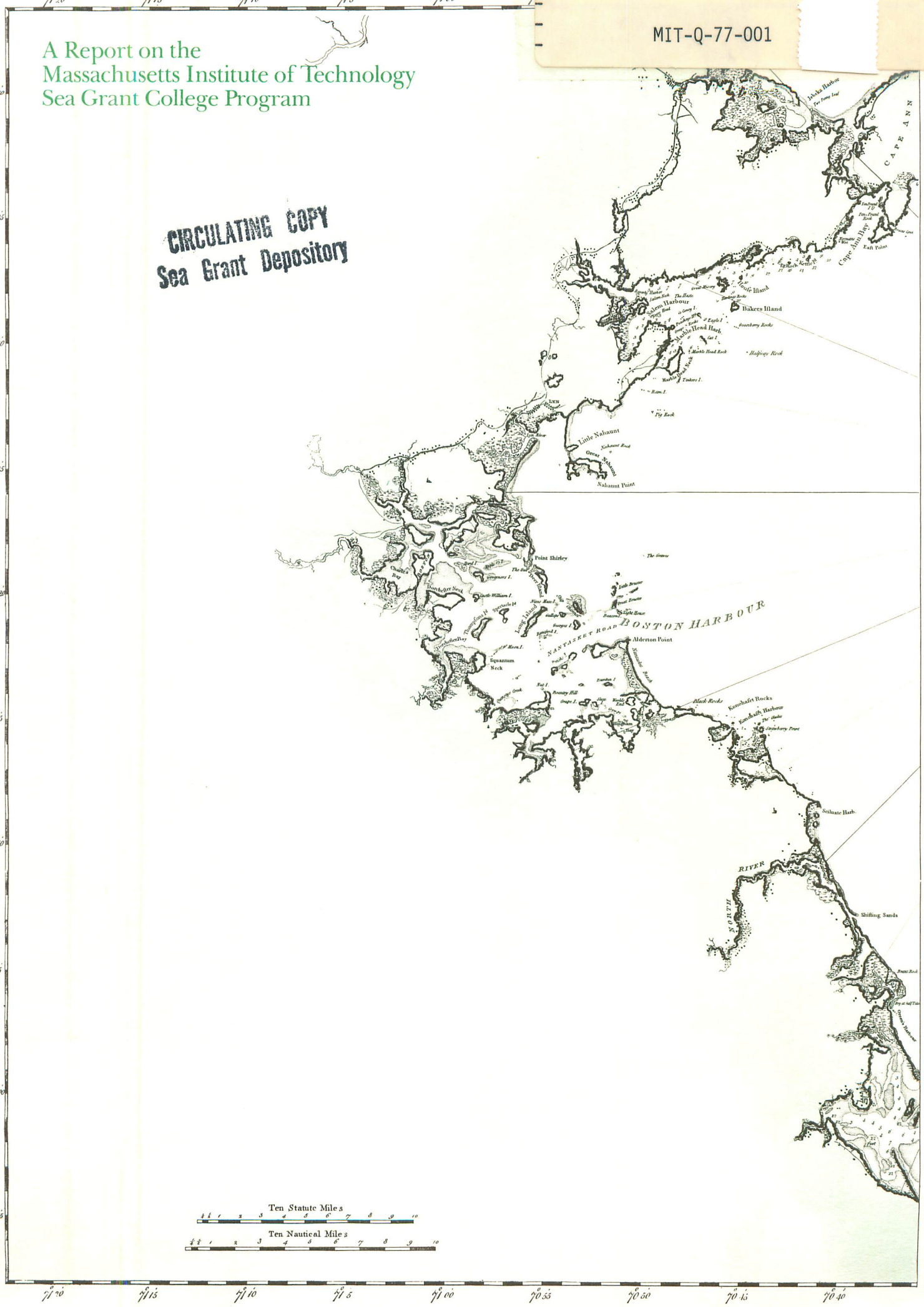
A Report on the
Massachusetts Institute of Technology
Sea Grant College Program



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Introduction

Nantasket Beach

In the last two decades Americans have realized that theirs is not a nation of boundless resources. During the early 1960s, concerned scientists, business leaders and citizens alerted the nation to the environment's limited ability to absorb wastes and chemicals and to accommodate continuous unplanned growth.

Americans listened and acted. They encouraged federal and state legislation to stem pollution and instituted zoning procedures in local communities to halt haphazard land development. As they saw that with care they could remedy past abuses, Americans gained new respect for the limits, the toughness and the potential of the world around them. Cleaner waters opened up new recreational areas, healthier estuaries meant more shellfish, and rehabilitated waterfronts provided new economic vitality for cities and towns.

In 1966, responding to the vigor and hopes of the marine community, Congress founded the National Sea Grant Program to provide a mechanism through which academia could contribute to the effective and thoughtful development of the nation's valuable ocean and coastal resources.

The program, university-based to tap the objectivity and expertise of academic researchers, relies upon the experience and perspective of leaders in marine businesses and industries as it pursues solutions to practical problems in protecting and utilizing our oceans and coasts. MIT is one of 27 major university programs in the Sea Grant network. Each program contributes individual strengths in the marine sciences, law, engineering, business management and urban planning and is responsible to a local constituency. Coordination by the national office in the National Oceanic and Atmospheric Administration of the Department of Commerce encourages diverse approaches to developing the food, energy and mineral resources in the nation's waters, and guarantees that citizens in communities throughout the Sea Grant network have access to a wide range of research and technical skills.

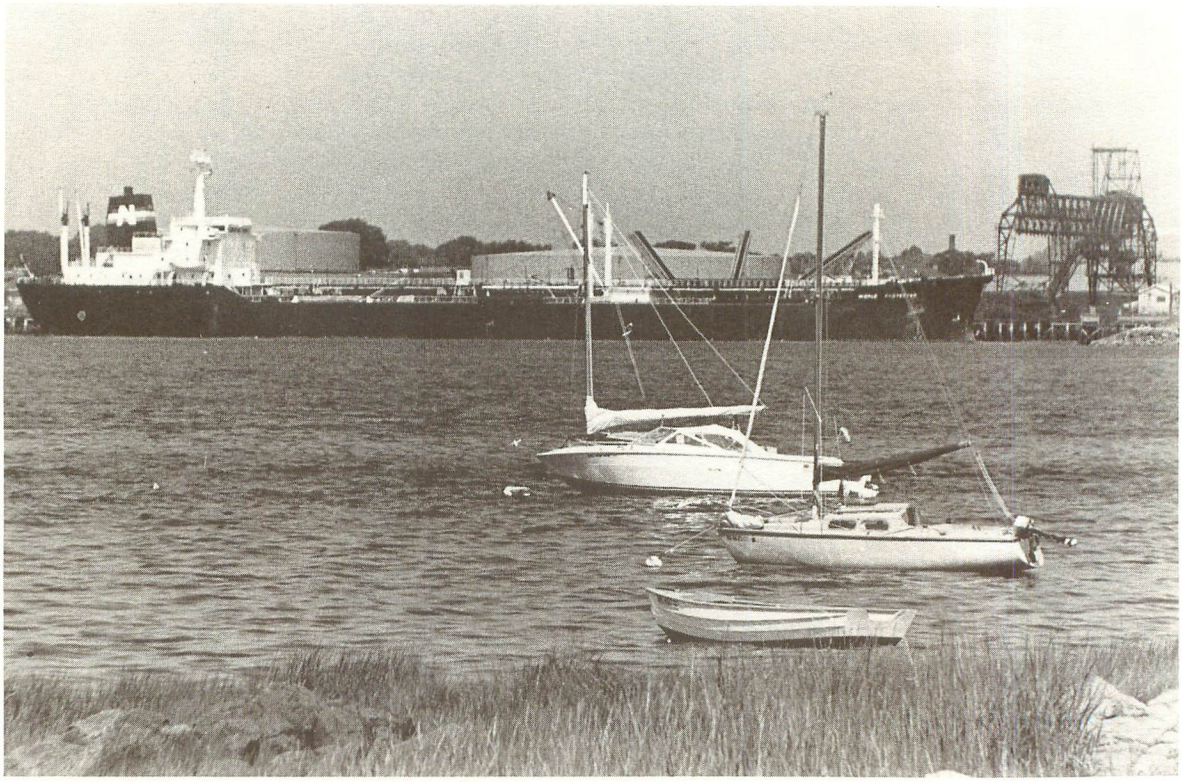
At MIT, Sea Grant draws upon 90 years of ocean-related engineering experience, a philosophy that stresses a multidisciplinary approach to technology development and an educational tradition that urges faculty and students to pursue solutions to society's real and practical problems.

During the seven years that MIT has been part of the Sea Grant network, the program's staff has worked to broaden its service to Massachusetts citizens. In recognition of these efforts, this year MIT was designated the nation's twelfth Sea Grant College, the only completely private university thus far to receive Sea Grant's highest recognition and honor.

Under MIT Sea Grant's guidance, a research vessel, the R/V EDGERTON, was outfitted as the Institute's ocean-going scientific laboratory. The 65-foot, 90-ton vessel is a tremendous new tool for university and industry researchers to use in exploring the waters along New England's coasts and on the continental shelf. In 1976/1977 we strengthened a partnership with the Commonwealth's other Land Grant College, the University of Massachusetts, and we expanded our commitment to marine education to include pre-university students in Massachusetts' public schools.

Understanding and development of the nation's marine resources can enrich the lives of all Americans, but the growth must be scrutinized by a public actively concerned with the health of our coastal and marine environments. We of the MIT Sea Grant Program are dedicated to helping Americans respond to opportunities in the seas while fostering careful application of marine technologies in tapping the seas' potential.

Dean A. Horn
Director



The Sea Grant Program stands apart from other scientific research programs because of its commitment to working with the public. Sea Grant specialists are informed about coastal processes and resource management, and have long years of experience with marine industries and the intricacies of working in the seas. The advisory service staff helps people apply the results of Sea Grant research, and encourages universities to direct their talents and resources to solving problems of particular concern to people whose vocations or interests are tied to the seas.

It is to the advisory service—the public service aspect of Sea Grant—that citizens, businesses, coastal communities and industries turn with questions about specific marine-related problems.

MIT/Marine Industry Collegium

Through the MIT/Marine Industry Collegium, more than 90 companies of national and international stature participate in and profit from MIT's marine research and ocean-oriented activities. The Collegium, established in 1975 as a working partnership between the MIT Sea Grant Program and U.S. industry, promotes commercial development and application of new marine technologies.

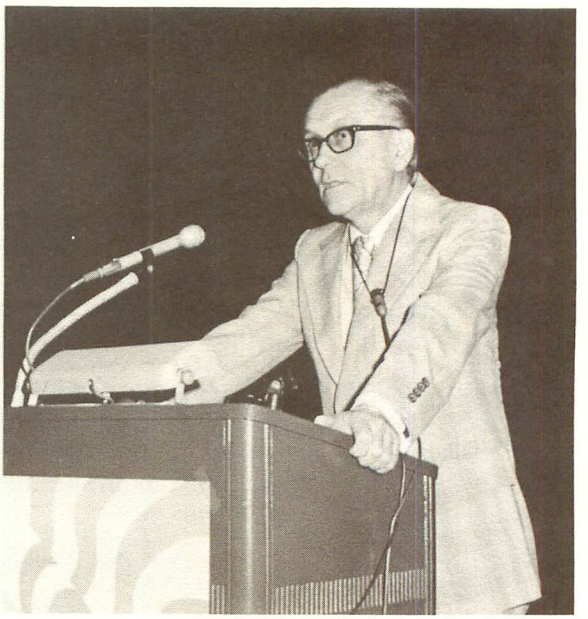
The Collegium identifies significant business opportunities emerging from marine research at MIT and within the nation's network of Sea Grant universities, and works closely with companies to translate these opportunities into profitable business ventures.

Collegium members from academia, government and industry meet four times a year to discuss concise, well-documented surveys of a specific marine business opportunity generated by Sea Grant research. These surveys describe a new technology or process, assess market potentials, and outline economic considerations. The meetings provide a forum in which members exchange ideas with MIT researchers, students, and with subject experts in the field.

Ideas and information exchanged through Collegium meetings, workshops and publications can result in new products and services, in improved techniques for working in the ocean, and in innovative approaches to the development and use of ocean resources.

Meetings during 1976/1977 focused on surveys on electron irradiation of sewage sludge, on closed-cycle mollusk aquaculture, on computer models for environmental engineering and research in near-coastal environments, and on oil spill clean-up technologies. This year, Sea Grant also sponsored the MIT Center for Policy Alternatives' special study on "Industrial Prospects for Chitin and Protein from Shellfish Wastes." This comprehensive study can be used by companies interested in developing and marketing products based on chitin, a cellulose-like material abundant in shellfish shells.

Dr. Alfred A. H. Keil



Massachusetts Advisory Programs

MIT Sea Grant public-oriented advisory services complete the link between Institute students and faculty and the people who can use the results of Sea Grant research. The results appear in forms as varied as new, improved equipment for fishing vessels, computer models for predicting the movement of sand along our shores, radical changes in fish processing methods, and plans to revitalize declining coastal towns. The program's diversity generates several outlets through which the advisory staff shares with the public the wealth of information at MIT and other Sea Grant universities.

The long-standing friendship between the MIT Sea Grant Program and the University of Massachusetts Cooperative Extension Service led to a new project, the Extension Sea Grant Advisory Program. This program gives Sea Grant staff members access to the research and technical strengths of both institutions—support that is vital to their role in helping Massachusetts citizens live and work in harmony with the seas.

This year, Sea Grant worked with four Cape Cod coastal communities in installing and monitoring the effectiveness of a new method for controlling and preventing shoreline erosion. Another project, development and testing of a safer trawl door hook-up system and ball coupler, came about through dialog with fishermen who risked losing hands and fingers during the hazardous process of hooking up trawl doors. Sea Grant also helps small businesses, such as fisheries and aquaculture farms, make their way, by offering technical assistance and by suggesting practical approaches to solving their marine-related problems.

Communications/Information Service

A communications staff publishes factsheets, technical and advisory reports, organizes publicity and works to translate research and technical information into usable forms. Staff members working with researchers and people interested in the individual research projects decide which methods to use in transferring timely information to people who can use it.

In addition to technical reports, this year Sea Grant published two special publications, "A Citizen's Guide to Sources for Marine and Coastal Information in Massachusetts" and "Extended Fisheries Jurisdiction: A Partially Annotated Bibliography with Special Reference to New England." The Sea Grant Information Center at MIT provides information for the public and the MIT community on topics of special interest to Sea Grant. The center has extensive information on aquaculture, coastal zone management, ocean mining, law of the sea, offshore oil and gas development, fisheries, and oceanographic instrumentation, as well as a collection of reports published by other Sea Grant universities.

Sea Grant Lecture

A highlight of Sea Grant advisory services for 1976/1977 was the Fifth Annual Sea Grant Lecture, "The United States and the Oceans: Opportunities for Independence." Alfred A. H. Keil, Dean of the School of Engineering and founder of the MIT Sea Grant Program, delivered the lecture calling for a coherent integrated national oceans policy to guide the nation's use of ocean and marine resources.

A panel discussion of industrial, governmental and academic perspectives on international and federal oceans policy followed the lecture. Participants were J. Herbert Hollomon, Director of the MIT Center for Policy Alternatives, George F. Mechlin, Vice President for Research, Westinghouse Electric Company, and Marvin Pitkin, Assistant Administrator for Commercial Development, U.S. Maritime Administration.

Fisherman secures trawl board to gallows frame.

Living Marine Resources

Proper management and husbanding of fish, one of the nation's great natural resources, can furnish increased quantities of protein-rich food and foster the economic well-being of the fishing and processing industries. The MIT Sea Grant Program, through its research, education and public information services, highlights the opportunities for nurturing and preserving living resources in our coastal waters.

Fishery Management

With the establishment in 1977 of a 200-mile fishery conservation zone, the National Marine Fisheries Service and the fishing industry's regional councils set domestic quotas to reduce overfishing of many of New England's fish stocks. At this time, it is difficult to assess the effectiveness of control measures because little is known about the natural fluctuation of fish populations, and because methods for recording catch size are imprecise.

A Sea Grant modeling project using the limited biologic and economic information available helps the troubled fishing industry devise a long-range management strategy for husbanding the nation's fish stocks. Professor John Devanney has developed a dynamic computer model that allows fishing stock managers to estimate stock population and age distribution of the yellowtail flounder on the fertile Georges Bank fishing grounds. By incorporating supply- and demand-based wholesale prices, the model estimates the economic effects that varying levels of fishing effort would have on the income of fishermen, on prices paid by consumers, and on the national economy. To enable the researchers to perfect their method, only one species was used in developing the model. However, the researchers are planning to expand the project to include other highly valued fish stocks in New England waters.

Improved Fishing Gear

Sea Grant researchers have produced an improved trawl board, the element of a fishing trawler's gear that holds the fishing net open as it drags behind the vessel. Because of its contoured shape, the new board spreads the net using hydrodynamic forces with an estimated decrease in drag of 20 to 40 percent over conventional rectangular boards. The reduction in drag could result in significant fuel savings or larger catches for the same fuel cost.

Arthur Clifton, MIT Sea Grant's marine liaison officer, and Cliff Goudy, who designed the new board while he was an MIT graduate student, are testing and modifying the board. Wharf Forging and Welding of Boston, one of the largest manufacturers of conventional boards, is contributing time and expertise by fabricating the new boards with materials supplied by Sea Grant. The board will be tested exhaustively during the next program year before the project is completed.

Skinning the Spiny Dogfish Shark

A prototype machine being designed and developed at MIT to automatically skin the spiny dogfish shark could help turn an abundant, underutilized species into a desirable and marketable product. The new machine, created by Professor David Wilson, closely follows a series of steps used by hand skinners who typically perform the task. The machine is about the size of an adult spiny dogfish shark—2 to 3½ feet long—and will be able to be used on board a fishing vessel as well as in an onshore processing plant. The engineers involved with the Sea Grant research project are consulting with machine manufacturers, and plan to have a partial design ready for testing in Summer 1978, when the fish will be plentiful in New England coastal waters.

The machine design evolved after Professor Cho Kyun Rha performed extensive tests of the stretching and tearing properties of spiny dogfish shark skin. The researchers also conferred with seafood processors to learn their experiences in skinning the fish, and to discuss which features, such as flesh color and the form of the skinned fish, have the greatest effect on successful marketing.

Cholesterol Levels in Fish

A reliable and relatively simple method developed to determine cholesterol levels in finfish and shellfish is helping to remedy a shortcoming of food labels by providing more accurate and complete nutritional information. The findings of a Sea Grant research team, led by Professor Samuel Goldblith and MIT Sea Grant Advisory Service Director, Ernst Pariser, are useful to doctors and dieticians concerned with the food intake of their patients, to seafood processors who must meet labeling requirements, and to people concerned about cholesterol intake in their diet.

Until recently, little reliable information was available on the cholesterol content of the edible parts of finfish, crustacea and mollusks. However, in testing more than 30 commonly-eaten species of raw and cooked fish, the researchers established that all of them were low in cholesterol, with typical servings containing between one-sixth and one-eighth the amount of cholesterol found in one egg. They also found that because cholesterol, which is found only in the fatty tissue of animals, is soluble in other fats, as much as one-third of the tuna's cholesterol migrates during processing into the vegetable oil in which the tuna is packed. Thus, much of the cholesterol can be discarded before the tuna meat is consumed.

Understanding Red Tide

Continuing research on the causes of toxic algal blooms, or red tides, is leading scientists closer to predicting bloom conditions. The blooms, which have occurred regularly in New England waters for the past five years, become a health hazard when the shellfish in the area filter the toxic *Gonyaulax tamarensis* cells from the water. When humans eat the tainted shellfish, they can be stricken with an ailment known as paralytic shellfish poisoning. Although not all blooms reach toxic levels, they frighten shellfish consumers, bringing heavy economic losses to shellfish industries.

With a research group, Professor Francois Morel, the first Henry L. Doherty Professor in Ocean Utilization, is studying estuarine locations on Cape Cod. Tests show that cysts, the dormant stage in the life cycle of the alga, represent a potential seed population for the annual blooms and may contribute to an increase of the geographic range of the blooms. The research also shows that revival of the cysts may synchronize early bloom development with rising and falling seawater temperatures. The knowledge of the existence of cysts in coastal sediments, along with monitoring of seawater temperature changes, may permit accurate forecasting of when and where toxic red tide blooms will occur.

Experimental coastal erosion control project uses sill bag method to raise beach.

Coastal Processes

Thoughtful application of technology is essential to the protection and preservation of the quality and beauty of Massachusetts' coast and neighboring waters. Sea Grant research on coastal erosion, nearshore currents and management of coastal zones encourages thorough consideration of the environmental and social impacts of development and exploration.

Sediment Transport

An analytic model devised by Professor Ole Madsen, the third Henry L. Doherty Professor in Ocean Utilization, will help engineers predict the rate of sand movement along the shore, and how installation of manmade coastal and nearshore structures will affect naturally occurring erosion and deposition. The model, which estimates the rate of wave-induced sediment transport, differs from existing models because it also predicts the distribution of sand transport with distance from shore, and considers grain size, a factor that can influence transport rates. An engineer using the model does not need a computer, but uses information, such as wave height and angle, beach slope and grain size in conjunction with a set of graphs Professor Madsen is devising to obtain transport rates. The design tool will be used by planners and engineers to locate structures where they will do the least harm to the coastal environment.

Modeling Massachusetts Bay

Sea Grant researchers in the Institute's Ralph M. Parsons Laboratory for Water Resources and Hydrodynamics have developed two-dimensional, descriptive mathematical models that predict the circulation and dispersion processes of Massachusetts Bay. Coastal zone planners and environmental engineers can apply the models toward preserving the Commonwealth's fertile coastal waters while fostering the onshore and offshore development that is crucial for its economy.

Under the direction of Professors Jerome Connor and Bryan Pearce, researchers used the models to determine the bay's natural capabilities for dispersing fresh- and wastewater effluents. The Massachusetts Bay models, which can also be applied to other coastal waters, have been used by the Boston Edison Company for thermal outfall studies, and for site evaluations in areas such as Great Egg Harbor, New Jersey, and Moreton Bay, Australia.

Coastal Erosion

Members of MIT Sea Grant's advisory service are working with four coastal communities on Cape Cod to learn if a relatively new erosion control measure can be used successfully on certain kinds of beaches.

The method uses plastic bags, called sill bags, to raise or perch the beach as sand builds up behind and in front of the bags. The bags, 13 feet long by 4 feet wide by 3 feet high, are placed parallel to the beach a few feet below the mean high water mark. The bags are filled on site with a pump and hose with sand from the foreshore and form a continuous protective barrier as they trap sand carried over them by waves and currents.

Sea Grant staff at the Virginia Institute of Marine Science reports the method's success on protected beaches within the Chesapeake Bay. However, the concept still requires testing in the more active, exposed Massachusetts coastal environment, particularly under harsh winter conditions. For one year, MIT Sea Grant's coastal engineer will measure and record the profiles of sill bag perched beaches at at least four coastal sites, to assess the effectiveness of the method in solving erosion problems, and to learn the best conditions and techniques for future installations.

Technology for Ocean Uses

Heightened interest in the oil deposits off the New England coast calls for more sophisticated technologies to be used in deep ocean construction and exploration. Sea Grant research on how materials, machines and structures respond to the ocean leads to more effective construction and repair offshore.

Response of Offshore Structures to Random Ocean Waves

Design of a structure to be placed in the ocean must undergo rigorous, detailed and expensive structural analysis so that the engineers can estimate how the structure will respond to battering by random ocean waves. Professor J. Kim Vandiver, the second Henry L. Doherty Professor in Ocean Utilization, is creating an analytic technique that helps engineers predict, simply and inexpensively, structural dynamic response to wave excitation. The technique is especially useful for early design stage estimates of structural life expectancy.

The approach does not require detailed features of the final design, and eliminates the gross approximations and cumbersome computations of existing techniques. An engineer using it needs to know only the structure's estimated natural frequency, the wave conditions typical to the structure site, and the gross geometric layout of the structure.

Professor Vandiver is currently studying ways to use liquids contained onboard offshore structures to reduce the dynamic response at the structural natural frequencies. The related reduction in structural dynamic response will result in increased fatigue life.

Undersea Robots and Telemanipulators

Sea Grant-sponsored research projects on unmanned, untethered, undersea vehicles work toward remote control systems for performing search, survey, repair and construction tasks in the oceans. Use of machines controlled by human operators on the water surface will spare human divers from performing many dangerous tasks, thereby reducing the high loss of lives and the tremendous sums invested in life support systems required by human divers.

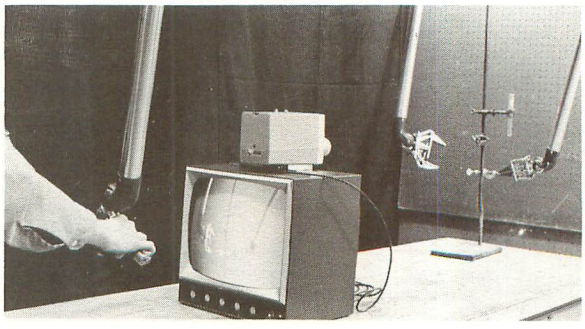
Guided by Professor A. Douglas Carmichael, students are fitting a side-scan sonar to a free-swimming, computer-controlled underwater robot designed and built five years ago by students in the MIT Ocean Engineering Summer Lab. The sonar device will increase the capabilities of the robot to collect oceanographic data and to perform certain search and survey missions.

In a related project, Professor Thomas Sheridan is building and testing undersea teleoperators with general purpose arms, hands, and video/sonar/tactile sensors. The machines assist manned or unmanned submersibles in better performing undersea tasks. The researchers are studying the intriguing problem of how best to direct the teleoperator, using a mix of human intelligence and automatic control.

Underwater Welding

Professor Koichi Masubuchi is developing welding and cutting techniques for construction and repair of offshore structures such as oil rigs, pipelines and underwater storage tanks. He has adapted the flux shielded arc welding method to eliminate the problems of rapid cooling caused when seawater comes into contact with the unhardened weld. With the adapted technique, the joining task is performed within an insulated, watertight plastic enclosure. A diver working outside the enclosure inserts an electrode through the plastic and the weld hardens before the water rushes through the puncture.

The MIT researchers are refining the welding method, conducting tests in a tank they have designed and built to simulate the high pressure ocean environment in which the welding tasks typically are performed. Not only will the improved underwater technique ease repair and construction tasks in the deep ocean, but it may also facilitate design and construction of offshore structures and installations so massive that they must be assembled at sea.



Laboratory demonstration of undersea telemanipulator

Undersea Degradation of Polymers

Polymers, especially polyethylene, are used to insulate cables that conduct electricity needed by offshore structures. However, mechanical stress and the unfavorable chemical environment of the ocean speed degradation of various common polymers.

Professors Richard Donnelly and Robert Cohen are modifying the surfaces of the polymers to increase their resistance to seawater degradation. Thus far, the continuing Sea Grant research has led to methods for determining the degree of degradation of polymers in a marine environment and to a surface treatment for polyethylene that allows coating procedures that could significantly enhance the stability of the polymers. Results of the project may broaden the applications of polymers for both ocean and non-ocean uses.

Measuring Soil Properties

Results of Sea Grant research on the support capacity of ocean sediments are helping engineers assess the risk that foundations of offshore structures might undergo excessive sediment movements, a potential cause of enormous damage to the installation and the surrounding environment. With land-based structures, soil properties are usually determined in the laboratory using "undisturbed" samples taken from the ground. But this procedure is very difficult and costly when working offshore, so Professors Mohsen Baligh and Charles Ladd are experimenting with a cone penetration device for *in situ* evaluation of the properties of marine sediments.

Measurements of the cone resistance and pore water pressure that develop during penetration help identify soil types and their strength-deformation characteristics. The researchers have correlated cone penetration test data with known soil conditions at three on-land sites and are now planning to perform similiar experiments at selected sites offshore. The research should enable a more rapid and economical assessment of the suitability of sites for offshore installations and better predictions of their performance.

Opportunities from the Ocean

The oceans, vast and mysterious, have long lured adventurous and creative minds with their bounty and potential. Sea Grant works with individuals, communities, companies and nations in pursuing opportunities in the seas, and helps them apply appropriate scientific, environmental and economic principles.

Chitin

Shellfish processing wastes comprise an abundant source of chitin, a natural material related to cellulose. Industrial interest in chitin and its derivative, chitosan, is growing because the materials have many promising applications in medicine, papermaking, adhesives, natural and synthetic fibers, pharmaceuticals and food processing.

In a continuing MIT Sea Grant project to foster industrial and commercial uses for chitin and chitosan, researchers are studying and refining processing techniques and controls for production of clear, flexible chitosan films previously developed through Sea Grant research.

Although the films made thus far at MIT are strong and impervious to air and water, experiments show that they vary in quality and strength according to processing methods and the quality and sources of chitosans used.

Professor Benjamin Averbach is pursuing research on the physical and chemical characteristics of chitosan, in film and other forms, and the ways in which the material's exceptional binding powers can be applied in adsorbing contaminants, including radioactive heavy elements, from polluted waters.

In April 1977, the MIT Sea Grant Program and the Massachusetts Science and Technology Foundation co-hosted the First International Conference on Chitin and Chitosan. The meeting, attended by 90 representatives from 14 nations, fostered interaction among researchers and companies worldwide as they continued to investigate chitin's properties, potentials and industrial applications.

Harnessing Wave Energy

Sea Grant researchers are investigating the mechanical and economic aspects of a system to extract energy from ocean waves. Such a system, used in coordination with other potential sources of energy from the ocean, could provide energy to ease the nation's dependence on fossil fuels.

Professors Chiang C. Mei and A. Douglas Carmichael are working to confirm and expand previous experimental data on a hollow floating device, known as a Salter cam, that is rocked by the waves and absorbs energy from them as they pass. The next step in the research process is to consider solutions to practical problems associated with the cam, such as anchorage of the cam, energy conversion, storage and transmission.

Policy for Deep Ocean Mining

New technology has made it possible to recover significant deposits of mineral-rich manganese nodules from seabeds in international waters. Professor J. D. Nyhart and research assistants have created a computer cost model that could be used by the U.S. government as a tool for creating an ocean mining policy which would consider both the rights of American investors and the international community. The model, which has been reviewed by representatives of both industry and government, calculates capital and operating costs of a "typical" deep-sea mining company. It allows users to estimate changes in tax laws, market conditions and delays in using existing technology on return on investment to the company. Congressional committees and government agencies, seeking to establish a stable investment climate for U.S. industry and to assure fair profit sharing arrangements with other nations, will benefit from the detailed economic information available through this model.

Offshore Technology Under Extended Jurisdiction

When the United States extended its territorial boundaries from 12 to 200 miles seaward, it assumed control of resource development off the nation's coasts. To help the government proceed with plans for enforcing regulations that apply within extended U.S. coastal waters, Professor J. D. Nyhart has developed a model that identifies existing laws on fishing, dumping, marine safety and the environment. The information, which has been included in several ocean law courses at MIT and Harvard, is being used to conduct a cost study for use in establishing enforcement procedures.

International Marine Technology Transfer

The 1976-1977 year saw completion of a comprehensive study to help the federal government establish an effective means for sharing marine science and technology with other nations. In light of growing realization that the earth's land resources are indeed limited, the researchers, led by Professor Judith Kildow, studied such questions as who will have access to data on marine resources, and how the information can be used by both developed and less-developed countries in exploring global resources. The project resulted in studies of socio-political-economic aspects of international marine technology transfer, of scientific and technical aspects, and in a proposal for a technology sharing program, with a hypothetical case study with Mexico and the United States as possible participants.

Dr. Harold E. Edgerton and Mr. Dean A. Horn watch as Mrs. Edgerton christens new MIT research vessel.

Research Vessel EDGERTON

Under the direction of Sea Grant Marine Liaison Officer, Arthur Clifton, MIT added a new ocean-going laboratory to its facilities this year. The Research Vessel EDGERTON is available through charter to engineers and researchers from the Institute, industry and other universities who need to gather data or to test equipment at sea. Compact by research vessel standards, the 65-foot, 90-ton ex-Army T-Boat is designed for small groups needing an economical and flexible working platform. The EDGERTON, outfitted and maintained by the Institute, is managed by Sea Grant for use in oceanographic and ocean engineering research along the New England coast or in deeper waters on the continental shelf.

Oil on the Water

Events during Winter 1976/1977 clearly proved that the combination of rough seas and obsolete oil tankers magnifies the threat of environmental and economic damage to our shores. MIT Sea Grant sponsors research in response to the need for equipment that can effectively contain oil on the high seas, and for basic information about the interaction of oil with waves and currents.

Understanding Oil

Currently, scientists and engineers do not understand precisely how various floating oils interact with seawater. In one Sea Grant project, Professors Jerome Milgram and Robert Van Houten have constructed a unique precision flume, a narrow channel that allows them to observe the unstable boundary between oil and the moving water that pulls oil bubbles beneath containment barriers. Because the channel has a design that minimizes turbulence, it allows accurate measurement of the effect of spilled oil in simulated seawater currents. The flume test results will be used to understand the important interactions and to specify more effective methods and equipment for cleaning up oil spills at sea.

Another ongoing Sea Grant project also can be applied toward improving oil slick control under typical offshore current and wave conditions. Professor Keith Stolzenbach and a research team reviewed and evaluated basic techniques being used at the present time for predicting the short- and long-term behavior of surface oil slicks.

Crisis Response to Oil Spills

The basic understanding gained through research enables Institute faculty to contribute solutions when oil accidents occur at sea. The Coast Guard's standard model for tracking and predicting the transport of oil spills is based largely on the 1972/1973 Sea Grant-sponsored Georges Bank Petroleum Study, by Professor John Devanney. And when the tanker ARGO MERCHANT grounded near Nantucket, Massachusetts in December 1976, Professor Milgram, who was working on a Coast Guard project to study dispersion of oil into the seas, went to the stranded vessel to observe the spill and its interaction with breaking waves. He subsequently wrote a Sea Grant report, "Being Prepared for Future ARGO MERCHANTS," outlining his observations and recommendations for preventing calamitous spills from damaging the coastline. The report, widely read by legislators, government officials and engineers, provided the basis for Professor Milgram's testimony before the House Subcommittee on Energy and the Environment.

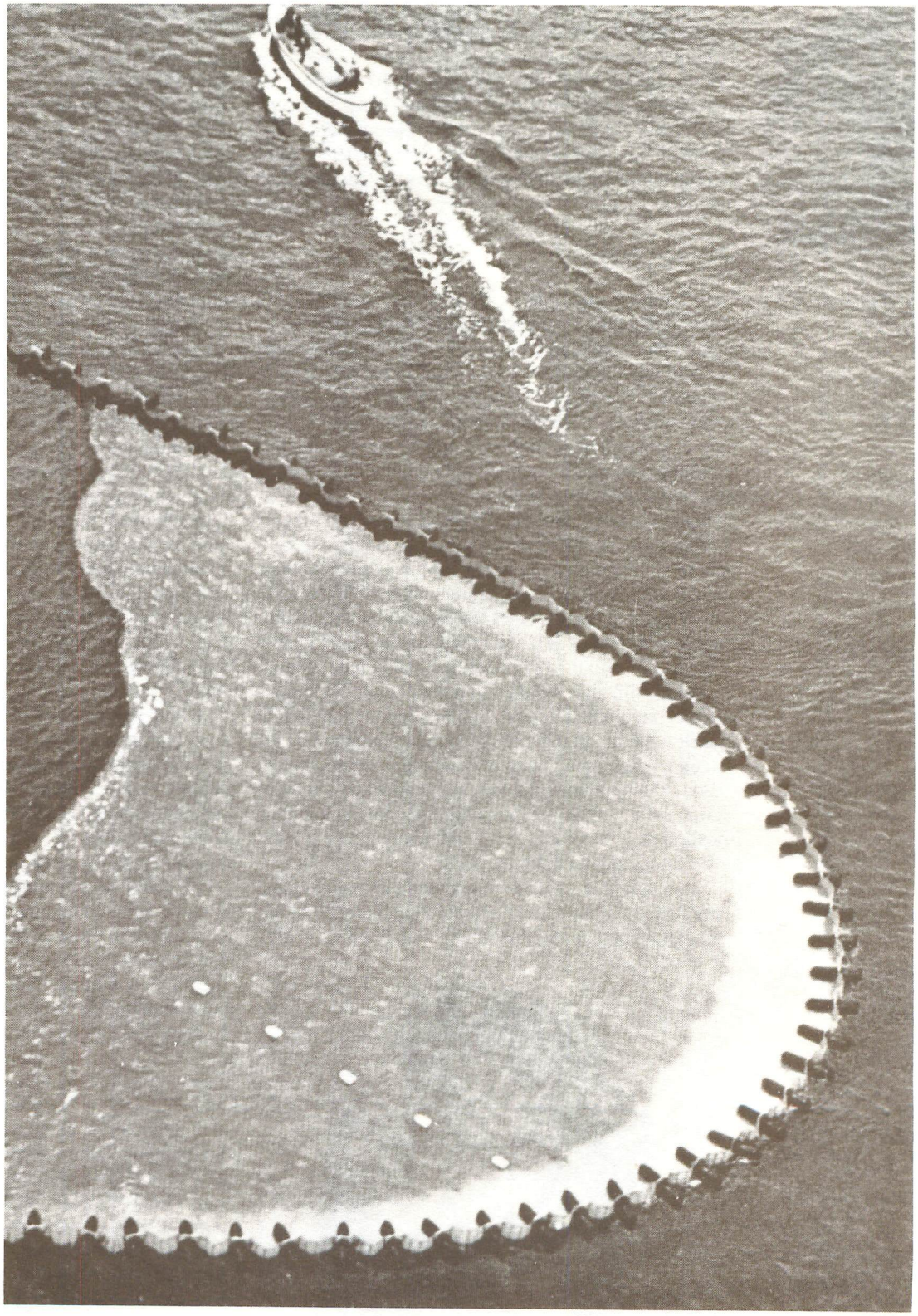
A second Sea Grant research project prompted by the ARGO MERCHANT crisis is a comprehensive assessment of the scientific community's response to the grounding and spill. Professor Stolzenbach treats the scientific work following the spill as a case study of post-spill science and evaluates the qualities of the various efforts.

Environmental Considerations

While Sea Grant is concerned with immediate and efficient response to offshore spills, an investigation of the natural environmental recovery of two shoreline areas known to have been innundated by spilled oil during World War II lends historical perspective to the problem. Sea Grant investigators Bradlee Campbell, Edward Kern and Dean Horn analyzed available information on tanker sinkings that occurred during the war within 50 miles from shore. During the first six months of the war, 20 times as much oil may have been spilled by the 100 tankers sunk by German submarines as was spilled by the ARGO MERCHANT.

The ocean engineers compared historical and present-day ecologies of the shoreline sites, and found no conclusive evidence of the effect of the oil on the environment. However, they recommend that biologists and environmental engineers continue the research, which may prove valuable in current debates over the long-term impacts of offshore petroleum development and the effects of deep-water ports on coastal citizens and industries.

Aerial photograph of an oil boom holding oil. The boom is being towed by two tow vessels out of the picture to the left.



Student researcher conducts laboratory experiments.

Through a variety of educational programs and activities, the Sea Grant Program, at MIT and across the nation, shares its awareness of the potential and power of the earth's water resources. By cooperating and learning, people participating in Sea Grant educational programs help advance understanding of the seas, and assume responsibility for protecting our marine wealth.

Student Summer Lab

Students in the MIT Sea Grant Program's summer ocean engineering laboratory gain practical experience in developing, building and testing equipment for use in the oceans. Through the project, bright, energetic and creative students increase their familiarity with ocean processes, while learning to cope with the problems of performing engineering tasks in the ocean environment.

In the sixth summer lab, MIT students joined with cadets at the Maine Maritime Academy in Castene, Maine to perform field trials on instruments they had independently designed and constructed during the school year. Some of the ocean engineering projects included the following: A controllable grappling hook, an oceanographic sampler dredge installation, a line tension meter, and a research project on mooring. Students continued research and testing on three projects from previous summer labs—an undercycle, or pedalled underwater vehicle for scuba divers, a buoy-mounted electric generator powered by winds or tidal currents, and a portable floating breakwater.

Students also conducted an eel survey of the Bagaduce River, and examined the feasibility of growing deep-sea scallops on a commercial scale.

Students take oceanographic measurements.

Lynn Harbor Redevelopment

In response to a request from the City of Lynn, Massachusetts, students enrolled in a Sea Grant education project continued an investigation, started in 1975/1976, showing that new uses for the once-bustling harbor area could help to revitalize Lynn's commercial base. Like many coastal industrial cities, Lynn, once a thriving center of commerce, industry and residence, suffers from a combination of population loss, lack of employment opportunities, a shrinking economic base, and physical deterioration of existing structures. However, the student study suggests that careful redevelopment could begin to remedy some of the problems.

Under the direction of Professor William Seifert, in 1976/1977 students in the interdisciplinary systems design subject responded to Lynn's request that they continue the study. With partial funding from the City of Lynn, the study team conducted a more detailed evaluation of the impact of the Massachusetts Coastal Zone Management Plan on the city, and of the technical, legal and economic aspects of redevelopment. The final study was presented to the Lynn Harbor Task Force, City Planning Office, City Council and all interested citizens in June 1977.

The project continues a long-standing Sea Grant education project that each year engages MIT students in solving a complex "real world" problem of current interest. Solution of these problems requires talents of students from technical, managerial, economic, socio-political and legal disciplines and encourages students to work as a coordinated project team. The Lynn project follows earlier student investigations of the problems and conflicts facing communities on Boston's South Shore, and of the natural, political, social and economic resources of Gloucester, Massachusetts, one of New England's leading fishing centers.

State-Industry/Sea Grant Internships

The successful internship of MIT student Kristopher Horvath in the Massachusetts Office of Coastal Zone Management led to the continuation of the internship project in 1977/1978. Through the internships, students gain practical, professional experience in ocean engineering and marine science through the opportunity to work in legislative offices, committees and

Participants in ocean engineering summer laboratory.

commissions, and with marine industries.

In 1976/1977, Mr. Horvath helped formulate Massachusetts' comments concerning a Mid-Atlantic lease sale. For this project, he gathered information on areas where there is a high interest in fishing, significant risk of oil spills coming ashore, and potential interference with established shipping patterns and spawning grounds. He also studied the activities and operation of the New England Fisheries Management Council, and prepared a flow chart of the federal decision process for approving the development of offshore oil and gas reserves.

Marine Educational Programs

Sea Grant fosters educational programs in marine science and engineering at MIT. Through the Henry L. Doherty Professorships in Ocean Utilization, Sea Grant encourages junior faculty members to become involved in expanding the uses of the oceans and their resources. In 1977, Professor Ole. Madsen was awarded the third Doherty Professorship for his research project to develop a model capable of measuring the rates of longshore sediment transport, and the resulting coastal erosion and deposition.

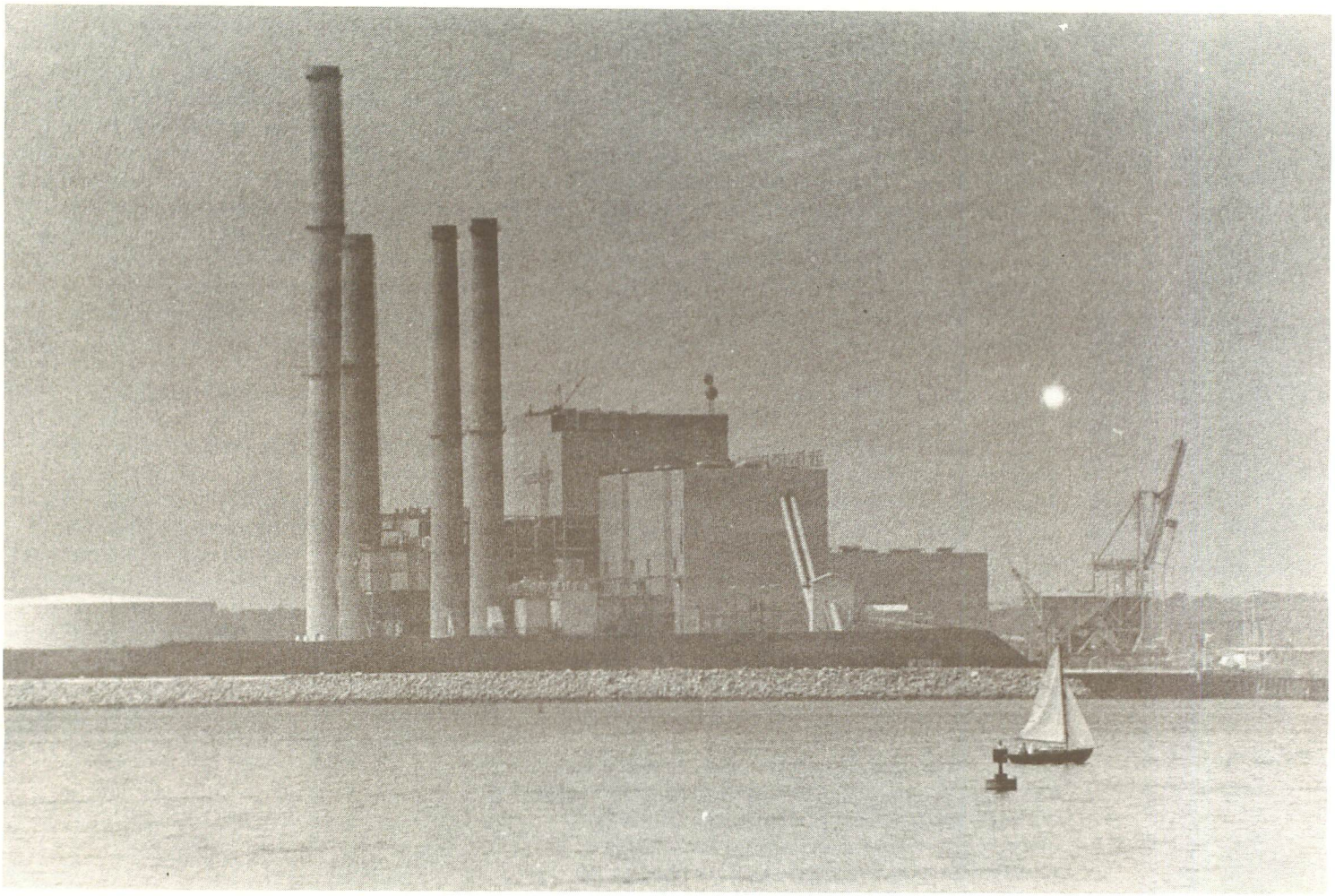
Through curriculum development related to Sea Grant goals, during academic year 1976/1977 the MIT Department of Ocean Engineering offered four new subjects: Boundary Layers, Free Surface Hydrodynamics, Offshore Engineering Design, and Introduction to Random Process in the Ocean. Sea Grant Program public education and training short courses expose participants in MIT's Summer Program to the latest techniques, developments and technical progress in selected marine resources fields. During Summer 1977, engineers and scientists from industry, business and government attended one-week courses cosponsored with the Office of Summer Sessions. Courses included: Transportation Systems Management and Analysis, Air Transportation, Port Planning and Development, Urban Transportation, Freight Transportation, Forecasting Transportation Demand, Design and Construction of Offshore Facilities, and New Frontiers in Welding Technology.

Commerical Fisheries Training Program

This year, Sea Grant initiated a project to expand the commerical fisheries training program for upperclassmen at the Massachusetts Maritime Academy. The program draws on the reservoir of highly motivated students, and trains them to be qualified, licensed professionals for New England's commercial fishing industry. As a public service, the program also will offer special workshops and sessions to retrain active fishermen who wish to improve their navigation, safety and management skills.

Marine Education at the Pre-College Level

MIT Sea Grant is helping to develop innovative marine education materials for use in classes from kindergarten through grade 12. With growing Congressional awareness and support for marine education at the elementary level, MIT Sea Grant is acting on its commitment to this area. During the last year, for instance, Sea Grant established firm connections with representatives of the New Bedford, Massachusetts public school system, and will cooperate in a long-term, intensive marine education development effort.



Fiscal Year 1977 Institutional Program Summary

For year beginning 1 July 1976

Program Management	Sea Grant Program Management	Mr. D. A. Horn	Continued project
	Project Development Opportunities	Mr. Horn	Continued project
Education and Training	Interdisciplinary Systems Design Subject	Professor W. W. Seifert	Continued project
	Student Summer Laboratory	Professor A. D. Carmichael and Mr. K. Keays	Continued project
	Ocean Engineering Curricula	Dr. I. Dyer	Continued project
	State Industry Internships	Professor J. D. Nyhart	Continued project
	Development of a Commercial Fisheries Training Program	Mr. W. D. DuPaul and Mr. A. B. Clifton	New project
Advisory Services	Advisory Services: Development, Operation and Management	Mr. E. R. Pariser	Continued project
	Communications/Information Service	Ms. E. Harding	New project
	Development of a Marine Industry Advisory Service	Mr. N. Doelling	Continued project
	MITSG/CES Marine Extension Service	Mr. Pariser and Dr. J. Noyes	New project
	Public Education and Training Short Courses	Professor J. M. Austin	Continued project
	Annual Sea Grant Lectureship	Dean Keil	Continued project
	Analysis of Decision Processes for the Sea Grant Program	Dr. J. H. Hollomon	New and completed project; report published
	First International Conference on Chitin/Chitosan	Mr. Pariser	New and completed project; report will be published

Research	The Hydrodynamic and Engineering Evaluation of an Ocean Wave Energy System	Professors Carmichael and C. C. Mei	New project
	Development of Joining and Cutting Techniques for Deep Sea Applications	Professor K. Masubuchi	New project
	Exploration and Evaluation of Engineering Properties of Marine Soils for Foundation Design of Offshore Structures	Professors M. M. Baligh and C. C. Ladd	New project
	Application of Teleoperators to Undersea Tasks	Professor T. Sheridan	New project
	Enhancement of the Stability of Common Polymeric Materials Against Undersea Degradation	Professors R. G. Donnelly and R. E. Cohen	New project
	Regulation of Offshore Technology Under Extended Jurisdiction	Professor Nyhart	Completed project; report will be published
	Dynamic Analysis of Offshore Structures	Professor J. K. Vandiver	New project
	Review and Evaluation of Oil Spill Trajectory Models for Use in Risk Assessment Associated With Deep Water Ports	Professor K. Stolzenbach	New and completed project; report published
	Oil Slick Control in Offshore Environments	Professor J. H. Milgram	Continued and completed project; report will be published
	An Improved Trawl Door Hook-up System	Mr. Clifton	Continued and completed project; report will be published
	Content, Composition and Fate of Physiologically Important Lipid Components in Raw and Processed Shell and Finfish	Professor S. A. Goldblith and Mr. Pariser	Continued and completed project; report will be published
	Georges Bank Fisheries Study	Professor J. W. Devanney III	New and completed project; report published
	An Improved Trawl Board for the New England Fishing Industry	Professor Vandiver and Mr. Clifton	New project
	Chemical and Structural Characterization of Chitin Derivatives for Industrial Applications	Professor B. L. Averbach	New project
	Development of Processes for Skinning the Spiny Dogfish Shark	Professors D. G. Wilson and C. K. Rha	New project
	The Sea Environment of Massachusetts Bay and Adjacent Waters	Professors Connor and B. R. Pearce	Continued and completed project; reports published
	The Role of Trace Metals on New England Red Tides	Professor F. M. M. Morel	Continued project
	Longshore Sediment Transport	Professor O. S. Madsen	New project

Study of a Cost Model of Deep Seabed Mining	J. D. Nyhart	New and completed project; report published
Computer Documentation Dissemination	Professor Connor	New project
Offshore Brine Disposal	Professor Stolzenbach	New project
Development of a Guide of Information Sources in the Field of Offshore Engineering	Ms. M. Chryssostomidis	New project

Advisory Services	Doelling, N.	An Invitation to Opportunity	MIT/Marine Industry Collegium, Massachusetts Institute of Technology, Cambridge, Mass.
	MIT/Marine Industry Collegium	Electron Irradiation, Sewage Sludge and Aquaculture: Marine Industry Advisory Service	Opportunity Brief 6. MITSG 77-14. Massachusetts Institute of Technology, Cambridge, Mass.
	MIT/Marine Industry Collegium	Closed-Cycle Aquaculture: Marine Industry Advisory Service	Opportunity Brief 7. MITSG 77-15. Massachusetts Institute of Technology, Cambridge, Mass.
	MIT/Marine Industry Collegium	Computer Models for Environmental Engineering and Research in Near-Coastal Environments: Marine Industry Advisory Service	Opportunity Brief 8. MITSG 77-16. Massachusetts Institute of Technology, Cambridge, Mass.
	MIT/Marine Industry Collegium	Oil Spills: Problems and Opportunities: Marine Industry Advisory Service	Opportunity Brief 9. MITSG 77-17. Massachusetts Institute of Technology, Cambridge, Mass.
	Ashford, N., D. Hattis and A. Murray	Industrial Prospects for Chitin and Protein from Shellfish Wastes	MITSG 77-3. Massachusetts Institute of Technology, Cambridge, Mass.
	Passero, B.	Marine-Related Research at MIT, Including Projects on Marine Resources, Ocean Utilization and Coastal Zone Management	MITSG 77-12. Massachusetts Institute of Technology, Cambridge, Mass.
	Passero, B.	Extended Fisheries Jurisdiction: A Partially Annotated Bibliography with Special Reference to New England	MITSG 77-5. Massachusetts Institute of Technology, Cambridge, Mass.

Keil, A. H., W. Hargis, G. Mechlin and M. Pitkin	The United States and the Oceans: Opportunities for Independence; 5th Annual Sea Grant Lecture	MITSG 77-1. Massachusetts Institute of Technology, Cambridge, Mass.
	Bringing the Oceans into America's Future: A Report on the Massachusetts Institute of Technology Sea Grant Program	MITSG 77-2. Massachusetts Institute of Technology, Cambridge, Mass.
	MIT Sea Grant: Oceans and Answers	Massachusetts Institute of Technology, Cambridge, Mass.
	Extension Sea Grant Advisory Program: Serving Massachusetts Citizens	Massachusetts Institute of Technology, Cambridge, Mass.
	Research Vessel EDGERTON	Massachusetts Institute of Technology, Cambridge, Mass.
Simon, C.	A Citizen's Guide to Sources for Marine and Coastal Information in Massachusetts	MITSG 77-13. Massachusetts Institute of Technology, Cambridge, Mass.
Extension Sea Grant Advisory Program	Survival in Cold Water	Marine and Coastal Facts No. 1. University of Massachusetts, Amherst, Mass.
Extension Sea Grant Advisory Program	Stabilization of Barrier Dunes by Vegetation	Marine and Coastal Facts No. 2. University of Massachusetts, Amherst, Mass.
Extension Sea Grant Advisory Program	Cholesterol in Finfish	Marine and Coastal Facts No. 3. University of Massachusetts, Amherst, Mass.

Living Marine Resources	Ezekiel, S., W. Kerfoot and G. White	Spectrofluorometric Differentiation of the Red Tide Alga, *Gonyaulax Tamarensis* from Other Algae Common to New England Waters	MITSG 77-18. Massachusetts Institute of Technology, Cambridge, Mass.
	Devanney, J. W., H. Simpson and Y. Geisler	The MIT Single-Species Fisheries Simulator: Application to the Georges Bank Yellowtail	MITSG 77-21. Massachusetts Institute of Technology, Cambridge, Mass.
Coastal Processes	Christodoulou, G. C., J. J. Connor, Jr., J. R. Pagenkopf and B. R. Pearce	Cafe II: A Two-Dimensional Finite Element Circulation Model	MITSG 77-6. Massachusetts Institute of Technology, Cambridge, Mass.; Ralph Parsons Laboratory for Water Resources and Hydrodynamics.
	Christodoulou, G. C., J. J. Connor, Jr., J. R. Pagenkopf and B. R. Pearce	Disper II: A Two-Dimensional Finite Element Dispersion Model	MITSG 77-7. Massachusetts Institute of Technology, Cambridge, Mass.; Ralph Parsons Laboratory for Water Resources and Hydrodynamics.
	Madsen, O. S.	A Realistic Model of the Wind-Induced Ekman Boundary Layer	MITSG 77-11. Reprinted from Journal of Physical Oceanography, Vol. 7, No. 2, March 1977.
Oil on the Waters	Horn, D. A., B. Campbell and E. Kern	Impact of Oil Spillage from World War II Tanker Sinkings	MITSG 77-4. Massachusetts Institute of Technology, Cambridge, Mass.
	Milgram, J.	Being Prepared for Future Argo Merchants	MITSG 77-10. Massachusetts Institute of Technology, Cambridge, Mass.
	Milgram, J. and R. Van Houten	A Flume for the Study of Contained Oil Slicks	MITSG 77-19. Massachusetts Institute of Technology, Cambridge, Mass.
	Stolzenbach, K., O. S. Madsen, E. Adams, A. Pollack and C. Cooper	A Review and Evaluation of Basic Techniques for Predicting the Behavior of Surface Oil Slicks	MITSG 77-8. Massachusetts Institute of Technology, Cambridge, Mass.

New Opportunities from the Oceans	Kildow, J.	International Transfer of Marine Technology, A Three-Volume Study	MITSG 77-20. Massachusetts Institute of Technology, Cambridge, Mass.
Technology for Ocean Uses	Baligh, M. M., V. Vivatrat and C. C. Ladd	Interim Report: Exploration and Evaluation of Engineering Properties of Marine Soils for Foundation Design of Offshore Structures	Massachusetts Institute of Technology, Cambridge, Mass.
	Garry, M. J.	Polymer Surface Modification Using a Surfactant Adsorption Technique	S. M. Thesis, Department of Chemical Engineering, Massachusetts Institute of Technology, Cambridge, Mass., 1977.
	Masubuchi, K., A. Moore, H. Ozaki, S. Prasad, C. Tsai and L. Zanca	Development of New, Improved Techniques for Underwater Welding	MITSG 77-9. Massachusetts Institute of Technology, Cambridge, Mass.
	Mei, C. C.	Numerical Theory of Water Wave Diffraction and Radiation	Annual Review of Fluid Mechanics, Vol. 10, 1978.
	Vandiver, J. K.	The Use of Finite Element Models in Dynamic Analysis of Offshore Structures	Finite Element Applications in Vibration Problems, American Society of Mechanical Engineers, Boston, Mass., 1977.
	Vandiver, J. K.	Structural Damage Detection by Measurement of Dynamic Response	Proceedings, Society of Naval Architects and Marine Engineers, No. T4-3, 1977.
	Schott, W. E. III	Response and Radiation of Structures in an Irregular Seaway	S. M. Thesis, Department of Ocean Engineering, Massachusetts Institute of Technology, Cambridge, Mass., 1977.
	Caven-Atack, J.	The Effect of Changes in Foundation Support Conditions Upon the Natural Response Frequencies of Bottom Supported Offshore Structures	S. M. Thesis, Department of Ocean Engineering, Massachusetts Institute of Technology, Cambridge, Mass., 1977.

	Mitome, S.	The Effect of Liquid Storage Tanks on the Dynamic Response of Offshore Platforms	S. M. Thesis, Department of Ocean Engineering, Massachusetts Institute of Technology, Cambridge, Mass., 1977.
	Yue, D. K. P., H. S. Chen and C. C. Mei	A Hybrid Element Method for Three-Dimensional Water Waves	International Journal for Numerical Methods in Engineering, 1977.
		A Hydrid Element Method for Calculating Three-Dimensional Water Wave Scattering	Civil Engineering Dept. Report 215, Ralph Parsons Laboratory for Water Resources and Hydrodynamics, Massachusetts Institute of Technology, Cambridge, Mass.
Education	Carmichael, D., K. Keays and D. Small	Ocean Engineering Summer Laboratory, 1976	MITSG 77-22. Massachusetts Institute of Technology, Cambridge, Mass.
	Herr, P., et al.	Managing Gloucester's Coast	MITSG 77-23. Massachusetts Institute of Technology, Cambridge, Mass.

Summary of Expenditures by Activity

		NOAA Grant Funds	University Matching Funds
Program Management	Program Administration	$ 90,200	$112,046
	Program Development	40,000	61,987
Marine Education & Training	College Level	20,200	60,100
	Vocational Marine Technical Training	37,600	35,610
	Other Education	17,300	12,866
Socio-Economic & Legal Studies	Marine Economics	202,500	8,088
	Ocean Law—Coastal	15,000	7,792
Marine Resources Development	Marine Extracts—Other	72,000	23,562
Marine Technology Research & Development	Ocean Engineering	165,800	81,440
	Resources Recovery & Utilization	89,700	40,410
Marine Environmental Research	Pollution—Oil Spills	20,700	11,971
	Environmental Models	184,200	62,001
Advisory Services	Extension Programs	203,600	99,229
	Other Advisory Services	90,000	50,652
	TOTAL	$1,248,800	$667,754

This summary is only approximate. In accordance with Federal grant requirements, the official financial report will be submitted by the MIT Comptroller to the Office of Sea Grant.

Participants and Contributors

Environmental Devices Corporation
Fishing Industry Support—Massachusetts
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Sea Grant Lecture Endowment Funds
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Westerbeake Fishing Gear Company—Boston
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