MIT SEA GRANT PROGRAM

OCEAN UTILIZATION AND COASTAL ZONE DEVELOPMENT

1 JUNE 1970 TO 30 JUNE 1972

M.I.T. Sea Grant Program

Completion Report

for

Coherent Area Project

Grant No. GH-88

for

1 June 1970 to 30 June 1972

OCEAN UTILIZATION

AND

COASTAL ZONE DEVELOPMENT

MITSG Report No. 73-3
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M.I.T. SEA GRANT PROGRAM OVERVIEW AND MANAGEMENT

The Massachusetts Institute of Technology established its Institute-wide Sea Grant Program in July 1970 to execute the Coherent Area Project (CAP), "Ocean Utilization and Coastal Zone Development," using Grant Number GH-88 from the Office of Sea Grant, National Oceanic and Atmospheric Administration. OSG extended this grant for one year to 30 June 1972 at no additional cost to the grant. This extension means that we are able to include additional studies and data in this report and to provide complete, rather than interim, reports on three of the first year projects. We are pleased to summarize all our activities under GH-88 and to complete, in this report, the Sea Grant annual report requirement.

M.I.T. has a long history of success in many and varied marine-related activities. The Institute is now directing a major effort toward effective utilization of ocean resources and development of the coastal zone in balance with environmental and sociological criteria. The Institute efforts are focused and managed through the M.I.T. Sea Grant Project Office under the directorship of Dr. Alfred A. H. Keil. The Sea Grant Program has the endorsement and support of M.I.T.'s administration and faculty. The Institute's Sea Grant Council, composed of eminent faculty members selected for their experience and expertise in relevant fields, cooperates with the Director in evaluating proposals and reviewing progress.

The major emphasis for the 1970-71 program year was to organize an effective operation and to direct a viable program that emphasized the education and training and the research categories. These, with the advisory services, are explicit requirements of mature Sea Grant programs. Our advisory service efforts included establishing a Marine Resources Reference Center, publishing and distributing reports, and organizing and implementing symposia and seminar meetings.

Sea Grant activities began at M.I.T. in 1969 when OSG awarded M.I.T. the first Sea Grant, GH-1. M.I.T. was to develop a series of ocean engineering textbooks based on lecture notes and course materials the M.I.T. faculty used. This project produced five ocean engineering textbooks: Stability and Motion Control of Ocean Vehicles, Martin A. Abkowitz; Ocean Engineering Structures, J. Harvey Evans and John Adamchack; Air, Water, and Interface Vehicles, Philip Mandel; Ocean Engineering Materials, Koichi Masubuchi; and Public Policy and the Use of the Seas, Norman J. Padelford. MITSG added three more books during this project year: New Dimensions of U.S. Marine Policy, Norman J. Padelford and Jerry E. Cook; Marine Decisions Under Uncertainty, John W. Devanney III; and Ocean Engineering Systems, John P. Craven.

Then early in 1970 the Institute developed plans for the M.I.T. Sea Grant Project Office while it negotiated with the National Sea Grant Program for the CAP, "Ocean Utilization and Coastal Zone Development." The Institute also established and approved primary goals for its Sea Grant Program:

- to facilitate transferring and applying experience and progress M.I.T. gains in related fields to ocean utilization and coastal zone development in a way which avoids or minimizes detrimental ecological change;

- to plan and to execute research and development in areas crucial to achieve this first goal;

- to broaden M.I.T.'s education program in ocean utilization and coastal zone development; and

- to assure expeditious dissemination and utilization of the results of marine-related research and development at M.I.T.

In July 1970 M.I.T. established the Sea Grant Project Office under Sea Grant Director, Dr. Alfred A. H. Keil, then Head of the Department of Naval Architecture and Marine Engineering (now the Department of Ocean Engineering). This new office had several functions. It was to provide the focal point for both Sea Grant and non-Sea Grant projects and programs at the Institute that had common interests in ocean utilization and coastal zone development. It was to attract and to interest Institute faculty and students in applying their knowledge and skills to solving marine-related problems--national, regional, and local--and to encourage the faculty to work together to plan various interdepartmental approaches to this problem-solving. It was also to establish liaison with government agencies, industry, and individuals who would be interested in increasing and expanding M.I.T.'s research and education effort consistent with MITSG's goals, and to work with all elements of government, industry, and education to identify marine-related problems that could benefit from Institute attention.

The Project Office has performed these functions, as well as carrying out its responsibilities for its CAP projects.

In addition to broadening interest and participation within the Institute, MITSG has directed special efforts during this project year to establish liaison with industry and state government in the Commonwealth. We have held several briefings on the Institute's Sea Grant programs for state and industry representatives. These began with a special briefing for the Governor and Lieutenant Governor in November 1970 and since then have included agencies in the Department of Natural Resources, the Department of Commerce and Development, the Department of Public

Health, and the Legislative Commission on Marine Boundaries and Resources, as well as the Secretary of Environmental Affairs, the Assistant Secretary of Environmental Affairs, and other individual officers of the Commonwealth and members of the Legislature.

Advisory service activities have included establishing the M.I.T. Grant newsletter, the Marine Information Transmitter, and publishing a CAP program brochure in spring 1971. In addition, MITSG has sponsored delegates at several technical meetings where they have presented technical papers. Among these meetings were the Offshore Technology Conference, the Marine Technology Society annual meeting, and the American Chemical Society annual meeting.

Finally, we acknowledge our appreciation to the Henry L. and Grace Doherty Charitable Foundation, Inc., for the three-year grant of funds that helped the Institute initiate its Sea Grant Program. Sea Grant is a matching fund program and the support from the Doherty Foundation--the primary source of M.I.T.'s matching funds during this first year--and Institute support made the Sea Grant Program at M.I.T. possible.

M.I.T. is committed to maintaining a viable, productive Sea Grant Program; it looks forward to participating in a strong, growing national program.

National Ocean Policy (Research)
Professor Norman J. Padelford, Professor Emeritus and Senior Lecturer, Departments of Ocean Engineering and Political Science

New Dimensions of U.S. Marine Policy, in which the authors reported the results of this research project during the first year of the CAP grant, is another book for the M.I.T. Ocean Engineering Series. In this book Professor Padelford and Jerry E. Cook, a research assistant, have examined the rapidly-evolving trends in national policy and law. New Dimensions complements Professor Padelford's earlier Sea Grant-sponsored book, Public Policy and the Use of the Seas.

Among the topics Professor Padelford and Mr. Cook have discussed are new goals for marine policy, the coastal zone, the continental shelf, marine resources utilization, pollution, and international uses of the seabed. Their book evolved from Professor Padelford's unique course on ocean policy. The course makes students aware of problems and provides them an opportunity study decisions similar to those they may face in the public sector in the future.

In their book the authors have collected documents relevant to U.S. marine policy developments during 1969 and 1970--e.g., statements, executive orders, statutes, position papers, and treaties. The authors have grouped the documents in chapters by topics or pressing interest areas and have written an introduction and an evaluation at the beginning of each chapter.

Professor Padelford says of these recent policy developments: "These have clearly added new dimensions to U.S. marine policy. They can be seen in part as complementing what has gone before. Taken as a whole, they have a unity of their own that marks a turning point in policy. This volume is therefore a complement to the earlier collection [Public Policy], but one may also view it as having its own internal consistency."

The authors designed the book to stimulate interaction between those scientists and engineers who are concerned directly with the marine environment and those policy-makers who operate in the political arena. Clearly, the work of the ocean scientist or the practicing engineer, as well as that of the government officer, is influenced by decisions that bear on the extent of territorial waters, the freedom of the seas, the utilization of the coastal zones, the development of marine resources, control of pollution, strengthening the merchant marine, and other problems. And, Professor Padelford added, only as the scientists and engineers make known their own enlightened views to the political decision-makers can the scientific community's and the nation's common interests be assured and advanced.

This collection, therefore, is to help the reader comprehend trends in contemporary policy of the oceans and to develop understanding of the processes by which broad concepts and goals are translated into specific policy actions.

M.I.T. Press published this book in late spring 1971 and it is now in its second printing.

Estuary Modeling (Research)
Professor A. T. Ippen, Institute Professor and
Director, Ralph M. Parsons Laboratory for Water Resources
and Hydrodynamics

By using mathematical modeling in one and two dimensions, researchers working at M.I.T.'s Parsons Laboratory for Water Resources and Hydrodynamics are developing ways to predict more accurately the impact of waste inputs into estuarial systems and of future man-made changes in physical configurations of estuarine systems. Professor Ippen and his Associate Investigators, Professors Donald R. F. Harleman and John D. Ditmars, made up the research team during this first year of a two-year M.I.T. Sea Grant research project.

In estuarine and coastal ecology, the distribution, in addition to pollutants, of temperature, salinity, and sediments, is essential in determining the health of the environment.

During this year, project personnel concentrated on developing (1) unsteady, tidal-time, one-dimensional models for salinity, temperature, and standard water quality parameters--e.g., biochemical oxygen demand (BOD) and dissolved oxygen (DO); and (2) tidal-time average, two-dimensional models for longitudinal and vertical variations of salinity and velocity. The tidal-time, one-dimensional models they developed include not only single-channel estuaries, but also multiple channels and branched estuarial networks.

Their one-dimensional models differ from earlier one-dimensional models that are time-averaged over one tidal period in that the M.I.T. models have predictive capabilities rather than the ability to fit observed data by empirical adjusting of parameters. In addition, because biological and chemical interactions characteristically have relatively short-period reaction rates, tidal-time models that consider advective and dispersive characteristics within a tidal cycle are essential to developing further modeling capabilities for ecological systems.

The researchers are using three different one-dimensional models to study: first, unsteady salinity intrusion in estuaries; second, water quality in a network of estuarine channels; and third, thermal discharges in rivers or estuaries. With a two-dimensional model, they are examining salinity and velocity distributions in estuaries.

To examine a single ecological parameter using the first one-dimensional model, the researchers predicted the movement of salinity in a Delaware estuary and compared it with field data, with good results. They are now working on a similar experiment on the Potomac. They are investigating applying the second one-dimensional model to field problems.

Their initial results with the two-dimensional model provided vertical velocity and salinity profiles which vary in a nonsimilar manner along an estuary's length. These findings agree with experimental observations they made in a salinity flume.

At the end of the second project year, after the researchers complete this two-year project, M.I.T. Sea Grant will publish the models and results as separate Sea Grant Reports.

Ocean Transportation and The Future of Atlantic Ports (Research)
Professor E. G. Frankel, Director, Commodity Transportation and Economic Development Laboratory and Professor of Marine Systems

Worldwide ocean transportation has changed significantly in just the last decade. Historic shipping firms have disappeared and new operators are replacing them--oil companies and container shippers, for example.

Several factors have contributed to this change--changing labor relation patterns; overall cargo handling and personnel costs; and newly developed technology. Shipping operations are evolving into more complex systems. Many operators now have integrated control not only over their ships, but also over terminals and other land facilities--and they are running their operations on a proprietary basis. Many are becoming integrated with other transportation industries. Others are participants in large multinational companies.

Furthermore, they have done this without government subsidies by becoming part of the control structures in the older companies; by raising and coordinating private money; or by merging. In the North Atlantic, for example, less than 20 years ago there were over 80 shipping firms; now there are about 20.

As part of these two related two-year projects, Professor Frankel and his colleagues in M.I.T.'s Commodity Transportation and Economic Development Laboratory studied these changes and considered some of the impacts these might have on the industry. In the ocean transportation project, they examined the development of the overall ocean transportation market and the status and development potential of ocean transportation technology. To do this, they

- analyzed the major commodities (defined by 20 major commodity types), collected data on other significant

commodity flows, and worked to determine a most effective coding of commodities and origin/destination pairs;

- determined freight rates and the rationale behind their establishment and, in particular, the effect of conferences and market demand on freight and charter rates;

- began a basic review of ocean transportation technology to establish a consistent format of technological parameters to permit effective evaluation and tradeoff of ship form, propulsion, and cargo handling and storage capabilities, directing this effort toward establishing meaningful boundaries between subsystems and effective criteria which include subsystem interdependency; and

- collected a large amount of statistics on major forms of ocean transportation and their components.

In the Atlantic ports project, they first

- collected relevant port statistics for all ports on the Atlantic seaboard;

- established a consistent format for evaluating ports' physical configurations, assets, and layouts and then analyzed physical parameters of various ports; and

- developed a format for financial and throughput data that permits one to extrapolate information from ports' reports in a consistent manner.

Second, they constructed a two-part general ports model--the first part was a port control model--financial, operating, technology use, investment, and interface control, and the second part a simulation model researchers could superimpose on the port control model to evaluate the effectiveness and utilization of various ports and their physical elements by using output from the port control model as well as commodity flow and similar statistics.

And third, they collected cargo flow data to begin their study of commodity flow. They limited their initial study to North Atlantic ports, but eventually they plan to expand it to include all Atlantic ports.

Squid Protein Concentrate (Research, Seed Project)
Professor S. A. Goldblith, Deputy Head, Department of Nutrition and Food Science

Squid, Loligo vulgaris, and related species abound in the oceans of the world, but, except in Japan, Italy, and other countries on the Mediterranean, they are seldom used as food. Because there is a severe protein shortage in the world today

Squid Protein Concentrate

Ms. Kahn is preparing a squid for a chemical analysis.

and because squid could be a significant New England fishery, scientists in M.I.T.'s Department of Nutrition and Food Science have begun research on methods of using the squid, an under-utilized protein source.

Leslie N. Kahn and E. Ray Pariser, working with Dr. Goldblith, have begun research to prepare an edible stable protein concentrate from squid that will be suitable for human consumption (in this experiment, they define suitable as dry, soluble, and nutritional).

The researchers did chemical analyses of the raw squid and found that over fifty percent of its protein was water-soluble. They then used several different isopropyl alcohol extraction techniques to try to develop a squid protein concentrate (SPC).

On this project, M.I.T. Sea Grant provided seed money for additional experimental equipment and salary assistance for Ms. Kahn. And this seed project became a full research project, Utilization of Squid for Processed Food Products, in M.I.T. Sea Grant's 1971-1972 Coherent Area Project.

Oil Oxidation by Marine Bacteria (Research, Seed Project)
Professor Phillips W. Robbins, Department of Biology

M.I.T. students, in a first-time biochemistry project, studied the mechanisms marine bacteria use to oxidize typical aromatic organic compounds in oil. More knowledge about these marine bacteria is important because ultimately it is marine bacteria's oxidative activities that finally accomplish ocean decontamination after an oil spill--not the more commonly known physical means for containing or for cleaning up the spilled oil.

Because very little information exists now about such marine bacteria--their nature and their activities--careful investigations into them would be biologically interesting as well as of possible practical value. For example, certain aromatic compounds that occur in crude petroleum accumulate in the residue fraction which fouls shorelines after the lighter hydrocarbon fraction from an oil spill has evaporated or marine bacteria have oxidized it. Marine bacterial species can use these compounds as sources of carbon and energy, yet scientists know little about the biochemical and oxidative reactions that must be involved.

In their experiments, the students used enrichment culture methods to isolate pure bacterial strains from sea water. They then each developed their own projects on the bases of their respective interests. These projects ranged from direct investigation of oil degradation to the purification and characterization of an enzyme involved in the oxidation of phenolic compounds.

Although one may consider these students' reports exploratory and unsophisticated, Professor Robbins said, they do reflect the abilities, skills, and interests of undergraduates who have an opportunity to explore basic level marine ecology problems. The students' interests in their projects demonstrate the benefits they gained from their independent research experiences. As a result, the Department of Biology will offer this course regularly in alternate years.

M.I.T. Sea Grant provided seed money for additional supplies and materials for the students' experiments in this first project and published four of the more significant students' project papers in the M.I.T. Sea Grant Report, Student Projects on the Oxidation by Marine Bacteria of Aromatic Compounds Found in Oil.

Interdisciplinary Systems Design Subject (Education and Training)
Professor W. W. Seifert, Department of Civil Engineering

Power, Pollution, and Public Policy, an MITSG report which the M.I.T. Press published, is the result of the 1970 Interdisciplinary Systems Design Subject, "New England Coastal Area Planning (NECAP)," under Professor W. W. Seifert's direction.

Dennis W. Ducsik, a graduate student in electrical engineering and management, compiled and edited the reports which 13 graduate students and five undergraduate students working on NECAP presented in May 1970 after a term's work with faculty from M.I.T. in engineering and economics and from Boston University Law School.

The final project effort involved examining, "from a wide range of interacting perspectives, the pertinent technological, economic, social, and political aspects" of four critical problem areas, Ducsik said. These, he continued, were (1) electric power production as an emerging problem in land use and environmental management; (2) the crisis in shoreline recreation; (3) sulfur oxide air pollution; and (4) coastal pollution with a focus on water quality in Boston Harbor. Each of the reports on these problems became a chapter in the book. Two other chapters--one which develops the economic and the political framework for analyzing these problems and the other which looks to the future at what form political reorganization at the regional level might take--complete the book.

The class had originally proposed to take a long-range look (i.e., a 50-year regional development plan for shoreline utilization) at the role the land-sea interface should play in New England's developing coastal area, Ducsik added. But, because of personnel limitations and time constraints, they decided to work toward more immediately and continuously applicable methods for dealing with the critical problem areas they had selected.

Ducsik also wrote summary articles based on two of the book's chapters--"Offshore Siting of Electric Power Plants: The Elimination of Conflicts in Land Use Management" and "The Crisis in Shoreline Recreation: A Report on Land Use Management in the Coastal Zone"--for Senator Henry N. Jackson's Papers on National Land Use Policy Issues. Senator Jackson, Chairman of the Senate Committee on Interior and Insular Affairs, used these papers as part of the material for hearings on a National Land Use Policy before that Committee in summer 1971.

For the 1971 Interdisciplinary Systems Design Subject, students working with Professor Seifert examined the "Potentials for Utilization of the Natural Resources of Saudi Arabia." Given that the tremendous volume of natural gas, which is now

Interdisciplinary Systems Design Subject: NECAP

Boston Harbor and Massachusetts Bay. MIT is in the lower left.

flared off, wasted at existing Saudi Arabian oil wells, would be the power source, this study could demonstrate, under optimum conditions, the feasibility of a total system approach to ocean resource utilization in coastal desert regions. Seeking a feasible project to integrate major technological development into the existing economic and social Saudi Arabian framework, the students (primarily graduate students) investigated several interrelated problems: producing electrical power, desalinating sea water, increasing agricultural efforts, desulfurizing gas, and producing fertilizer, cement, aluminum, magnesium, and iron and steel. This study, Professor Seifert said, provided the students a vehicle with which they could participate in a broad-based, ocean-related project that effectively exposed them to the many interrelated issues one encounters in macroengineering.

Virgil Cox, a graduate student in engineering, outlined the aims of the project and, after the other students' presentations, summarized the group's research. If this projected plan for development were to succeed, Saudi Arabia would have a broader export base which could stabilize the total economy and open opportunities for Saudi Arabian entrepreneurs. But the program is energy-dependent and too little available natural gas would mean too few spinoffs to broaden the economic base. And, if it were to fail, the development would destabilize the total economy.

After the students had presented their plan at an open meeting in the spring, representatives from industry, from U.S. governmental agencies, and from Saudi Arabia questioned them. Several of the representatives observed that the students had handled a difficult problem extremely well and that their own questions and criticisms were as those directed not at students, but at professional investigators.

The students are preparing the final report on this project. When they complete it, M.I.T. Sea Grant will publish it as a Sea Grant Project Report.

Each of these projects achieved what Professor Seifert describes as the principal objective of the Interdisciplinary Systems Design Subject, an innovative approach to engineering education: "to engage upperclassmen and graduate students from a number of different departments in a coordinated systems investigation of a complex, real-world problem which is of considerable current interest and the effective study of which requires talents from the technical, managerial, economic, and socio-political disciplines."

He continued, "The project they select provides the students, who are nearing the completion of their formal educations, with a unique experience and an opportunity to relate and to apply their educations to an important, current problem; to serve as a member in a coordinated team effort; to be responsible for producing specific results under a realistic time pressure; and to

make an oral presentation to cognizant individuals from industry, academic institutions, and government agencies."

"Finally," he said, "because they select real-world problems, the program can also realize its second objective: producing results which should be useful to the group facing that particular problem, as well as to others who are facing similar problems."

To maximize the availability of the project's results, the students' final effort is preparing a report which, after they and others refine and edit the group's original work, becomes a published book, available to all interested organizations and individuals. Preparing this report is one more important part of the education process.

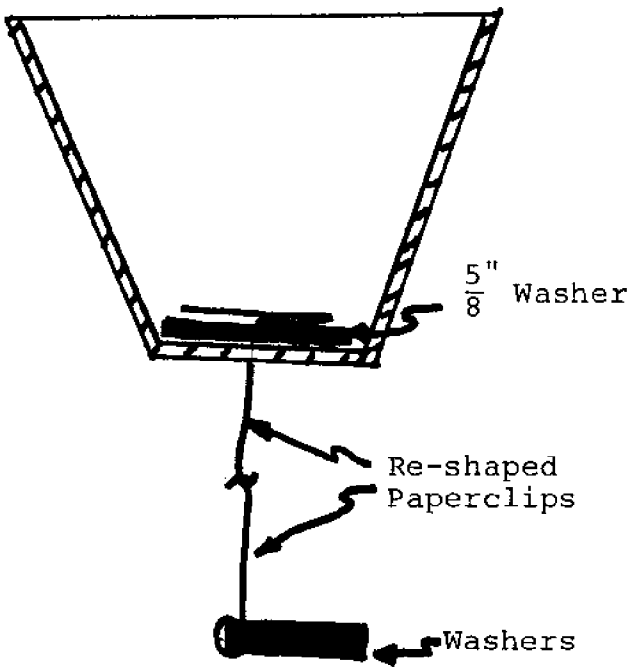
Ocean Engineering Student Summer Laboratory (Education and Training)
Professor Damon E. Cummings, Department of Ocean Engineering
Professor David Wyman, Department of Ocean Engineering
Maine Maritime Academy

In July, 14 M.I.T. students in ocean engineering, oceanography, and electrical engineering tested and used instruments they themselves had designed and built during the 1970-1971 spring term. During that month, in Castine, Maine, they and ten students from Maine Maritime Academy (MMA) confronted--and often resolved--problems ocean scientists and engineers encounter in the field. Among these: operating equipment in rough, salty, or polluted water; coping with the problems of navigation, moorings, stability, underwater searching--both from on the surface and beneath it as divers; and interpreting and writing up data.

Professor Cummings emphasized that, although some of the equipment the students designed and built and the data they collected may be of ultimate value, the program's primary aim was to educate the students about the problems one encounters when trying to apply theory and classroom experience to equipment and procedures and striving to do this without the great expensive support characteristic of larger industrial or government projects.

Judging from several students' conclusions, this educational experiment was successful and rewarding for them, and the experience came early in their academic careers (many of the students were first- and second-year undergraduates). Thus, the students said, it helped them afterwards to select academic subjects which would make their undergraduate curricula more meaningful professionally. It also accelerated their levels of engineering and scientific sophistication in experimental design problems--both in designing and building an instrument and in making it work in the marine environment.

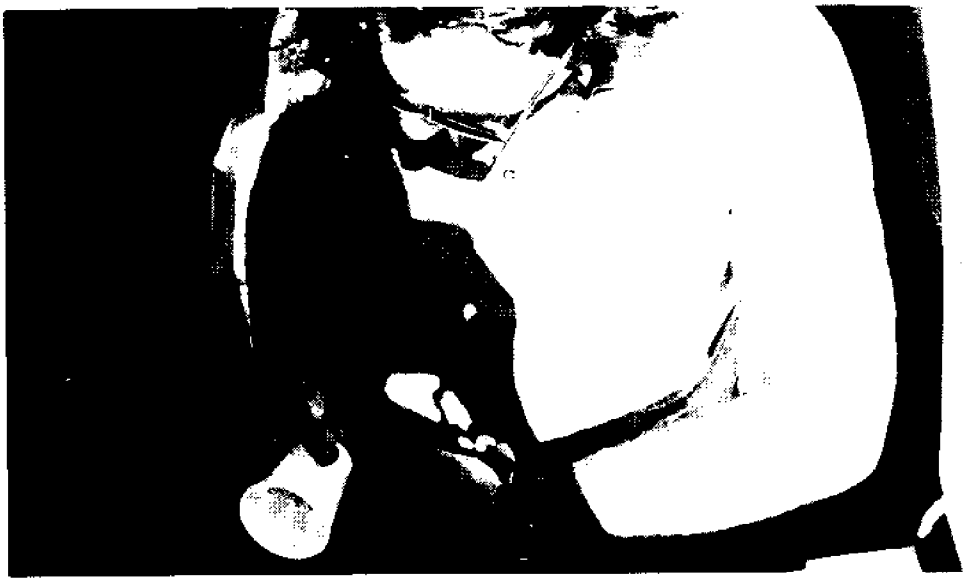
The group had two objectives toward which it worked in July.



...In all our designs we strive for simplicity, reliability, ease of construction and/or preparation, and accuracy. This device is no exception. The heart of the device is a 6 oz. styrofoam cup, the same used for take-out orders in many restaurants. The shape of the cup ensures that no matter what orientation it has relative to the local current, it will have sufficient drag so that it can be assumed that the cup acts as a particle of fluid. From here it is a logical step to weight the cup so it sinks to the bottom, and then upon impact releases the weight in order for the cup to return to the surface. Thus only one person on the surface is required to operate this device. With the range, direction, and time for the round trip, the average current can be determined.

For weight we used a combination of 1/2" and 5/8" galvanized washers attached to each cup with two paper clips reshaped into hooks...

Robert Powers, 1971
(pages 67, 71)



CUP
ADJUSTMENT

THE DROP

CUP
SINKING
NEXT CUP
READY
FOR
DROP

One was to search for and try to recover an MMA 31' Shields sailboat which sank in Penobscot Bay in summer 1970. Some of the students spent a weekend in May making a sonar search for the wreck with Professor Cummings and Dr. Harold E. Edgerton, Professor of Electrical Measurements, Emeritus, but they were unsuccessful. Then again during July, in the course of searching for the sailboat, the group built a side-scanning sonar from a fathometer with help from Professor Ira Dyer, Ocean Engineering. But, despite this special sonar and other instruments and techniques, the group still did not find the sailboat.

In achieving their second objective, collecting data about various water movements and the resulting pollution dispersion in Penobscot Bay, they were more successful. Using the instruments they designed and built--from a styrofoam cup current meter to a modified cassette recorder--they plotted currents in the Cape Rosier area, an area where that winter a strip copper mine which was emptying its waste into the then-dammed Goose Pond would shut down. From the data they collected, the students concluded that, if Goose Pond were undammed, its wastes would flow into Penobscot Bay in the Cape area and pollute it more than was then the case. The current-measuring crews also believed that substantial differences existed among the speeds and the directions of different water strata than have previously been identified. They made water quality measurements and preliminary marine fauna surveys to use for comparison with measurements that others would take after the mine shut down.

Much of the students' work included scuba diving. Several M.I.T. faculty and staff helped the students prepare for this part of their summer laboratory. Each student diver was required to pass the NAUI qualifications. Arrangements were made with the Engineering Design and Analysis Laboratory, University of New Hampshire, to borrow UNH's decompression chamber for the month. Two of the laboratory staff delivered the chamber and trained the students to operate it.

MITSG issued as a Sea Grant Report the group's final report on their summer's work, Ocean Engineering Student Summer Laboratory, Summer 1971. It included statements of the program's educational aims, brief descriptions of the students' instruments, and an analysis of the data they collected and the conclusions they drew from it. This highly successful education program is being continued by the introduction of new research objectives each year that will make each project effort unique and independently productive.

Ocean Engineering/Marine Transportation (Education and Training)
Professor John W. Devanney III, Associate Professor of Marine Systems

Marine Decisions Under Uncertainty was first a course in the Department of Naval Architecture and Marine Engineering, then a

special course in M.I.T.'s 22nd annual Special Summer Programs curriculum and, finally, a textbook.

Professor Devanney developed the course and taught it first during the 1971 spring term as part of the department's shipping and shipbuilding curriculum. In the summer program, he and Joseph B. Lassiter III taught the one-week course which 40 shippers and shipping industry and government representatives from the United States and abroad attended.

M.I.T.'s Commodity Transportation and Economic Development Laboratory and the M.I.T. Sea Grant Program cooperated on this course. Professor Devanney wrote Marine Decisions Under Uncertainty because "the systematic treatment of uncertainty has received little attention in marine practice or the marine literature." The book, he said, is an attempt to help shipowners, ship charterers, and other marine investors to answer the question, "How can I analyze what I cannot predict, and how, after I have analyzed different possible decisions, do I choose which decision is a good one?"

"A most human question," he continued, "is: Did [I] make a good decision or didn't [I]?...We must make a distinction between a good decision and a good outcome. The decision-maker in one of the textbook's problems made a good decision because he based it on logic and his available knowledge. Whether or not the outcome is good depends on the vagaries of chance. Psychologically, perhaps the most basic difference between decision-making under certainty and under uncertainty is that in decision-making under uncertainty you cannot judge a decision by its outcome."

The text's first three chapters are an elementary introduction to decision-making under uncertainty, Bayesian decision theory, and dynamic programming, respectively. They assume no prior knowledge of these techniques.

The final three of its six chapters apply these techniques to what Professor Devanney considered a representative spectrum of marine problems that involve substantial uncertainties. These three chapters presuppose an increasing level of probabilistic sophistication; Chapters 5 and 6, particularly, assume some familiarity with continuous random variables and density functions. The arguments in these three chapters are basically illustrated applications of the same principles Professor Devanney discussed in the first three chapters.

Readers and users have reviewed the book favorably. By December 1972, the publisher, Cornell Maritime Press, had sold 683 copies in the United States and 55 abroad. These figures include the initial 250-copy distribution by the M.I.T. Sea Grant Program. Professor Devanney is continuing the ocean engineering course developed under this project and uses the book for the course text.

Ocean Engineering/Ocean Environment: The Evolution and Utilization of Marine Mineral Resources (Education and Training)
Dr. Alfred A. H. Keil, Director, M.I.T. Sea Grant Project and Dean, School of Engineering

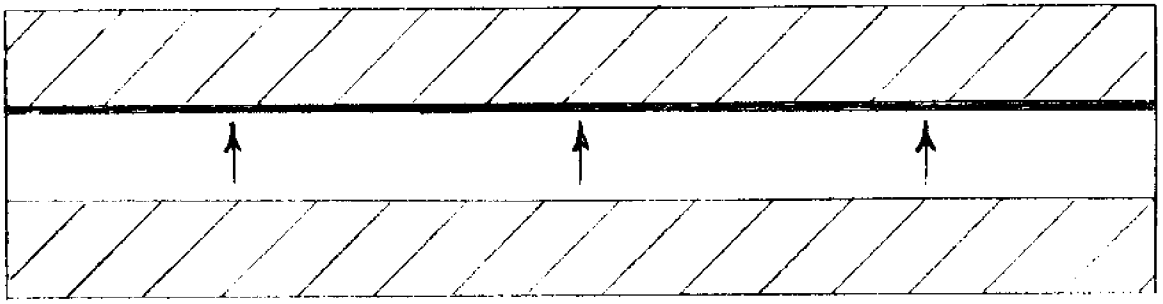
In response to an established need for a special subject that would acquaint ocean engineering students with the physical processes that create or destroy the natural mineral resources of the seas, this project first supported a special seminar subject during the January 1971 Independent Activity Period at M.I.T. Professor Keil and his research assistants, H. S. Lahman and J. B. Lassiter III, developed the initial lecture notes. They revised these and used them in the regular academic subject, 13.93, "Evolution and Utilization of Marine Resources," which Professors Keil and Devanney first offered in the fall term 1971. They revised and edited the lecture notes again after the fall term.

The economics of deciding how to use marine engineering and sciences in the search for and the collection of marine mineral resources is one of the subjects the authors of the M.I.T. Sea Grant Report, The Evolution and Utilization of Marine Mineral Resources, consider. Lahman and Lassiter, working with Dr. Keil, have also discussed the processes by which these resources evolved and thus how best to locate them.

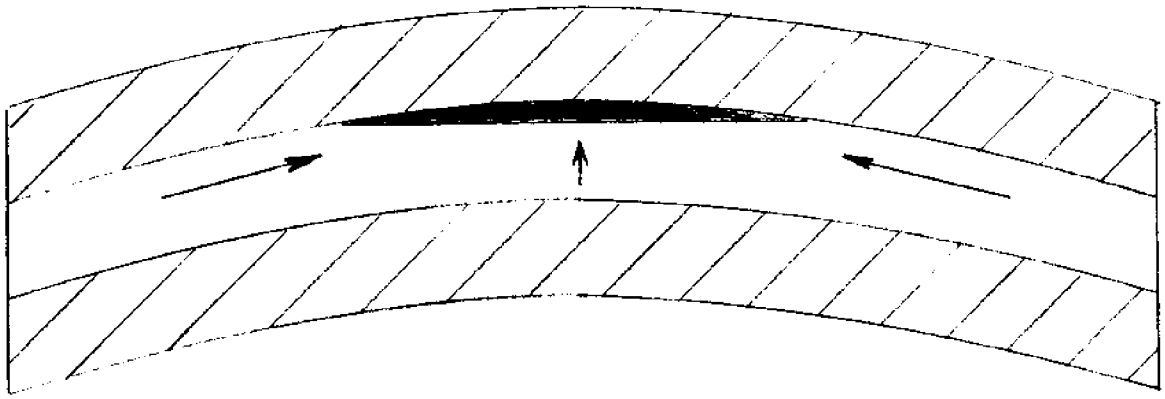
In this report, the MITSG researchers provided an introduction to marine mineral resources, their environments, and some techniques one might use to locate them. But this is not, they emphasize, a reference text for specialists. Nor does the report deal with any of the environmental problems one might have to confront in marine minerals exploration or development. The report is instead a coherent overview of some of the basic problems for, say, an operations manager or an ocean engineer who has no experience with marine resources exploration or development so that he may discuss problems with the technical field explorationist or the marine geologist and better understand and evaluate their data, comments and conclusions.

The current, relatively small development of marine mineral resources means that few general techniques or practices have evolved on which one may base retrieving these resources. And these practices one must use include elements from many disciplines: among these, science, engineering, transportation, and economics. To complicate the problem further, each instance of ocean minerals' retrieval now seems unique simply because there is such relatively limited experience on which to draw.

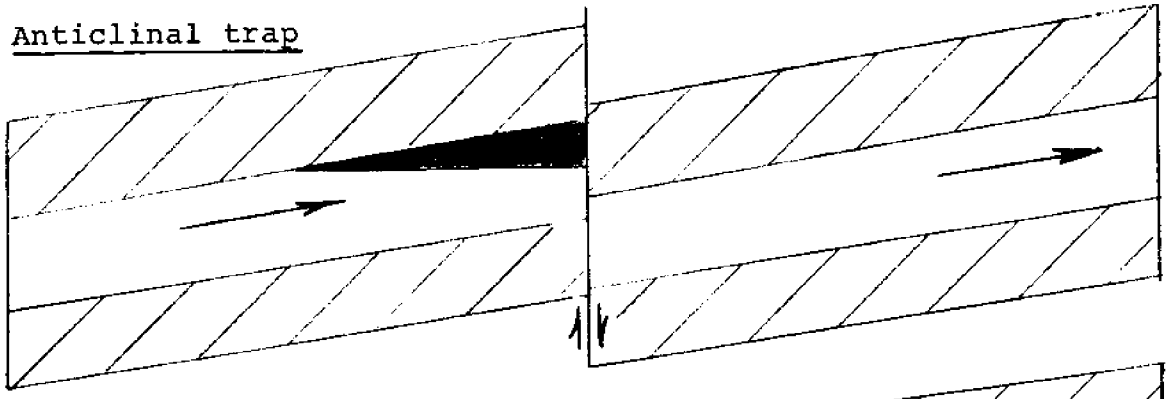
This completed project provides a much needed course for ocean engineers: "Evolution of marine resources as a result of oceanic and geological processes. Application of natural resource economics--including planning of exploratory and development programs--for selecting suitable marine resources for efficient utilization. Application of marine technology and adaptation of land-based resource technology." (M.I.T. course catalog, 1971-1972.)



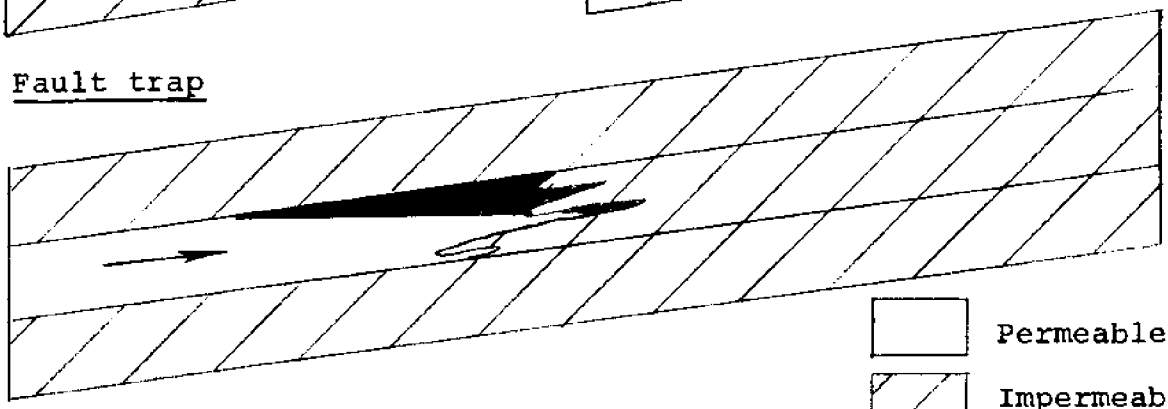
Horizontal layering



Anticlinal trap



Fault trap



Stratigraphic trap

Types of petroleum traps
(pages 101--102)

M.I.T.'s Department of Ocean Engineering is using the Sea Grant report as the textbook for this course, and both Massachusetts Maritime Academy and Maine Maritime Academy are using it as a reference for courses in their curricula.

Marine Resources Reference Center

The Reference Center serves not only the MIT community, but also other academic institutions, government agencies, and industries.

Marine Resources Reference Center (Advisory Services)
Professor Norman N. Jones, Department of Ocean Engineering

Over 250 individuals from M.I.T., Woods Hole Oceanographic Institution, other academic institutions, government agencies, and industry used the Marine Resources Reference Center during 1970-1971. This initial indication of broad interest has led M.I.T. Sea Grant to improve and to expand both the collection and the facilities in the Reference Center as a major Advisory Service effort.

The Center, which Sea Grant and the Department of Ocean Engineering began to build on the existing Naval Architecture and Marine Engineering departmental library, now includes not only departmental material, but also marine-related reports from many sources, including government agencies and other Sea Grant institutions as well as relevant reference materials on marine resources utilization. The Reference Center decided against collecting and duplicating the many specific types of materials which are available in the M.I.T. library system, electing instead to seek cooperative arrangements with relevant libraries.

During the year, the Reference Center staff and the M.I.T. Sea Grant project personnel considered several of the long-range changes that should take place to expand the new Center and to make it an effective Advisory Service. These included returning certain administrative and academic functions to the Department of Ocean Engineering; contacting other academic institutions and government agencies for information for the Center's users; and broadly seeking user suggestions about improving the Center. The project personnel in this way began to enlarge the collection and to define subject areas for concentration. The Center's Information Officer, Barbara Passero, is classifying and cataloguing the Center's reports (approximately 5,000 of them), most of which were published during the last decade and many of which are a legacy from the Naval Architecture and Marine Engineering departmental library. She and student assistants are doing this in a way which permits the Center to use a regular catalog system now and to expand into a magnetic tape system later if this becomes desirable.

Mrs. Passero has also begun to collect data for a research index of M.I.T. faculty and staff with marine-related interests.

Sea Grant Related Reports and Information (Advisory Services)
Dr. Alfred A. H. Keil, Director, M.I.T. Sea Grant Program,
and Dean, School of Engineering

M.I.T. has nearly ten times more marine-related research projects that sources other than the M.I.T. Sea Grant Program

support. Final reports on these important, timely projects are frequently limited to minimal distribution, and to many fewer copies than their results merit.

Therefore, the M.I.T. Sea Grant Program, as a special Advisory Service project, decided to publish selected reports and to give them broad dissemination through the Sea Grant distribution list. Using part of its matching fund grant from the Henry L. and Grace Doherty Charitable Foundation, Inc., M.I.T. Sea Grant has been able to publish and to distribute these related reports during this first project year:

- Economic Factors in the Development of a Coastal Zone, Devanney et al., MITSG 71-1;
- Economic Aspects of Solid Waste Disposal at Sea, Devanney et al., MITSG 71-2;
- The Economics of Fish Protein Concentrate, Devanney et al., MITSG 71-3;
- "The Economics of Arctic Oil Transportation," Lassiter and Devanney, MITSG 71-4;
- Ocean Engineering Systems, Craven et al., MITSG 71-6;

  and

- Directory of M.I.T. Research Projects Related to Marine Resources, Ocean Utilization, and Coastal Zone Development, Horn, MITSG 71-9.

The first three reports Professor Devanney and others wrote (for a complete list of authors of related reports, please see Publications, p. 26) are the results of special studies they did for the National Council on Marine Resources and Engineering Development, Executive Office of the President. M.I.T. Sea Grant had printed and distributed over 750 copies of these reports during the project year. Because of the continuing number of requests from federal and state agencies, the United Nations, academic institutions, industry, and individuals both in the United States and other countries, M.I.T. Sea Grant reprinted over 300 copies in 1971 and 1972.

The fourth report Mr. Lassiter and Professor Devanney did at M.I.T. with research support from the Department of Naval Architecture and Marine Engineering. Schiff und Hafen, the official publication of the German Society of Naval Architecture, published the paper originally in their November 1970 issue.

Dr. Craven's book, for which three M.I.T. students provided major compilation and editorial assistance, drew on support not only from the M.I.T. Sea Grant Program and the Doherty Foundation, but also in part on funds for sponsored research from the

Sperry Rand Corporation. Dr. Craven developed the material in this book for his M.I.T. course, "Ocean Engineering Systems," which he taught in the Department of Naval Architecture and Marine Engineering in 1969-1970. M.I.T. Press published this book as one of the M.I.T. Ocean Engineering Textbook Series. The book is in its second printing and is being translated into Japanese.

Mr. Horn compiled the Directory of M.I.T. Research Projects in June 1971 to help answer frequent requests to the M.I.T. Sea Grant Office for the type of information in the Directory. He drew primarily on the M.I.T. Industrial Liaison Program's Directory of Current Research, but he also consulted various Institute departments, laboratories, and research offices. This is a report the Sea Grant Marine Resources Reference Center also uses frequently to answer questions regarding Sea Grant and related research from outside the Institute as well as from within M.I.T.

The Sea Grant Project Office has sent all these publications to those on the standard Sea Grant mailing lists and to many others as well, either as complimentary copies or in answer to requests for specific reports. Based on the demand for the information published, M.I.T. Sea Grant has extended this seed project as a full Advisory Services Project for the second year of the CAP, 1971-1972.

PUBLICATIONS UNDER SEA GRANT GH-88

Economic Factors in the Development of a Coastal Zone, J. W. Devanney III, E. Derbis, W. W. Seifert, and W. Wood, MITSG 71-1 (NTIS No. PB195224), November 1970.

Economic Aspects of Solid Waste Disposal at Sea, J. W. Devanney III, V. Livanos, and J. Patell, MITSG 71-2 (NTIS No. PB195225), November 1970.

The Economics of Fish Protein Concentrate, J. W. Devanney III, and G. Mahnken, MITSG 71-3 (NTIS No. PB195226), November 1970.

"The Economics of Arctic Oil Transportation," J. B. Lassiter III, and J. W. Devanney III, MITSG 71-4, November 1970.

New Dimensions of U.S. Marine Policy, Norman J. Padelford and Jerry E. Cook, MITSG 71-5 (NTIS No. COM 71-00782), MIT Press, April 1971.

Ocean Engineering Systems, John P. Craven with T. Gray Curtis, John R. Mittleman, and James M. Patell, MITSG-71-6, MIT Press, April 1971.

Marine Decisions Under Uncertainty, J. W. Devanney III, MITSG 71-7, Cornell Maritime Press, November 1971.

Power, Pollution, and Public Policy, Dennis W. Ducsik, editor, MITSG-71-8, MIT Press, January 1972.

Directory of MIT Research Projects Related to Marine Resources, Ocean Utilization and Coastal Zone Management, Dean A. Horn, compiler, MITSG 71-9 (NTIS No. COM 71-00924), June 1971.

Student Projects on the Oxidation by Marine Bacteria of Aromatic Compounds Found in Oil, P. W. Robbins et al., MITSG 71-10 (NTIS No. COM 71-00878), June 1971.

Ocean Engineering Summer Laboratory, 1971, Damon E. Cummings and David Wyman et al., MITSG 72-3 (NTIS No. COM 72-10327), October 1971.

The Evolution and Utilization of Marine Mineral Resources, H. S. Lahman and J. B. Lassiter III, MITSG 72-9, June 1972.

Summary of Expenditures

	Sea Grant	Matching
Program Management	$46,400	$26,250
Education and Training	70,000	39,550
Research	90,100	50,900
Advisory Services	11,400	6,500
	217,900	123,200

This summary is only approximate. The official financial report will be submitted by the M.I.T. Comptroller to the office of Sea Grant in accordance with the federal grant requirements.