MIT SEA GRANT
WINTER 1980

Quarterly Report

A Management Scheme for Boston Harbor

The Boston Harbor Management Team: (left to right) Tabors, Hack, De Neufville, Kildow, Warren.

One of the largest and most picturesque harbors on the East Coast, Boston Harbor once housed a thriving port with busy wharves. With much of that activity relegated to the past, today's Harbor is making an uncertain transition. Restaurants and residences line much of the waterfront, while many land parcels lie vacant or unused. The Port of Boston, fragmented across the Harbor area, receives various types of cargo.

A casual visitor to Boston Harbor might notice the pollution or the absence of marina space, or may wonder where the water-related activity has gone. With more than 100 government agencies claiming jurisdiction, it is clear why no message about the Harbor gets to the public. What, if anything, is happening in the Harbor?

In an attempt to understand and perhaps improve the situation, an interdisciplinary group at MIT recent commenced a Harbor management project. Principal investigator Judith Kildow, Associate Professor of Ocean Policy in the MIT Department of Ocean Engineering, explains that the project aims primarily at facilitating communications. "We're trying to come up with some management mechanisms" rather than to create a master plan, she stresses.

The overall project objective is to design some alternative management schemes that will improve environmental conditions, public access and economic development in the Harbor area, and to piece together a working philosophy for the Harbor. Management has been troubled by the lack of well-defined areas of responsibility, as well as by multiple and sometimes conflicting interest groups and jurisdictional units. Among the many governmental bodies involved are the City of Boston, Massport, Massachusetts Office of Environtal Affairs, nine cities and towns bordering the Harbor, and the Massachusetts Legislature.

The MIT group intends to remain as non-judgmental as possible, says Professor Kildow. "Essentially we're taking the coastal zone concepts and suggesting where public intervention might assist in achieving certain objectives. We hope to pose a series of alternative strategies and legislative packages and be as value-free as we can," she continues. As an academic body without vested interest in the outcome, the group, she feels, can be more outspoken and objective than politically appointed commissions or special interest groups.

In a recent meeting, some of the group's sponsors and people from the Coastal Zone Management office "sat and talked to each other about Harbor problems, which they never do," she recalls approvingly. "As we draw groups together to discuss the problems, we're creating a communications process which I'm sure will have a life of its own." Currently "the turf problems are just incredible," recounts Professor Kildow. "It's typical for all cities. When you have the degree of sovereignty that each group has, each wants to maintain it unless they can come together in some cooperative benign project."

Investment and market incentive and constituent pressures can overcome the stalemate caused by political problems, says Professor Kildow. However, such a drive for action and change has not occurred in Boston. For the past 100 years, she maintains, the city has focused attention on Cape Ann, Marblehead and Cape Cod, while neglecting its own harbor.

As a start toward progress, the Massachusetts Legislature passed a bill in December 1979 to establish a Harbor Commission. William M. Bulger, President of the Massachusetts Senate, has enthusiastically supported the Sea Grant proposal. "We will meet with the Commission and let them know that we exist, what we've been doing, and that we're informally a study group for them," says Kildow.

Plans for the next half year include completing the land-use survey, selecting and completing case studies of investment patterns, environmental conditions and public access, and confirming strategies for dealing with Harbor

issues. The committee intends to get feedback to these strategies, to coordinate with the Boston Harbor Commission and to begin to package legislative proposals. They hope to complete a study of New England inter-port cooperation and to continue analyzing the market potential for the Port of Boston. In addition, they want to complete a public access plan.

Working with Professor Kildow are Gary Hack, Associate Professor in the Department of Urban Studies and Planning; Richard De Neufville, Professor of Civil Engineering; Lee Warren, Lecturer in the MIT Writing Program; and Richard Tabors of the Energy Lab and Urban Studies. Student assistants are George Blossom, Steve Cassella, Barbara Cole, Amy Philipson, James Spaul, Koji Tsunokawa and Jennifer Zeien. Funding comes from Sea Grant, Coastal Zone Management, Massport, Boston Shipping Association, Inc., and Boston Seaman's Aid Society.

Acoustical Telemetry: a New Underwater Communications System

The modulated high-frequency hums and beeps coming from the February 13th MIT Marine Industry Collegium meeting slightly resembled the song of some marine mammal, but that was not the source. An array of electronic and microprocessing equipment set up in the Sea Grant conference room was transmitting messages using a new underwater communications system developed by a team of researchers from MIT and the Woods Hole Oceanographic Institution (WHOI). Headed by MIT Professor Arthur B. Baggeroer from the Departments of Ocean Engineering and Electrical Engineering, the group displayed and described a system of acoustical telemetry which promises to free remotely operated vehicles (ROVs) from the restrictions of exchanging information with surface operators through a tether.

At present the tethers, which are needed to carry power and transmit instructions and information, are one of the key weaknesses in existing ROV technology. Not only do they tangle easily on platform legs and underwater debris, but they create a tremendous amount of drag, restricting the independence and the movement of underwater vehicles.

For the offshore industry, removal of the tether will increase the mobility and efficiency of ROVs for platform maintenance, pipeline inspection, and recovering lost equipment from the sea floor. For scientists, a new communication system will help them work in new oceanic frontiers off the continental shelves.

At the morning session of the Collegium meeting, Baggeroer described how the group's current work rests on the "cutting edge" of several new technologies. Advances in microprocessing have contributed significantly to broadening the potential for direct acoustical communication in the undersea environment. High data rates can now be achieved using small, lightweight processors that are easily built into mobile ROVs. He also noted the relevance of improvements in underwater transmitters at WHOI, frequency shift keying experiments in England, and recent U.S. Navy sonar experiments. Building on this past work, the Woods Hole-MIT research group, which includes Associate Professor Jeffrey Shapiro from MIT's Department of Electrical Engineering, Ocean Engineering student William Hanot, and Donald A. Koelsch and Keith Vonder Heydt from WHOI, are developing a communications system to overcome the multipath distortions that have severely limited underwater communications previously.

Baggeroer has been leading the task of applying communications theory to the encoding of digital data through frequency shift keying of acoustic signals. He uses an Intel 8085 microprocessor to convert "4 bits" of data into an error-correcting 8 bit code, represented as chords of 8 tones. The 4 bits encoded into these 8 tone messages give the system flexibility for making tradeoffs between quantity of data, range, error rate, and redundancy. The chords are transmitted directly through the ocean environment in a frequency band centered at 50 kHz. Each 4 bit message is accompanied by two additional signals. A 60kHz tone serves as a reference; any deviation in frequency indicates to the receiver that there has been a Doppler shift and tells what adjustments are necessary in decoding the message. A 30 kHz signal sent as 100 microsecond tone bursts synchronizes the receiving signal.

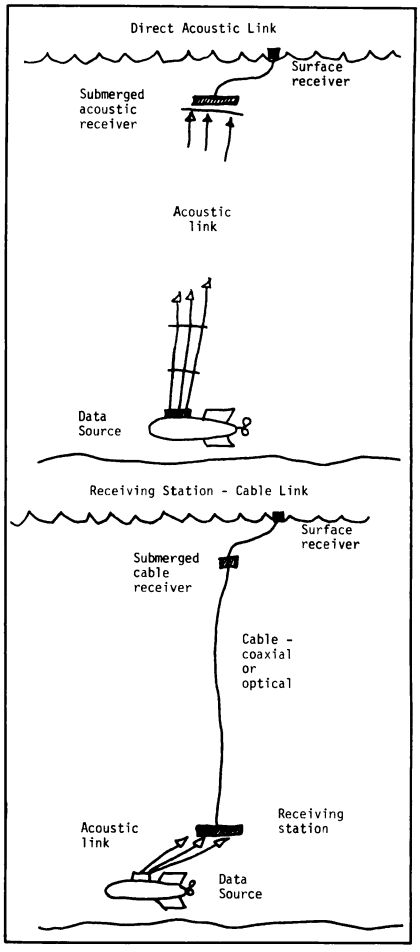

Figure 1: Proposed Communications Systems

Figure 1 shows two embodiments of the communication system proposed by the Sea Grant-sponsored group. Both are intended for near vertical

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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, Room 370, Cambridge, MA 02139. Telephone: (617) 253-4307.

path telemetry, but one is for shallow water work where the ROV would send data directly through an ocean channel, while the other for deep water would use a receiving station linked to the surface by an extremely lightweight, highly sensitive fiber optical cable. This aspect of the research is being done by Professor Shapiro, who explained that the optical cable, unlike the heavy tethers used at present, would have low drag and would not require a large crew and heavy retrieval equipment for release and recovery.

Baggeroer noted efforts to overcome severe reverberation problems that are prevalent in shallow water, refractive conditions. He explained how the researchers have employed frequency hopping to overcome this. By shifting the carrier of the successive 8-tone messages into slightly different frequencies between 45 kHz and 55 kHz, they are able to wait until the reverberation dies before reusing each frequency channel. Other efforts to decrease multipath effects are being made through the use of a directional data transmission system which they have borrowed from sonar and radar technology. A 4 x 8-element, steered array consists of small transmitters, each with a prescribed signal time delay that points the encoded chords in a direction controlled by an operator on the surface. The array has a beam width of about 15 x 17 1/2 degrees, which provides an engineering balance between signal gain and the possibility of pointing errors.

When the messages reach the receiver, they are split into 3 separate signals--the 8 tone blocks, the Doppler signal, and the synchronizing signal. Using FFT techniques, each 8 bit data segment is reconstructed from the frequency spectrum, and the original 4 bit message is derived from an error-correcting algorithm.

The Sea Grant researchers are close to achieving their short-term goal of transmitting around 4 kilobits of information per second. Long-term they are aiming for 10 kilobits. These rates can be manipulated to accomodate the variables of individual ROV assignments such as task complexity, error tolerance, distance from the data source to the decoding receiver, acoustic channel characteristics, and ocean conditions.

At the end of the Collegium presentation, Norman A. Doelling, Manager of the MIT Marine Industry Advisory Service, asked the researchers to report on future plans. According to Baggeroer, in the coming year they will complete the design of the decoding system, which has been slowed by difficulties in getting solid state components. The next step will be to package the decoding and transmitting equipment for ocean submergence; they will then complete plans to test the system off the dock at Woods Hole, and later in deeper waters from the deck of MIT's Research Vessel EDGERTON.

Salt Water: a Potential Contaminant

For years, in a resort town on the coast of southern Portugal, hotel owners and orange growers competed for the same limited groundwater supplies. Today their battle is over, and both sides are losers. Salt water has contaminated local wells because too much fresh water was extracted to irrigate fields and operate hotels. As a result, the orange groves are dying; and the hotels must depend on expensive piping systems to bring supplies from dams many miles away.

Underground saltwater intrusion is a potential problem for many island and coastal peninsular communities, especially those facing rapid development and growth. At MIT, the Sea Grant Program is sponsoring the research of Professor John L. Wilson III in the Department of Civil Engineering to help communities predict saltwater intrusion. Professor Wilson and a research associate, Antonio Sa da Costa, have created a numerical model that will help hydrologists predict the effects of different pumping rates on local groundwater supplies and will provide an advance warning to communities threatened by saltwater contamination of freshwater supplies.

Saltwater intrusion has received less attention in the press than other potential sources of groundwater contamination, such as faulty septic tanks, sewage effluents and chemical wastes. Nonetheless, the presence of too much salt can make local water supplies unfit for human consumption and for nourishing wildlife and vegetation.

How does saltwater intrusion occur? The source of fresh groundwater is precipitation--rain or melting snow. The sea stretching inland underground meets this fresh water at the boundary of an aquifer. Aquifers are many sizes and shapes but in the most common coastal aquifer the interface between the fresh water and salt water intersects impervious clay or rock boundaries. In another common aquifer configuration, the fresh water "floats" on top of the salt water in the shape of a concave "lens." act keeps the salt and fresh water apart: precipitation recharge from the top and the flow of fresh water seaward provide a force from above,

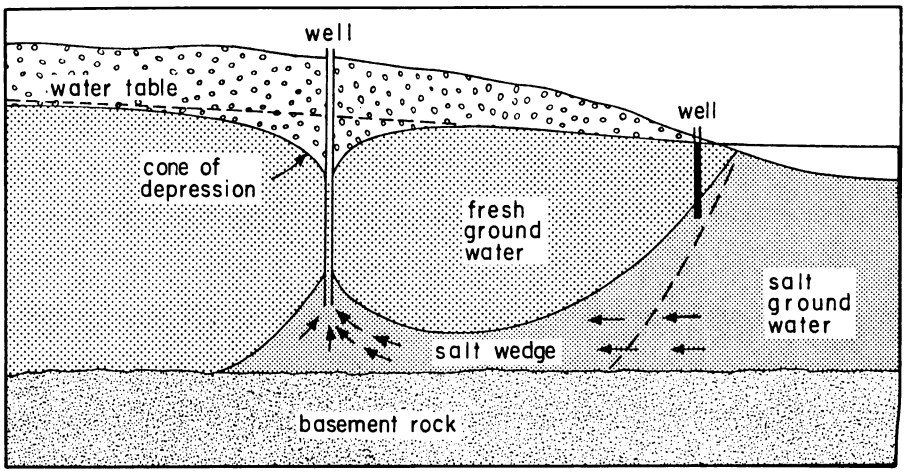

Figure 2: A saltwater wedge beneath a freshwater aquifer, contaminating a large supply well and a small well near the shore.

while the greater density of the underlying salt water exerts a counter force from below.

When there is enough rain or snow to replenish extracted fresh water, the balance is maintained. If, however, the aquifer is pumped too heavily by a coastal community, a depression develops in the freshwater layer near the point of extraction. If water continues to be taken from the aquifer, without adequate recharge from precipitation, the depression enlarges and greater volumes of seawater move in to fill the void (see Figure 2). The larger the void, the more brackish the water becomes. This whole hydrological process moves fairly slowly, so that a watchful community can identify and thwart saltwater intrusion when it is still just a threat, not a serious danger.

The Sea Grant Saltwater Intrusion Model (SWIM) is being developed by Professor Wilson and Dr. Sa da Costa for use in monitoring existing groundwater supplies. And it will also have important applications as a predictive tool, since it can assess the effects of proposed industrial and residential development schemes prior to community approval.

Based on solutions to groundwater flow equations, SWIM locates and describes the saltwater and freshwater interface under different pumping and recharge conditions. The model's input data include the amount and location of water usage and assumptions about precipitation levels, porosity and permeability.

Other types of models have been developed to examine groundwater flow situations but none has been specially designed to examine saltwater intrusion on islands and coastal peninsulas. SWIM can be applied repeatedly to different locations with various groundwater conditions. Analytical models make simplifying assumptions about the input data used to evaluate groundwater conditions whereas SWIM can employ equations adjusted for complicated aquifer boundary conditions or hydrodynamic flow.

The two researchers have completed the numerical model and in the coming year will calibrate and verify SWIM on Martha's Vineyard, where they have worked closely with the Island's development commission and with the U.S. Geological Survey. The final step in this Sea Grant project will involve the preparation of a user's manual. It is hoped that the model will be useful to hydrologists or water quality experts in many communities in the United States and abroad.

MIT Summer Session

The MIT Sea Grant College Program and MIT's Summer Session Office will sponsor several week-long courses at MIT this summer for practical engineers and professionals in ocean-related fields. The courses include: "Corrosion: The Environmental Degradation of Materials" (July 7-11); "Analysis of Welded Structures" (August 11-15); "Port Management and Operations" (August 11-15); "Port Planning and Design" (August 18-22). Also, in conjunction with the Center for Transportation Studies, MIT Sea Grant will be sponsoring five transportation courses: "Transportation Systems Management" (Part I, August 4-8; Part II, August 11-15); "Urban Transportation" (Part I, August 4-8; Part II, August 11-15); "Freight Transportation" (Part I, August 4-8; Part II, August 11-15); "Forecasting Transportation Demand: Basic Concepts, Modelling Techniques, and Advanced Approaches" (Part I, August 4-8; Part II, August 11-15; Part III, August 18-22); and "Transportation Network Analysis" (August 13-15).

Two special programs are being sponsored in June: "The Theory and Hands-on Use of Design Computer Programs in Naval Architecture" (June 16-20); and "The Theory and Hands-on Use of Design Computer Programs in Ocean Engineering" (June 23-27).

Brochures describing the courses in greater detail are available through the Sea Grant Quarterly Report office. For information on accomodations and registration, contact: Office of Summer Sessions, E19-356, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Cambridge, MA 02139.

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Abstracts

☐ Effect of Liquid Storage Tanks on Dynamic Response of Offshore Platforms

J. Kim Vandiver and Shuhei Mitome
MITSG 79-9J 8 pp. $1.00

Arising from studies of structural integrity and vibration response of offshore structures, this paper suggests that liquid storage tanks, used on oil rigs for water, fuel, mud and crude oil, can be designed to eliminate adverse dynamic properties and to maximize the damping of the structure. Analytical procedures which can account for the effects of liquid storage tanks are presented. The study introduces optimum tuning of the tanks to absorb platform response frequencies, for which no new equipment is needed.
Reprinted from: Applied Ocean Research, 1979, Vol. 1, No. 1.

☐ A Numerical Model of Seawater Intrusion in Aquifers

Antonio A. G. Sa da Costa and John L. Wilson III
MITSG 79-27 245 pp. $8.00

SWIM is a numerical two-layer horizontal flow computer model describing seawater intrusion in freshwater aquifers. It provides a much-needed tool for coastal and island developers, who must maintain an adequate, stable water supply in sensitive groundwater areas. Applications and verifications of SWIM are included: 1-D seawater intrusion, development of a freshwater lens over sea water; seawater intrusion into a leaky coastal aquifer; injection of fresh water into a saline aquifer; and seawater intrusion toward a pumping well. A users manual will be published next year.

☐ Longshore Sediment Transport Data: A Review

Ole S. Madsen, David W. Ostendorf and Andrea S. Reyman
MITSG 79-28J 14 pp. $1.00

This journal reprint is a review of the methods and data bases of Watts (1953), Caldwell (1956) and Komar (1969) which led to the well-used longshore sediment transport equation in the Shore Protection Manual (SPM-73), U.S. Army (1973) Coastal Engineering Research Center. Agreement between assumptions and reported data is assessed. Because of questions concerning the wave energy flux factor and the use of tracer technology, the review concludes that the results of the SPM-73 equation should be regarded as no better than order of magnitude estimates.
Reprinted from: Proceedings of the 16th Coastal Engineering Conference, ASCE, Hamburg, West Germany, 1978.

☐ A Citizen's Guide to Sources for Marine and Coastal Information in Massachusetts

MITSG 79-29 54 pp. $1.00

This 1979 edition of our Citizen's Guide lists over 100 Massachusetts agencies, information centers, and organizations concerned with and important to marine and coastal affairs. Each entry includes office hours, address, and telephone numbers, as well as a brief description of the objectives, specialties and services of each entry. A detailed subject index provides easy interest-group reference.

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☐ **Investigation of Mechanical Properties of Raw Flesh and Skin of Spiny Dogfish (Squalus Acanthias)**

Juan A. Menjivar, Rong Chen, ChoKyun Rha
MITSG 79-30J 10 pp. $1.00

Although not widely studied, mechanical properties of fish are important as objective design parameters in processing and equipment manufacture. Spiny dogfish research is precipitating advances in an economical, mechanical method of skinning this underutilized species. Tensile strength, breaking elongation, adhesive work, shear strength, and shear work tests were performed. The effects of flesh and skin location and of heat treatments were also assessed. Reprinted from: Journal of Textural Studies, 10, 1979.

☐ **The Effects of Surface Phenomena on the Spreading of Oil on Water**

Riyaz A. Fazal and Jerome H. Milgram
MITSG 79-31 170 pp. $4.00

When oil spills occur, separate chemical components thin out or coagulate. Present models incorporate bulk behavior information, but do not account for fractionation. Spreading--of four kinds of crude extracted from around the world, as well as a mixture of pure hydrocarbons and of diesel fuel--with regard to individual oil properties is studied in this report. Spreading effects determined not only by bulk properties, but also by properties of the individual components of the oil led the report to conclude that more physical and chemical studies are needed to improve oil spill modeling.

☐ **Understanding the Oceans: Motivating Today's Youth To Work for Tomorrow. Eighth Annual Sea Grant Lecture and Symposium**

MITSG 80-1 22 pp. No charge

In the Eighth Annual Sea Grant Lecture and Symposium, Dr. Herman R. Branson, scientist and educator, and president of Lincoln University since 1970, discussed how to help women and minorities to overcome existing impediments and encourage their participation in careers in the marine field. Dr. Mary P. Rowe of MIT, Dean Roderick M. White of the Coast Guard Academy, Dr. James W. Mayo of the Department of Energy, and Mr. Logan Sallada of the Human Resources Division of the national office of Management and Budget, participated in the discussion and debate as panelists.

☐ **A Report on the Massachusetts Institute of Technonology Sea Grant College Program: 1 July 1978 to 30 June 1979**

MITSG 80-2 48 pp. No charge

This annual report of the MIT Sea Grant College Program covers the accomplishments of the 1978-1979 Program Year. Project summaries define Sea Grant's research commitment to innovative and safe uses of ocean and coastal resources and show how advisory plans help to transfer information to the public and ensure that knowledgeable decisions can be applied to the balanced and beneficial development of the ocean resources. Descriptions of the Program's education projects illustrate a range of efforts to train and inspire a marine literate citizenry. Fiscal summaries and listings of publications, participants and contributors, and Sea Grant's staff are included.

☐ **Directory of MIT Sea Grant Program Publications, 1978-1979**

MITSG 80-3 No charge

This publication directory covers all MIT Sea Grant Program education, advisory, and research publications for the years 1978 and 1979, including 4 slide-tape presentations. Each is described in a brief abstract, and price and ordering information is given. Also included are author, publication number, and subject and title indexes. This volume complements MITSG 78-6, a directory listing all MIT Sea Grant Program publications for 1970-1977.