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Quarterly Report

Systems Approach to Oil Spill Clean-up

Zero oil spills sounds like a good slogan, but it can't stand up as a realistic objective. Somewhere in the design, manufacture, or operation of ships, refineries, or offshore platforms, human error will inevitably trigger an accident. Thus, each year industry and government officials work simultaneously to reduce spills wherever possible, and clean them up wherever necessary.

Those people responsible for clean-up decisions face an extremely complex problem, according to MIT Sea Grant principal investigators J.D. Nyhart, Professor of Management in the Sloan School of Management and Department of Ocean Engineering, and Harilaos N. Psaraftis, Assistant Professor of Marine Systems in the Department of Ocean Engineering. The two researchers stress that the people who formulate laws and regulations and specify oil spill response must cut through a web that includes law, economics, environmental science, management and logistics.

Each oil spill is unique. Different kinds and volumes of oil escape in different places under random weather conditions. And each time, someone must decide what kind of equipment is needed for clean-up, and must locate and mobilize it. Then someone must assess the damages, decide who might be liable, and settle on compensation. Every aspect of these decisions is fraught with ambiguities and unknown variables. The U.S. Coast Guard has developed a response system, which in many ways has been highly effective. But no overall management comprehensively covers oil spill clean-up problems.

At an MIT Sea Grant Marine Industry Collegium meeting in 1979, Ralph Bianchi, a clean-up equipment manufacturer, suggested that MIT organize a research project that could clarify related issues. He noted that the most common spills, those in the moderate range of 100,000 gallons, needed particular attention. Professors Nyhart and Psaraftis prescribed systems analysis. The result will be an economic and regulatory model that integrates all aspects of spill clean-up into a coherent decision-making process.

During the past two years Nyhart and

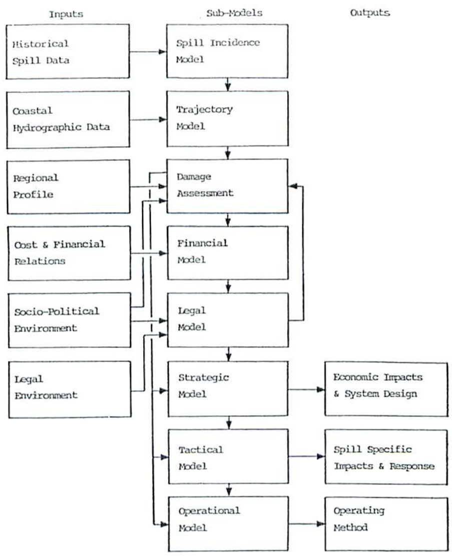

Figure 1. Diagram shows inputs to submodels that, combined, help assess potential costs for developing a comprehensive clean-up system and implementing it for specific spills.

Psaraftis have worked with an advisory committee of organizations concerned with the costs and damages of oil spills. The committee includes the U.S. Coast Guard, the U.S. Navy, the Oil Spill Control Association of America, JBF Scientific, Texaco, Atlantic Richfield, the Doherty Foundation, the Commonwealth of Massachusetts, the National Office of Coastal Zone Management, the Sierra Club, the New England Legislative Caucus, and the Oil Spill Intelligence Report. The committee and the research team are working together to collect input data and critique the model as it evolves.

The Sea Grant team believes that several characteristics of the model are especially desirable. It is modular so that modifications can be plugged in as new technology and scientific information become available. Sensitivity analysis has been applied to test unconfirmed data and parameters. Countering arguments that the lack of reliable data in the oil spill clean-up problem might preclude a good model, the researchers maintain that "it is precisely this factor that makes the need of a systems study critically important. A sensitivity analysis on vague parameters is a sound way to establish the degree of importance of the parameter in relation to an overall problem."

The model's hierarchical structure with three levels—strategic, tactical, and operational with interwoven submodels as shown in Figure 1—is perhaps its most important characteristic. The fully constructed model analyzes the technical, legal, logistical, and environmental facets of comparing the costs and damages of choosing various clean-up system options, or of deciding to let the marine environment absorb "acceptable" levels of damage.

The strategic model is designed for planning the kinds, quantities, and locations of equipment to be stockpiled for responding to different spills over a specified time. The strategic model makes it possible to observe costs over the life cycle of the response system, including capitalization and maintenance of all stand-by equipment.

Tactical and operational models apply to particular spills. The first identifies and specifies sets of available equipment, e.g., a skimmer, pump, and sorbent, or a sophisticated combination of a skimmer, boom, and barge. The tactical tool helps the user determine how long equipment will take to reach a site and estimates dispatching and operating costs. The operational model helps decide how to use the equipment in actual weather and sea conditions for different volumes and kinds of oil.

Both the tactical and operational models can examine various cost options. The decision maker can weigh various combinations of clean-up and damage costs to make desired tradeoffs.

When the model has been completely tested in 1983, it will be a valuable planning and tactical tool for all concerned with oil spills: lawmakers, government agencies, oil spillers, the clean-up industry, fishermen, and other coastal interests. Alternative, time-phased responses for combatting either hypothetical or actual spills can be simulated on the model, and will help train people for clean-up work. Additionally, the model will suggest business opportunities for manufacturers of clean-up equipment and for suppliers of related services. While oil spills cannot be completely eliminated, a system that can lessen clean-up costs and damages is a step toward reducing many of the associated problems.

Coal-fired Ships

"If a ship consumes 100 tons of oil per day at $200 per ton and spends 300 days a year at sea, the fuel bill is $6 million a year. Keeping the same ship at sea but switching to coal at $50 per ton costs just $2.4 million," calculates Dr. Chryssostomos Chryssostomidis of the MIT Department of Ocean Engineering.

Up until about 50 years ago, coal was a standard ship fuel before being replaced by oil. According to economic studies at MIT, that trend might reverse itself, and indeed a recent report by the National Research Council's Maritime Transportation Research Board recommended that every effort be made to implement coal as the primary marine fuel.

Since the heating value for coal is about 7400 to 15,000 BTU/lb compared to 18,700 for marine diesel and fuel oil, usually 50 percent more coal than oil is needed for the same job. Oil is easier to store, handle, burn, and usually pollutes less. However, coal costs less and with its abundant coal reserves the US would not be chained to foreign suppliers. Depending on where it is extracted, coal varies considerably in composition, ash, BTU produced per pound, sulfur and moisture content. Technological developments in coal burning, handling and ash disposal suggest that some of coal's inherent problems can be handled effectively.

Given the low demand for new ships today, studies at MIT are analyzing the conversion of existing ships from oil to coal. Conversion results in increased capital expenditures, the extra weight of coal, additional machinery and ash-retention equipment which would cut into the payload. In case local regulations prohibit burning coal in port, some ships will carry double fuel and power systems so they can switch to oil if necessary.

Some factors considered in the MIT economic analysis are costs such as insurance, port and canal fees, price of coal and an extra employee to help out. An additional five days are allowed for maintenance, since the coal ships represent new technology. Combinations were tried for different costs, including purchase of a new coal-fired boiler, loss of earnings and yard cost. Important variables in the computer program for economic feasibility, besides the cost of fuel, are speed, vessel size, distance travelled and the density of the coal.

Current pollution regulations might affect the 20 percent of ships that are larger than 30,000 hp regarding sulfur emissions only. The Coast Guard allows ash to be dumped outside of territorial waters, except where a specific anti-dumping regulation exists. However, many important minerals in ash—oxides of silicon, aluminum, iron, calcium, magnesium, titanium, sodium, potassium and sulfur—could possibly be extracted and recycled, rather than dumped. Ships are being designed to hold three days of ash accumulated in port and before the ship gets far out enough to dump.

Air pollution from a coal-burning ship may occur as liquid mist, gaseous fumes or solid particulate matter, depending on the boiler design and characteristics of the coal. Gaseous pollutants are primarily oxides of sulfur, which react with water to form sulfurous and sulfuric acid, and nitrogen. At full power, a 5000 SHP coal-fired ship could produce 55 lbs/hour of particulate emissions. Collection devices for removing particulates include electrostatic precipitators, inertial separators, mechanical filters, wet washers and combinations of the above.

An estimated 250 million tons of coal would be needed in ports to supply seaboard trade. Since the total international trade in coal now runs about 398 million tons, switching large numbers of ships over from oil would cause a massive upheaval in the whole distribution system. The port development and infrastructure necessary to transport adequate amounts of coal into ports, areas which Chryssostomidis believes need attention, are being examined by the Maritime Administration.

Starting with a new design of a coal-fired ship is easier than converting an existing ship, says Chryssostomidis. "Even on a successful conversion, the new design is better because we don't have to obey the limitations of the existing ship." However, with overabundant tonnage available now, "it makes sense to convert the existing overtonnage rather than scrap it." Australia, Japan and Italy have ordered new large coal-fired vessels, and in the US the Quincy (MA) shipyard is building the first American coal-fired ship of the '80s. Supertankers and other large vessels in particular need to be examined as possible candidates for conversion.

The project is supported by Sea Grant and the MIT Department of Ocean Engineering. Others involved in the work include George Peteras, Ipatios P. Drossos, William Stockton, and students of the Principles of Ship Design and Engineering Systems Design classes.

Marine Consortium Runs Unique Oceans Course

As the Law of the Sea negotiations showed, ocean issues no longer fit into tidy categories such as scientific, fisheries, political, minerals. Future oil exploration in the teeming Georges Bank fishing grounds has brought the conflicting issues and interests very close to home for New England residents. Taking an overview of contradictory issues is particularly difficult given the narrowly focused training of most specialists.

The Massachusetts Bay Marine Studies Consortium believes that an interdisciplinary approach can best lead to some understanding of the many forces acting upon ocean questions. Two years ago this association of faculty members from Boston-area colleges developed a semester-long undergraduate course called "Into the Ocean World," which stresses the complex nature of aquatic studies and the interrelationships of the various perspectives.

Reflecting the interdisciplinary structure, the 38 students who just finished the course this spring were equally divided between science and nonscience majors. The 25 participating educational institutions which together form the Consortium represent small and large universities, two- and four-year colleges, and public and private institutions.

"Into the Ocean World" immerses students in an extensive reading list, lectures, term projects and two weekend field trips packed into the busy spring semester. Topics selected by the students for their final projects reflect their diverse interests: water quality in Boston Harbor, the Harbor islands through the centuries, sea chanties, evolution of the concept of seafloor spreading, economics of the lobster industry, and the ocean as a source of thermal energy.

Participants in this unique course become acquainted with many perspectives that influence current marine issues. Learning about different marine professions helps them make informed career choices. They can bring their own particular skills to a marine related topic. Students, particularly those from small or specialized schools, are exposed to indi-

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The MIT Sea Grant *Quarterly Report* reviews the Program's marine-related activities at the Massachusetts Institute of Technology. Free subscriptions are available on request from the MIT Sea Grant College Program, Building E38-302, Cambridge, MA 02139. Telephone (617) 253-3461.

viduals or areas which they would not otherwise encounter on their home campuses.

Begun under a grant from the MIT Sea Grant Program, the Consortium was officially incorporated earlier this year and is securing tax-exempt standing under federal and state laws. It started as a group of Boston area faculty members interested in different aspects of marine studies. "Into the Ocean World," the Consortium's major effort to date, has proven highly popular with its students and teachers alike. Financed initially by MIT Sea Grant and now supported by membership fees and voluntary contributions, the group is exploring other educational ventures.

"Getting 25 institutions to shed their institutional identities and cooperate is a major accomplishment," remarks Jay Kaufman, program coordinator and educational specialist with MIT Sea Grant. Trouble spots in organizing an interinstitutional, interdisciplinary class included tuition, conflicting school schedules and course credits. Accreditation was initially difficult, since the class evades even the standard general categories of humanities, social science or physical science. After considerable negotiations, all participating schools agreed to accept the course grades. Kaufman adds, "The grade distribution didn't reflect either the difference between science and non-science majors, or the schools the students came from."

With personal expertise in history, oceanography, nautical archaeology, and anthropology and marine management, the four instructors insure a diverse set of views. Initially, teachers were extremely concerned with integrating their various viewpoints into a unified perspective. But eventually Kaufman realized that "students really responded well to getting a look at a lot of different people in lots of different fields. This year we were at least as concerned with that diversity as with integration. There was much more interaction among the four teachers this year, and we generated more interaction among the students."

The diversity showed up clearly on the Boston Harbor field trip on April 11 and 12. At four different test sites around the Harbor some students ran a variety of electronic, biological, ecological and chemical experiments to collect data for their major projects. Throughout the trip the experimenters constantly transferred water to sample bottles, took readings, washed down equipment, tried to scoop up thick black bottom muck with the bottom corer, watched instruments, and added chemicals.

Those students not actively involved in the sampling relaxed as they viewed the experiments with varying degrees of

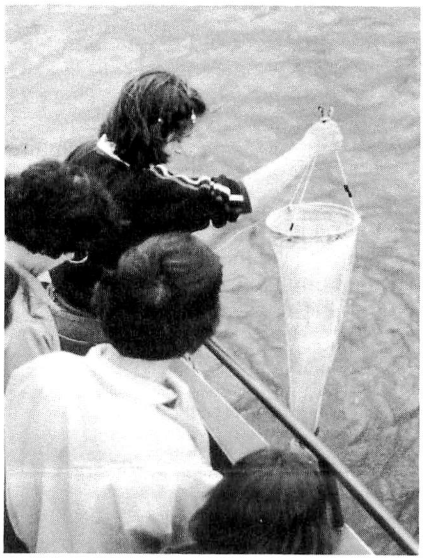

Figure 2. Students perform experiments during field trip in the Boston Harbor.

curiosity. Instructor William Fowler provided historical and geographical commentary as the boat sailed past newly built luxury condominiums and rotting wharves dating from when Boston was a major shipbuilding center. In keeping with the multidisciplinary approach, some of the conflicting interests which complicated waterfront renewal were discussed.

The class unloaded at Thompson Island in Boston Harbor to scrutinize the samples taken on board, then settled in at the island's educational center dormitory. Before sailing back to Boston on the following day, they conducted additional experiments and studied the island's ecology, nature and history.

According to Kaufman, "The success of 'Into the Ocean World' reflects both the need for new initiatives in interdisciplinary marine studies and the viability of cooperation among institutions. Given the complex nature of marine studies and the economics of higher education, the Massachusetts Bay Marine Studies Consortium is looking forward to a successful fund-raising campaign and expansion of its programs.

Studying Tidal Power in New England

Tapping the power of ocean tides to produce electricity could provide a renewable energy source with free fuel. But tidal power remains unharnessed in the US because it has been impractical and expensive compared with fossil fuels, hydroelectric power and nuclear energy. Building a tidal plant is expensive, and tides produce power only twice a day which may not coincide with local demand. In addition, it is too costly to store the energy until it is needed or transmit it to distant users. Only at sites in Alaska and Maine is the range between high and low tides sufficient to make large-scale regional plants feasible and competitive with existing sources of energy. However, the facilities might cause environmental damage over large coastal areas.

At MIT's Department of Mechanical Engineering, Professor James A. Fay is working with graduate and undergraduate students to study the economic, technical and environmental feasibility of small-scale tidal generating plants. Although small plants could not be the sole source of energy for an area, they could supply power locally for limited numbers of users or feed into a power company network. The New England coast, especially in Maine, offers possible sites for small plants.

Professor Fay and co-workers Mark Smachlo, Thomas Faust and Jane Johnston are determining such factors as the best equipment to use, economic conditions that would make a plant practical, optimal methods of operation, and the effects of changes in tidal flow on the marine environment. These studies aim to provide guidelines for judging the feasibility as well as planning and operating a small plant at any chosen site.

Tidal plants operate in almost the same way as hydroelectric generating plants, directing water through turbines to produce electricity. The plants are built at tidal inlets—across the mouths of rivers or entrances to bays. Small plants could generate from 100 kilowatts (kW) to 10 megawatts (mW) of electricity, depending on the size of the tidal pool and the tidal range. (Ten megawatts is enough energy to power about 10,000 homes.)

Each plant requires a dam stretching across the inlet entrance, a powerhouse with turbines to generate electricity, and a gate, or sluiceway. The dam and powerhouse account for the main expenses in building a tidal plant. While the initial investment can be substantial, the fuel for generating energy is free. The rates charged for the power will determine whether these plants could pay for themselves, Fay says.

The MIT researchers are investigating which methods of operation would produce the most power at the cheapest cost. For example, turbines generally operate well in only one tidal direction, although they can be designed to operate in two directions. While the double direction turbine is usually inefficient and costs more to build, it generates 20% more energy than a one-way turbine. However, it may be possible to redirect both ebb and flood tides to flow in the same direction. This scheme to send water through the turbines twice may be more productive than either the single or double direction operation.

Professor Fay says that "the major obstacle to developing tidal power is its marginal economic value." Currently more expensive than fossil fuels, nuclear power and hydropower, it is an unattractive investment. Although it costs about as much to build a tidal plant as a hydroelectric plant, many idle hydro dams could be put back into service by adding new turbines. In the future, tidal power may be attractive as a supplementary energy source in areas without hydropower or when the cost of fuel rises further. Already, construction costs for tidal power plants which were formerly considered prohibitive seem less unreasonable in relation to increasing fuel costs.

Over the next year of the Sea Grant project, Professor Fay and co-workers will focus on the environmental and legal aspects of tidal power. There are potential problems. For instance, even a small dam impeding the natural movement of water and marine life in and out of a tidal inlet might damage the local marine environment. Because the dams would block boats and interfere with fishing and recreation, the rights to passage could become an issue. In future work, the MIT researchers will apply some of the economic and technical findings from their previous studies to evaluate one or two sites.

While small-scale tidal power is being debated in the US, a large-scale tidal plant has been generating electricity at the Rance estuary in northwestern France since 1967. With a tidal range of almost 40 ft, the plant can provide up to 240 mW of power, and is linked to a utility network. Although the plant's 24 turbines can turn in both directions, the reverse direction is not currently used because it operates inefficiently.

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Announcement

MIT Receives New Grant From NOAA

On July 1, 1981 the MIT Sea Grant College Program commenced a new grant year with an award of $1,650,000 from the National Oceanic and Atmospheric Administration (NOAA) in the Department of Commerce. The grant is MIT's twelfth since it joined the national Sea Grant network in 1970. Projects under the grant will integrate research, education and advisory services to promote the development and management of ocean resources.

Sea Grant was established by Congress in 1966 to infuse public monies into interrelated, but disparate, aspects of ocean and coastal uses that have demonstrated benefits for much of the nation. These uses include among others food from the seas, energy, waste disposal, and recreation.

Offshore the oceans offer a harsh environment while along the coastlines fragile and unique marine ecosystems dictate kinds and methods of operation. At MIT, Sea Grant sponsored projects help to mitigate harmful effects of human intervention while helping industry and government to reduce costs, improve efficiency, and ensure human safety in marine work.

Training people to excel as engineers, scientists, and managers also falls within Sea Grant's purview. Therefore, students are funded as assistants to MIT's faculty on research projects. In addition, academic subjects based on state-of-the-art technology are available to graduate and undergraduate students, and to professionals in the marine field. Through advisory services, courses at the Massachusetts Maritime Academy offer opportunities for fishermen to improve fishing and business skills.

Advisory services maintain strong ties to the entire community who can apply Sea Grant's research results. The Marine Industry Advisory Service (MIDAS) is regularly in touch with 96 national and international companies and 9 government agencies who are members of a collegium. The members can meet formally with MIT and other university researchers five times a year at day-long workshops; and informally when they share data and expertise in the development of research. State and local companies and organizations work closely with the Massachusetts Marine Liaison Program to identify pressing research needs and apply the results.

Publications describing all research results in depth are available through the Communications/Information Service. A small reference facility in the Sea Grant office also offers access to a range of literature on many marine-related subjects.

This announcement is a brief overview of Sea Grant's research projects for the coming year. If you have any questions, feel free to contact the Communications Manager, MIT Sea Grant, 77 Massachusetts Avenue, Cambridge, MA 02139.

Sea Grant Research 1981–1982

Offshore Facilities

Rapidly expanding construction in the offshore environment calls for data and analytical procedures to design, build, emplace, monitor, and maintain structures for increasing supplies of gas and oil, generating power, or disposing of wastes.

Design Against Collision for Offshore Structures.
Joao G. Oliveira, Assistant Professor, MIT Department of Ocean Engineering.
Project duration: July 1, 1980-June 30, 1983.
Develop and implement a set of procedures and recommendations for the design of steel offshore structures to limit the extent of ship collision damage. Research will evolve a theory to predict energy absorption of typical tubular steel members, determine what structural layouts and combinations of parameters absorb energy best, and develop appropriate fender systems.

Mechanics of Cable Systems with Offshore Applications.
H. Max Irvine, Associate Professor, MIT Department of Civil Engineering.
Michael S. Triantafyllou, Assistant Professor, MIT Department of Ocean Engineering.
Project duration: July 1, 1981-June 30, 1984.
Devise simple analytical solutions for the problem of flow excited cable dynamics; apply to preliminary design theory for mooring systems for anchoring small instrumentation buoys to large offshore platforms.

Analysis of Geophysical Information in Offshore Geotechnical Exploration.
Gregory B. Baecher, Associate Professor, MIT Department of Civil Engineering.
Project duration: July 1, 1980-June 30, 1982.
Investigate the use of acoustical profiling to determine geotechnical properties offshore. Research to estimate the reliability of the profiling to make inferences about layer thickness, depth, seabed continuity, and to find anomalies. Information will be incorporated into a model for statistical analysis.

Ultimate Capacity of Offshore Friction Piles in Clays.
Mohsen M. Baligh, Associate Professor, MIT Department of Civil Engineering.
Amr S. Azzouz, Research Associate, MIT Department of Civil Engineering.
Charles C. Ladd, Professor, MIT Department of Civil Engineering.
Project duration: July 1, 1981-June 30, 1984.
Develop a better understanding of pile-soil interaction to predict the ultimate capacity of axially loaded friction piles in marine sediments. The information should help make offshore structure design more efficient.

Unmanned Underwater Work Systems

Research focuses on developing innovative components and systems, using the most advanced theories and techniques to improve human performance in remotely controlled unmanned work vehicles for underwater tasks.

Remote Control Techniques for Unmanned Underwater Work Vehicles.
Thomas B. Sheridan, Professor, MIT Department of Mechanical Engineering.
Project duration: July 1, 1981-June 30, 1983.
Design and demonstrate a device that can be remotely controlled by a human operator using a limited bandwidth video or acoustic image system; demonstrate techniques for simulating and evaluating remote control systems; minimize relative motion problems through computer-aided techniques; and apply research to retrofitted undersea vehicles.

Touch (Proximity and Contact Force) Sensing for Undersea Manipulators. Thomas B. Sheridan, Professor, MIT Department of Mechanical Engineering.
Project duration: July 1, 1981-June 30, 1983.
Design touch sensing to make manipulators flexible and dexterous in completing tasks identified by industry; and develop alternative schemes to process and display information for human operators.

Performance of the Digital Acoustic Telemetry System (DATS) for

Communication from Untethered Vehicles and Sensors.
Arthur B. Baggeroer, Professor, MIT Department of Ocean Engineering and MIT Department of Electrical Engineering and Computer Science.
Donald Koelsch, Research Specialist, Woods Hole Oceanographic Institution Department of Geology and Geophysics.
Keith von der Heydt, Research Associate, Woods Hole Oceanographic Institution Department of Geology and Geophysics.
Project duration: July 1, 1981-June 30, 1983.
Evaluate the performance capabilities of the MIT-developed Digital Acoustic Telemetry System (DATS), particularly error rate versus data rate for a variety of offshore conditions.

Coastal Processes

MIT Sea Grant research aims at understanding the complex interactions among the physical, chemical, and geological processes of the coastal ecosystem so that the consequences of human activities in the near-shore environment can be anticipated and managed.

Enhancement of Hydrodynamic Circulation in Semi-Enclosed Water Bodies.
Jerome J. Connor, Professor, MIT Department of Civil Engineering.
Keith D. Stolzenbach, Associate Professor, MIT Department of Civil Engineering.
Project duration: July 1, 1981-June 30, 1982.
Implement a new computational scheme using frequency domain techniques for calculating tidal circulation in small embayments with irregular shape and topography; apply scheme to the study of generic solutions to improve circulation in semi-enclosed water bodies. A marina in Hull, Massachusetts will serve as a case study for application of the scheme.

Tidal Induced Transport in Salt Marsh Ecosystems.
Harold F. Hemond, Assistant Professor, MIT Department of Civil Engineering.
Keith D. Stolzenbach, Associate Professor, MIT Department of Civil Engineering.
John Teal, Senior Scientist, Woods Hole Oceanographic Institution.
Project duration: July 1, 1981-June 30, 1982.
Identify and quantify dominant (tidal) hydrological processes of salt marsh ecosystems to develop techniques that will estimate how dissolved and suspended substances travel and disperse in a marsh, using a minimum of site specific data.

Analysis of Growth Strategies of the New England Red Tide Organism: *Gonyaulax tamarensis.*
Sallie W. Chisholm, Associate Professor, MIT Department of Civil Engineering.
Project duration: July 1, 1979-June 30, 1982.
Understand the physiological ecology of *Gonyaulax tamarensis.* Will measure *in situ* growth rates of an estuarine bloom and examine the organism's capabilities to vertically migrate. Laboratory and field results will be incorporated into a model which predicts the rate of export of *G. tamarensis* cells into coastal waters.

Trace Element Uptake in the Marine Food Chain.
Morteza Janghorbani, Senior Radiochemist, MIT Nuclear Reactor Laboratory.
Project duration: July 1, 1978-June 30, 1982.
Compare yield and trace element uptake and accumulation in a food chain grown with sewage effluent as the primary nutrient. Will also study the effect of electon bombardment on intensive culture systems of sewage effluent that is typical of large U.S. industrial coastal communities.

Living Resource Utilization

Advanced technology compatible with socio-economic, environmental, and regulatory constraints can contribute to more efficient use of the oceans' living resources.

High Efficiency Brayton-Cycle Engine for Marine Propulsion.
David Gordon Wilson, Professor, MIT Department of Mechanical Engineering.
Project duration: June 1, 1981-June 30, 1984.
Develop a regenerative Brayton-cycle system to meet the needs of fishing vessels for propulsion, auxiliary power, heating, and cooling requirements.

Design and Fabrication of Microcapsules for Fish Larvae Feed.
ChoKyun Rha, Associate Professor, MIT Department of Nutrition and Food Science.
Project duration: July 1, 1981-June 30, 1984.
Engineer a complete feed for fish larvae grown in a mariculture system. A desirable fabrication process would control solubility, texture, density, and the size and shape of feed for specific fish species.

Isolation of Bioactive Compounds from Sharks.
Robert Langer, Associate Professor, MIT Department of Nutrition and Food Science.
Julianne Glowacki, Research Associate, Boston Children's Hospital.
Project duration: July 1, 1980-June 30, 1984.
Determine if shark cartilage contains a known inhibitor of tumor growth, and purify and biochemically characterize that inhibitor for application in medical tests on animals.

Synthesis of Chitosan Structure Matrix for Foods.
ChoKyun Rha, Associate Professor, MIT Department of Nutrition and Food Science.
Project duration: July 1, 1979-June 30, 1982.
Use a structural matrix developed from chitosan to develop a fabrication procedure and synthesize several foods including fruit, meat substitutes, and bread.

Technology Development and Management for Ocean Uses

Many projects sponsored by Sea Grant fit under specific categories such as Offshore Facilities and Coastal Processes; but others, like those listed below, cover a range of research that opens new areas of opportunity, improves existing methods of operation, or solves difficult marine-related problems.

Enzymatic Removal of Hazardous Pollutants from Industrial Aqueous Effluents.
Dr. Alexander M. Klibanov, Assistant Professor, MIT Department of Nutrition and Food Science.
Project duration: July 1, 1981-June 30, 1983.
Investigate whether the enzyme peroxidase, present in horseradish, can remove phenol and aromatic amines. These compounds in industrial wastewater can be toxic to fish and carcinogenic for humans.

Small-Scale Tidal Power in Eastern New England.
James A. Fay, Professor, MIT Department of Mechanical Engineering.
Project duration: September 1, 1980-June 30, 1982.
Prepare a report that will evaluate the environmental, economic, and technological aspects of building small-scale (100 kW to 10 mW) tidal power projects in New England.

On the Rational Selection of Strengthening Criteria for Navigation in Ice.
Paul Xirouchakis, Assistant Professor, MIT Department of Ocean Engineering.
Project duration: July 1, 1981-June 30, 1984.
Develop a structural design methodology for the rational selection of ice strengthening criteria for ships, particular attention being given to failure modes from maximum levels of ice loading.

Development of a Liquid Crystals Kit for the Structural Integrity Assessment of Fiberglass Watercraft.
James H. Williams Jr., Professor, MIT Department of Mechanical Engineering.
Project duration: July 1, 1980-June 30, 1982.
Devise a quantitative, inexpensive, non-destructive technique, using liquid crystals, to identify and evaluate the size and significance of structural fiberglass flaws. Researchers will package technique in an easy-to-use kit that employs a calibration block to assess flaws.

Development of Fully Automated and Integrated "Instamatic" Welding Systems for Marine Applications.
Koichi Masubuchi, Professor, MIT Department of Ocean Engineering and MIT Department of Materials Science and Engineering.
Project duration: July 1, 1980-June 30, 1982
Following a background study of existing welding machines and tools and a survey of the market, researchers will engineer an instamatic cassette system that can be used by people with no previous welding skills to repair in enclosed compartments, on board ship, or for salvage work.

Putting the MIT Oil Spill Model to Work.
J. D. Nyhart, Professor, MIT Sloan School of Management and MIT Department of Ocean Engineering.
Harilaos N. Psaraftis, Assistant Professor, MIT Department of Ocean Engineering.
Project duration: July 1, 1981-June 30, 1983.
Implement economic and regulatory model, developed during the past two years, to analyze existing clean-up policy and decision-making processes so that regulatory, legislative and operational changes can be made in oil spill clean-up management.