientele Reactions Toward Fish Utilization • To broaden the market for fresh fish in New England, a mail and telephone survey was carried out by the Department of Food Science and Technology, Nutrition and Dietetics to learn how much fresh fish is served in food service systems in Rhode Island and why the amount and variety is not greater. The answers, which have now been tabulated, give fish marketers a clear indication of ways in which they might increase sales.

Survey responses show that neither price per se nor lack of consumer enthusiasm for fresh fish limits its institutional use. Instead, unreliable availability, price fluctuation, and inadequate storage facilities in the institutions themselves are the most important factors. If the fishing industry could manage to offer fish — or a variety of fish, depending on seasonal abundance — in guaranteed amounts and at a stable price, food service systems might be expected to buy more fish.

The survey was addressed to 141 colleges, universities, schools, nursing homes, and senior citizen meal sites in the state. A total of 117 responded, an excellent percentage. Seventy-eight percent of college and university dining services, hospitals, and nursing homes regularly buy fresh fish, and it is used in 50 percent of schools and senior citizen meal sites.

Half of all fresh fish bought in Rhode Island by these systems comes from local fish markets, according to the survey, and the balance from large suppliers and individual fishermen. More than 95 percent of the buyers were satisfied with species, quality, and delivery of the product. But 60 percent criticized the absence of ice in packaging and of labels that identify the origin of the fish. Ice is critical in maintaining quality for those food service systems which lack special facilities for storing fish. Labeling of product origin is of concern because of "truth in menu" regulations.

The survey also disclosed another factor that limits fresh fish use in institutions: cutting and weighing each portion adds to labor costs. Fresh fish delivered in portions would be more acceptable.

A paper describing the survey results was submitted to the *National Marine Fisheries Service Review*, and news releases were sent to food industry and fishing industry trade journals and seafood councils. Radio spots on the survey were also aired in New England.

Physiological Ecology of the Toxic Red Tide Dinoflagellate • The periodic appearance of red tides along the northern Atlantic coast can spell several types of disaster. When these phytoplankton population explosions involve the species *Gonyaulax tamarensis*, the infamous carrier of paralytic shellfish poisoning (PSP), they represent not only a major public health hazard but significant economic loss for many businesses in the area. Even red tides caused by nontoxic dino-

flagellates can be devastating to the commercial fishing industry. A prolonged and little understood bloom in the New York Bight a few years ago killed off $76 million worth of surf clams.

Because the Atlantic coast of North America is fourth in importance among areas where PSP is a public health hazard, and because *Gonyaulax* appears to be moving southward toward the rich shellfish areas around Narragansett Bay, there is a tremendous need to understand the biological and chemical mechanisms involved in its spread.

A two-year study by GSO researchers, concluded in 1981, sought the answers to several questions: How do temperature, light intensity, and nutrients affect growth, survival, and toxicity of *Gonyaulax?* Can growth rate be speeded? (If blooms could be induced, it would greatly increase scientists' predictive capability.) What are the rates of grazing on *Gonyaulax* by zooplankton and mollusks and the accompanying transfer of paralytic shellfish toxin?

At the time the study began, there were two opposing views of how red tides occur in the sea. The commonly accepted one was that dinoflagellates are slow growers and that when they appear as red tides they represent accumulations of organisms caused by small-scale circulation patterns in the ocean. The opposing view was that blooms are the result of accelerated growth rates triggered by unknown factors.

To test the latter hypothesis, researchers grew 16 species of dinoflagellates, including three clones of *Gonyaulax*, in outdoor chambers using Narragansett Bay water. Their observations proved that many dinoflagellates are capable of very fast growth, in contrast to what had been previously believed. Growth rates three to nine times as high as those considered normal were documented.

Additionally, they discovered that dinoflagellates can be grouped into opportunistic and survivor species on the basis of growth rates, with several behavior subgroupings in each category. Previously it had been thought that dinoflagellates exhibited a uniform growth response.

Following a variety of studies, the researchers concluded that the mechanisms for red tide outbreaks vary between species of dinoflagellates, making it appear unlikely that any one mechanism is responsible for blooms. This, too, was contrary to the popular perception.

Enzymatic Processes to Preserve Fresh Fish • As fresh fish gains popularity with American consumers, food technologists have been increasing their efforts to find ways of slowing down spoilage so that non-frozen fish can be marketed far from the coast.

Modified-atmosphere storage, which uses high levels of carbon dioxide to inhibit microbial growth, has been tested by individual processors with varying success, and a number of studies have been made of the value of adding antibacterial compounds to the ice in which fish is held. Ice alone is only moderately successful in preserving freshness.

Hypobaric storage, which places the fish in a flowing stream of air nearly saturated with water, at a reduced pressure and low controlled temperature, appears to have great potential. It is already used commercially to extend storage time for meat and vegetables, but will probably not be widely accepted by fish processors until the market shows higher profits than it does presently.

An integrated approach to the problem has been taken at URI by a team which includes a food biochemist, a food microbiologist, and a food technologist/engineer. Over the past two years, they have developed a modified atmosphere with enzymatic systems, a method they believe has more flexibility than the carbon dioxide system.

Three enzymatic systems were tested: an enzyme dip for whole or filleted fish, enzymes mixed with the ice in which the fish is held, and an enzyme-saturated algin blanket surrounding the fish. All three were found to extend shelf life of fish by 40 to 50 percent in ordinary refrigerated storage. Glucose oxidase proved to be the enzyme most readily available commercially at low cost.

A new finding from their study was that the enzyme treatment changed the pattern of deterioration in fish, slowing down the intrusion of bacteria. Three zones of deterioration were identified. In the first, bacteria break down the slime layer normally covering fish; in the second, bacteria begin to invade the skin; in the third, they begin to break down proteins and lipids, causing the characteristic "rotten fish" smell. The enzyme system successfully delays the onset of each of these stages. A paper submitted by a graduate student in the group at the annual meeting of the Institute of Food Technologists in June 1981 was judged one of the best papers on microbiology presented.

Another facet of the work by the URI team combined the enzymatic system with hypobaric storage. Using a demonstration unit built on campus, they showed that the combination of the two was synergistic. The shelf life of fish was extended by a surprising 30 to 35 days, or about 90 percent longer than with ordinary refrigerated storage.

Several fish processors plan to try out the enzyme system, which will cost them a few cents a pound to use. However, because it offsets moisture loss, and hence weight loss, in stored fish, they expect the cost will be balanced by having more pounds of fish to sell. A producer of smoked fish is also interested in determining whether the process will solve his marketing problems.

If it becomes economically attractive, the researchers believe the combined enzyme and hypobaric system will have the greatest commercial future. A plant using this process would not be forced to freeze all surpluses of fresh fish but could store the fish until market conditions were favorable for selling it fresh.

Ongoing Research Projects

Thirteen projects, begun in 1978-79, are still in progress. Six are related to marine biological research, four to commercial fishing and seafood science, two are marine policy studies, and one is concerned with aquaculture.

Aquaculture

Live brine shrimp, *Artemia*, is the feed of choice for cultured fish and shellfish in certain critical phases of their development. Previous Sea Grant-supported studies at URI have demonstrated that there is considerable variation in the nutritional quality of different geographical strains of *Artemia*. The present study is trying to pinpoint the causes of high mortalities in marine larvae fed certain *Artemia* strains and to compare certain variables in two of the areas that produce commercial supplies of them.

Ecosystems Research

A comprehensive, multidisciplinary study of Rhode Island's coastal ponds and lagoons was begun in 1978 (see "Research Projects Completed in 1980-81"). Three of the projects connected with it will be completed in 1982-83. They are concerned with an estimate of the fish and shellfish in the ponds, the development of carbon-nitrogen-phosphorus budgets, and, finally, management options and techniques for the pond complex based on the vast quantity of information that has been gathered by University researchers.

Research continues on red tide and paralytic shellfish poisoning in order to explore the various methods that can induce red tide blooms.

Because New England marshes are on the Atlantic flyway, it is important to understand their role in annual migration. A study is underway to investigate the impact that ditching for mosquito control has on the marsh avifauna.

The state's most seriously polluted waters and sediments are in the Providence River and Upper Bay area. A current project will identify the sources, method of transport, and geochemical fate of metal-organic complexes in these waters, a considerable aid to the EPA and to state agencies in their efforts to deal with pollution.

Fisheries and Seafood Science

Work to develop better fishing gear for the industry has been underway for a long time at the University. Building on earlier modifications to the popular URI 340 trawl, a current project is aimed at refining it further and testing it against industry-developed nets.

A serious need in fisheries management is good, recent data on the cost of fishing. Historically, however, obtaining such data has been difficult and expensive. Two researchers are testing a method that may prove to be more economical.

A chemical engineer, two food scientists, and a biochemist are building on earlier Sea Grant-supported work as they address the problem of by-product recovery from seafood-processing industries.

Another project will supply information on the nutritional value of fish at various stages of preparation, from raw to ready-to-eat. Upcoming labeling requirements and increased marketing of unfamiliar fish products will make this information extremely useful to the seafood industry.

Policy Studies

A study, which could also be classified under marine transportation, is evaluating the four main options that the United States has for reacting to the United Nations Conference on Trade and Development (UNCTAD) Code of Conduct for Liner Conferences. The emphasis will be on evaluating the pluses and minuses associated with each option for the United States. This information will be valuable to a number of government bodies.

In the second policy study, a political scientist, a lawyer, an anthropologist, and an economist have teamed up to compare information, strategy, and decision-making among the New England, North Pacific, and Gulf Fisheries Management Councils. The result will be a model useful to fisheries management.

Program Development

Thirteen special projects received support from Program Development funds in the period 1979-81. Typically, these short-term studies are undertaken to meet immediate needs in the marine community. In some cases, they can be completed in a year or less; in others they may point the way to useful longer-term investigations under other funding.

One such project involves an innovative approach to managing Rhode Island's important scallop fishery. A computer program was developed to calculate growth rates and yields so that fisheries managers can choose harvesting dates on the basis of scallop size rather than the calendar. Since the time when scallops reach a given size varies from year to year, using this method can improve yield 10 to 20 percent in a good scallop year. In a boom year, the economic benefit could be on the order of $100,000. Although the system will be demonstrated first with scallops, it can be used with any short-lived fish or invertebrate, and has considerable potential for pond rearing in commercial aquaculture. It may be the first step in developing a long-range management plan to improve yields in multi-year-class and multispecies fisheries.

Many Rhode Island lobstermen have long felt that a combined lobster-crab fishery is not feasible, but tests of a new trap design produced in the Department of Zoology may prove them wrong. It was fabricated after long-term study of lobster and crab behavior showed that behavioral interactions, not differences in population distributions, accounted for low catches of both species in the same trap. Work done on this project by a graduate student won her the Sea Grant Association Award for Student Research in the Master's Category.

Other completed projects were in such diverse areas as food science and nutrition, community planning, marine biology, seafood marketing, and economics.

New URI trap design raises hopes for a combined lobster/crab fishery.

Project Status Fiscal Year 1980

	Project Number and Title		*Planned Termination Date*	*Date Initiated*
Advisory Services	A/AS-3	Marine Advisory Service	None	1975
	A/COM-1	Center for Ocean Management Studies	1983	1977
	A/CR-5	Coastal Resources Center	None	1971
	A/RS-1	Applications of Remote Sensing: MAS and Coastal Zone Management	1980C	1979
Education	E/FT-1	Fisheries and Marine Technology	1981	1968
	E/MA-2	Master of Marine Affairs	1980C	1977
	E/ME-2	Marine Resource Economics, Ph.D. Program	1982	1977
Coastal Resources	R/CL-1	Development and Verification of Hydrodynamic and Dispersion Models for Coastal Ponds	1981	1978
	R/CL-2	Waterfowl in Coastal Ponds	1981	1978
	R/CL-3	Submerged Macrophytes in Coastal Ponds	1981	1978
	R/CL-4	Sediment Transport and Depositional Patterns in Coastal Ponds	1981	1978
	R/CL-5	Fisheries of Coastal Ponds	1981	1978
	R/CL-6	Management Options for Coastal Ponds	1981	1978
	R/CL-7	Carbon, Nitrogen, and Phosphorus Budgets for Coastal Ponds	1982	1979
	R/ES-14	Circulation Dynamics of Narragansett Bay	1981	1978
	R/MR-3	Study of Marine Recreational Fishing in R.I.	1980C	1977
Fisheries	R/F-26	Analysis of Changes in Capital Stock in New England Fisheries	1980C	1978
	R/F-27	Tank Testing URI 340 Series Trawl	1980C	1978
Aquaculture	R/A-12	Marine Pathology	1981	1978
	R/A-13	Salmonid Aquaculture in New England: An Economic Analysis	1980C	1978
	R/A-14	Salmonid Production: A Program in Environmental Physiology	1981	1979
Food and Drugs	R/D-6	Distribution Mapping and Typing of Toxic Dinoflagellates	1981	1979
	R/D-7	Physiological Ecology of the Toxic Red Tide Dinoflagellate	1981	1979
	R/T-10	Study of Reactions to Use of Fish in R.I. Food Service Systems	1980C	1978
	R/T-11	Biochemical Composition of Brine Shrimp in Aquaculture	1980C	1978
	R/T-12	Enzymatic Processes to Preserve Fresh Fish	1981	1979
Management and Development	M/PM-1	Program Management	None	1971
	M/PD-1	Program Development	None	1973

C indicates project was completed in that year.

Project Status Fiscal Year 1981

	Project Number and Title		Planned Termination Date	Date Initiated
Advisory Services	A/AS-3	Marine Advisory Service	None	1975
	A/COM-1	Center for Ocean Management Studies	1983	1977
	A/CR-5	Coastal Resources Center	None	1971
	A/D-1	Marine Awareness Through Drama	1981C	1980
Education	E/FT-1	Fisheries and Marine Technology	1981C	1968
	E/ME-2	Marine Resource Economics, Ph.D. Program	1982	1977
Socioeconomic and Legal Studies	R/F-29	Alternative Methodologies in Collecting Data in Fishing	1982	1980
	R/OL-1	U.S. Interests in UNCTAD Code of Conduct for Liner Conferences	1982	1980
	R/SP-1	Decision-making Behavior in Regional Fisheries Management Councils	1982	1980
Coastal Resources	R/CL-1	Development and Verification of Hydrodynamic and Dispersion Models for Coastal Ponds	1981C	1978
	R/CL-2	Waterfowl in Coastal Ponds	1981C	1978
	R/CL-3	Submerged Macrophytes in Coastal Ponds	1981C	1978
	R/CL-4	Sediment Transport and Depositional Patterns in Coastal Ponds	1981C	1978
	R/CL-5	Fisheries of Coastal Ponds	1981*	1978
	R/CL-6	Management Options for Coastal Ponds	1981**	1978
	R/CL-7	Carbon, Nitrogen, and Phosphorus Budgets for Coastal Ponds	1982	1979
	R/E-13	Impact of Mosquito Ditching on Salt Marsh Avifauna	1983	1980
	R/ES-14	Circulation Dynamics of Narragansett Bay	1981C	1978
Fisheries	R/F-28	Tank Testing of Fishing Trawls	1982	1980
Aquaculture	R/A-12	Marine Pathology	1981C	1978
	R/A-14	Salmonid Production: A Program in Environmental Physiology	1981C	1979
	R/A-15	Studies in Brine Shrimp	1982	1980
Food and Drugs	R/D-6	Distribution Mapping and Typing of Toxic Dinoflagellates	1981**	1979
	R/D-7	Physiological Ecology of the Toxic Red Tide Dinoflagellate	1981C	1979
	R/T-12	Enzymatic Processes in Preservation of Fresh Fish	1981C	1979
	R/T-13	Recovery of By-products from R.I. Seafood Industry	1982	1980
	R/T-14	Nutritional Evaluation of Stored, Processed Cooked Fish	1982	1980
Management and Development	M/PM-1	Program Management	None	1971
	M/PD-1	Program Development	None	1973

C indicates project was completed in that year.
* Project extended one year to 1982.
** Project extended two years to 1983.

Activity Budget Fiscal Year 1980

	NOAA Grant Funds	*University Matching Funds*
Marine Resources Development		
Aquaculture	$73,052	$46,282
Living Resources Other Than Aquaculture	45,838	9,112
Marine Extracts and Toxins	54,714	18,464
Socioeconomic and Legal Studies		
Marine Economics	69,501	14,448
Marine Recreation	31,750	29,958
Marine Technology Research and Development		
Resources Recovery and Utilization	71,562	26,608
Marine Environmental Research		
Research and Studies in Direct Support of Coastal Management Decisions	30,818	52,791
Ecosystems Research	281,586	81,454
Marine Education and Training		
College Level	62,217	134,206
Vocational Marine Technician Training	45,518	104,473
Advisory Services		
Marine Advisory Service	380,000	168,025
Center for Ocean Management Studies	20,000	62,393
CZM and MAS Applications of Remote Sensing	17,258	---
Program Management and Development		
Program Management	95,360	7,538
Program Development	96,826	2,145
TOTAL	$1,376,000	$757,897
ROUNDED TO	---	$757,900*

*While matching is shown at $757,900, the University of Rhode Island does not wish to claim matching for audit purposes for more than one-third of the total cost of the University of Rhode Island Sea Grant Program.

Activity Budget Fiscal Year 1981

	NOAA Grant Funds	*University Matching Funds*
Marine Resources Development		
Aquaculture	$80,995	$54,709
Living Resources Other Than Aquaculture	33,710	24,933
Marine Extracts and Toxins	79,734	31,261
Socioeconomic and Legal Studies		
Marine Economics	33,418	---
Ocean Law — International	10,515	5,225
Sociopolitical Studies	37,792	---
Marine Technology Research and Development		
Resources Recovery and Utilization	121,555	59,079
Marine Environmental Research		
Research and Studies in Direct Support of Coastal Management Decisions	39,450	43,405
Ecosystems Research	331,628	103,326
Marine Education and Training		
College Level	41,616	43,371
Vocational Marine Technician Training	37,693	117,075
Advisory Services		
Marine Advisory Service	418,922	180,828
Other Advisory Services	32,036	65,574
Program Management and Development		
Program Management	113,195	9,774
Program Development	97,741	50,000
TOTAL	$1,510,000	$788,560

*While matching is shown at $788,560, the University of Rhode Island does not wish to claim matching for audit purposes for more than one-third of the total cost of the University of Rhode Island Sea Grant Program.

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Note: The P number at the end of citation is the order number used by the Publications Unit of the URI Marine Advisory Service.

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