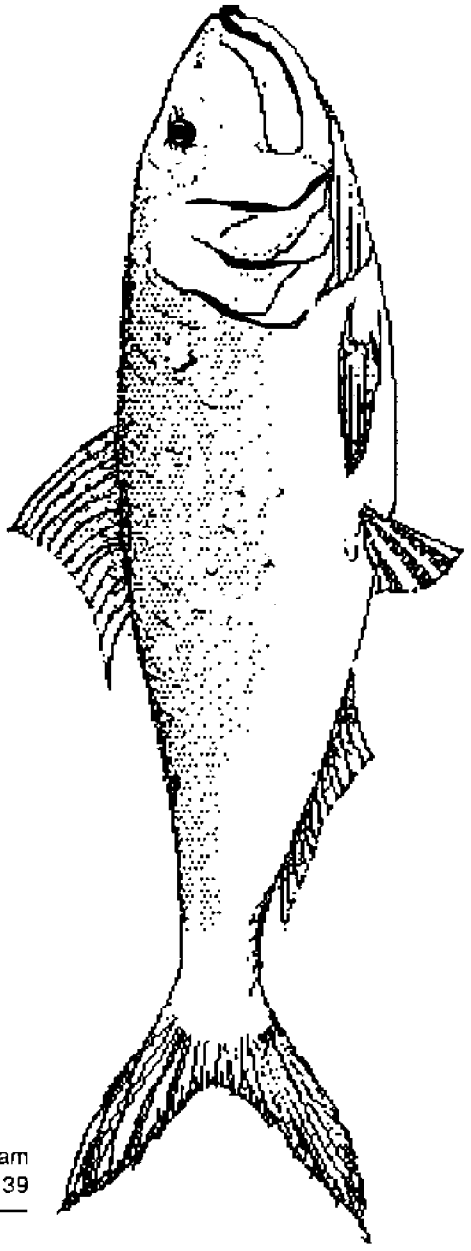
MIT-L-90-001 C2

COPY ONLY

Sea Grant Depository

# DIRECTORY OF MIT SEA GRANT COLLEGE PROGRAM PUBLICATIONS



MIT Sea Grant College Program
Cambridge, Massachusetts 02139

# 1971-1990

# Directory of MIT Sea Grant College Program Publications

MIT Sea Grant College Program
Cambridge, Massachusetts
September 1990
MITSG 90-12

© MIT Sea Grant College Program

ISBN #1-56172-002-X

Compiled by: Hilary Thornton
Edited by: Karen Hartley
Produced by: Leah McGavern
Cover by: Tekla McInerney

# HOW TO ORDER A SEA GRANT PUBLICATION

Since MIT became part of the national Sea Grant network of universities in 1968, the program has issued more than 450 technical, advisory and educational publications. These publications represent the range of Sea Grant-sponsored research and the program's dedication to making useful information available to any audience concerned with the use of the nation's marine resources. This volume complements MITSG 78-6 and 86-11, directories listing all MIT Sea Grant College Program publications from 1971-1986.

Technical, advisory and education reports published by the MIT Sea Grant College Program may be obtained from one of several sources described below.

## Ordering from MIT Sea Grant

Most reports are available from the Sea Grant Communications/Information Service. The price listed with each entry includes the cost of printing, handling and fourth class mailing. Reports can be mailed first class for an additional fee. Order forms are provided in the back of the directory. If applicable, enclose a check or money order payable to the MIT Sea Grant College Program. Mail the form and payment to:

MIT Sea Grant College Program
Publications Department
Room E38-356
292 Main Street
Cambridge, MA 02139

Please refer to the MITSG number when requesting publications. The first number following the letters MITSG indicates the year in which the publication was produced, followed by where the report falls in the series.

## National Sea Grant Depository

Individuals, businesses, agencies and universities can borrow all publications—1971-1990—for 30 days from the National Sea Grant Depository, Pell Marine Science Library, University of Rhode Island, Narraganset, RI 02282. The Sea Grant Information Center at MIT also maintains a complete inventory of the publications, which may be read on the premises. Out-of-print items may be found in either of these locations.

## National Technical Information Service

Reports for which an NTIS number is given may be ordered from the U.S. Department of Commerce, National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161. Phone: (703) 487-4600. Because NTIS requires prepayment, and prices of paper or microfiche copies of the publications are subject to change, write or call NTIS for a price quotation.

## Outside Publishers

Some listings indicated that certain reports must be ordered from publishing companies. The addresses of these companies are:

Hemisphere Publishing Corp.
79 Madison Ave.
NY, NY 10016

John Wiley & Sons
605 Third Ave.
NY, NY 10158

Marcel Dekker Inc.
270 Madison Ave.
NY, NY 10016

The MIT Sea Grant *Quarterly Report* abstracts new technical reports, advisory and education publications. If you would like to be added to the mailing list, please write to the MIT Sea Grant College Program, Room E38-300, MIT, 292 Main Street, Cambridge, MA 02139.

## Editor's Note

**Publications prior to 1980 are not abstracted in this volume.** For abstracts of publications published before 1978, please refer to MITSG 78-6, Volume 1 of MIT Sea Grant Program Publications 1970-1977. For abstracts of publications published in 1978 and 1979, please refer to MITSG 86-11, Volume 2 of MIT Sea Grant Program Publications. The following abstracts describe all MIT Sea Grant publications from 1980 through spring of 1990.

# TABLE OF CONTENTS


HOW TO ORDER A SEA GRANT PUBLICATION ..... 1
RESEARCH ..... 4
Coastal Processes ..... 4
Waves and Currents ..... 4
Seawater Intrusion ..... 6
Salt Marshes ..... 6
Coastal Zone Management ..... 8
Energy and Marine Mineral Resources ..... 9
Alternative Energy Sources ..... 10
Fisheries ..... 11
General ..... 11
Fisheries Management ..... 11
Fisheries Gear and Equipment ..... 11
Underutilized Species ..... 14
Processing ..... 15
Marine Biology ..... 16
Algae and Red Tide ..... 16
Biotechnology ..... 17
Pollution ..... 21
General ..... 21
Oil Spills ..... 21
Waste Disposal and Treatment ..... 23
Pollutant Transport ..... 23
Ocean Engineering ..... 25
General ..... 25
Arctic and Ice Technology ..... 25
Materials and Testing ..... 25
Underwater Welding ..... 28
Underwater Vehicles ..... 28
Hydrodynamics ..... 32
General ..... 32
Ship Hydrodynamics ..... 33
Offshore Structures ..... 34
General ..... 34
Risers and Cables ..... 34
Soils and Foundations ..... 37
Hydrodynamic Loading and Structural Response ..... 39
Marine Architecture ..... 41
Marine Policy ..... 43
ADVISORY SERVICES ..... 44
MIT Marine Industry Collegium ..... 44
Opportunity Briefs ..... 45
EDUCATION ..... 52
Fisheries Engineering ..... 52
Lectures and Seminars ..... 53
Sea Grant Lecture and Seminar Series ..... 53
Robert Bruce Wallace Lectures ..... 55
Other Lectures ..... 55
Engineering Education ..... 56
GUIDES AND DIRECTORIES ..... 57
NEWSLETTERS & BROCHURES ..... 58
ADVISORY REPORTS AND FACT SHEETS ..... 58
PROGRAM MANAGEMENT ..... 59

# RESEARCH

## Coastal Processes

see also MODELING OF COASTAL PROCESSES—CIRCULATION, DISPERSION, AND WAVES, page 47.

### Waves and Currents

**Chen, H.S, Chiang C. Mei, and Dick K.P. Yue.** A HYBRID ELEMENT METHOD FOR CALCULATING THREE-DIMENSIONAL WATER WAVE SCATTERING. MITSG 76-10. NTIS: PB-262 040/AS. $5.

**Christodoulou, George C., and Jerome J. Connor.** NUMERICAL MODELING OF DISPERSION IN STRATIFIED WATERS;. MITSG 76-17. NTIS: PB-263 379/AS. No charge.

**Christodoulou, George C., Jerome J. Connor, James R. Pagenkopf, and Brian R. Pierce.** CAFE-1—A TWO DIMENSIONAL FINITE ELEMENT CIRCULATION MODEL. MITSG 76-11. Out of print.

**Christodoulou, George C., Jerome J. Connor, and Brian R. Pierce.** MATHEMATICAL MODELING OF DISPERSION IN STRATIFIED WATERS. MITSG 76-14. NTIS: PB-264 091/AS. Order from NTIS.

**Christodoulou, George C., Jerome J. Connor, James R. Pagenkopf, and Brian R. Pierce.** DISPER-1—A TWO-DIMENSIONAL FINITE ELEMENT DISPERSION MODEL. MITSG 76-12. Out of print.

**Christodoulou, George C., William F. Leimkuhler, and Arthur T. Ippen.** MATHEMATICAL MODELS OF THE MASSACHUSETTS BAY; PART III—A MATHEMATICAL MODEL FOR THE DISPERSION OF SUSPENDED SEDIMENTS IN COASTAL WATERS. MITSG 74-14. NTIS: COM-74-10977/AS. Order from NTIS.

**Christodoulou, George C., James R. Pagenkopf, Brian R. Pierce, and Jerome J. Connor.** A USER'S MANUAL FOR "DISPER-2"—A MULTI-LAYER FINITE ELEMENT DISPERSION MODEL. MITSG 77-7. Out of print.

**Connor, Jerome J., John D. Wang, Douglas A. Briggs, and Ole S. Madsen.** MATHEMATICAL MODELS OF THE MASSACHUSETTS BAY; PART I—FINITE ELEMENT MODELING OF TWO DIMENSIONAL HYDRODYNAMIC CIRCULATION; PART II—ANALYTICAL MODELS FOR ONE- AND TWO-LAYER SYSTEMS IN RECTANGULAR BASINS. MITSG 74-4. NTIS: COM-74-10190. $4.

**Dailey, James E., and Donald R.F. Harleman.** NUMERICAL MODEL FOR THE PREDICTION OF TRANSIENT WATER QUALITY IN ESTUARY NETWORKS. MITSG 72-15. NTIS: COM-73-10147. Order from NTIS.

**Deguida, Richard, Jerome J. Connor and Brian R. Pierce.** APPLICATION OF ESTIMATION THEORY TO DESIGN OF SAMPLING PROGRAMS FOR VERIFICATION OF COASTAL DISPERSION PREDICTIONS. MITSG 76-16. NTIS: PB-263 413/AS. No charge.

**Dommeruth, Douglas G., and Nitindra R. Joglekar.** TIME SERIES ANALYSIS OF OCEAN WAVES. MITSG 87-8TN. 129pp. $5.

In this report, the simulation of ocean wave kinematics by digital convolution techniques is presented. In deep water, the vertical attenuation and horizontal propagation of ocean waves are solved analytically. In shallow water, these problems are solved using the fast Fourier transform. The authors show that the convolution integrals required to simulate irregular waves are more efficient than summing sinusoids. Guidelines for the processing of real wave data are established. The technique is validated by comparing data acquired in a wave tank with simulated results. Application of this method are demonstrated with examples.

**Doret, Stephen C., Donald R.F. Harleman, Arthur T. Ippen, and Brian R. Pierce.** CHARACTERISTICS OF CONDENSER WATER DISCHARGE ON THE SEA SURFACE (CORRELATION OF FIELD OBSERVATIONS WITH THEORY). MITSG 73-12. NTIS: COM-73-11294. $4.

**Frankel, Sheila M., and Brian R. Pierce.** DETERMINATION OF WATER QUALITY PARAMETERS IN THE MASSACHUSETTS BAY

(1970-1973). MITSG 74-8. NTIS: COM-74-10269. Order from NTIS.

**Greer, Matthew N., and Ole S. Madsen.** LONGSHORE SEDIMENT TRANSPORT DATA—A REVIEW. MITSG 79-28J. NTIS: PB80-164-536. Reprinted from *Coastal Engineering Conference—proceedings* (16th: 1978: Hamburg, West Germany) sponsored by the American Society of Civil Engineers.

**Graber, Hans C., and Ole S. Madsen.** A PARAMETRIC WIND-WAVE MODEL FOR ARBITRARY WATER DEPTHS. MITSG 88-7J. 7pp. Single copies free; subsequent copies $1 each.

This paper derives a finite depth wind-wave model by extensions of methodologies and concepts developed in the context of deep water wind-wave models to include finite depth effects. A hybrid parametric wind-wave model is based on an energy flux transport formulation and includes shoaling, refraction, and bottom frictional dissipation, as well as finite depth modifications of the atmospheric input of non-linear wave-wave interaction source terms. The model is applied to predict wave characteristics resulting from a complex frontal system that passed over the Atlantic Remote Sensing Land Ocean Experiment site in 1980. Predicted behavior is supported by observation. Reprinted from *The Ocean Surface*, Y. Toba and H. Mitsuyasu, editors.

**Graber, Hans C., and Ole S. Madsen.** A FINITE-DEPTH WIND-WAVE MODEL. PART I—MODEL DESCRIPTION. MITSG 89-17J. 19pp. $2.

Wave growth as waves propagate from deep to shallow water is limited by wave- bottom interactions. But few field measurements exist to help model the energy balance of shallow water waves and the relative importance of finite-depth processes. In order to understand surface waves in finite-depth water, the authors present a numerical model for wave behavior in a limited-depth sea. The study shows that bottom friction is as important as nonlinear energy transfer in controlling spectral shape in shallow water, that the spectral peak wanders towards higher frequencies, and that equilibrium energy spectra depend on bottom roughness. Reprinted from *Journal of Physical Oceanography*, November 1988.

**Madsen, Ole S.** MASS TRANSPORT IN DEEP-WATER WAVES. MITSG 78-18J. Reprinted from *Journal of Physical Oceanography*, Vol. 8, No. 6, 1978. No charge.

**Madsen, Ole S.** A REALISTIC MODEL OF THE WIND-INDUCED EKMAN BOUNDARY LAYER. MITSG 77-11J. NTIS: PB-271 148/AS. Reprinted from the *Journal of Physical Oceanography*, Vol. 7, No. 2, 1977. Order from NTIS.

**Madsen, Ole S., David W. Ostendorf, and Andrea S. Reyman.** A LONGSHORE CURRENT MODEL. MITSG 78-16J. NTIS: PB-290-225/AS. Reprinted from *Coastal Zone '78: proceedings of the Symposium on Technical, Environmental, Socioeconomic and Regulatory Aspects of Coastal Zone Management* (1978: San Francisco) sponsored by the American Society of Civil Engineers. Order from NTIS.

**Madsen, Ole S., Ying-Keung Poon, and Hans C. Graber.** SPECTRAL WAVE ATTENUATION BY BOTTOM FRICTION—THEORY
-and-
**Madsen, Ole S., and Michael M. Rosengaus.** SPECTRAL MODEL FOR WAVE ATTENUATION BY BOTTOM FRICTION—EXPERIMENTS. MITSG 89-23J. 22pp. Single copies free; subsequent copies $1 each.

To predict waves at finite depths, researchers must know how much wave energy is lost due to bottom friction. This study builds on a recently derived relationship between spectral descriptions and statistics of individual waves to bridge the gap between two methods of computing spectral wave attenuation due to bottom friction. The researchers present a simple method that needs only the surface wave spectrum (based on height and period) and the bottom roughness for calculation of wave attenuation by bottom dissipation. The method is shown to be accurate for the important range of intermediate to shallow water waves. Reprinted from *The 21st International Coastal Engineering Conference*, 1988.

It is necessary to consider the bottom roughness, or wave friction factor, when predicting the attenuation of waves propagating in finite water depth over a movable bottom. This study presents experimental results for the attenuation of a spectrum of waves in these conditions. The attenuation of individual frequency components was expressed in terms of friction factors, and it was found that these factors exhibited only minor variations. These findings support the

simple theoretical model proposed by Madsen, et al. above. Reprinted from *The 21st International Coastal Engineering Conference*, 1988.

**Manohar-Maharaj, Veshpati, Robert C. Beardsley, and Joseph Karpen.** SPRING RUN-OFF AND NUTRIENT- SEAWATER DENSITY CORRELATIONS IN THE MASSACHUSETTS BAY. MITSG 74-9. NTIS: COM-74-10407. $4.

**Milgram, Jerome H.** WAVES AND WAVE FORCES. MITSG 76-19. NTIS: PB-263 423/AS. No charge.

**Mollo-Christensen, Erik L.** THE LARGE VARIABILITY OF WATER QUALITY IN COASTAL WATERS AND SUGGESTIONS FOR HOW WE CAN HANDLE THEM. MITSG 73-4. Reprinted from *Tools for Coastal Zone Management*. (Marine Technology Society). $1.

**Ostendorf, David W. and Ole S. Madsen.** AN ANALYSIS OF LONGSHORE CURRENTS AND ASSOCIATED SEDIMENT TRANSPORT IN THE SURF ZONE. MITSG 79-13. NTIS: PB-298-291/AS. $8.

**Pagenkopf, James R., George C. Christodoulou, Brian R. Pierce, and Jerome J. Connor.** A USER'S MANUAL FOR "CAFE-2"—A TWO LAYER FINITE ELEMENT CIRCULATION MODEL. MITSG 77-6. Out of print.

**Parker, Bruce B., and Brian R. Pierce.** THE RESPONSE OF MASSACHUSETTS BAY TO WIND STRESS. MITSG 75-2. NTIS: COM-75-10598/AS. $3.

**Wang, John D., and Jerome J. Connor.** MATHEMATICAL MODELING OF NEAR COASTAL CIRCULATION. MITSG 75-13. NTIS: COM-75-10889/AS. $5.

## Seawater Intrusion

**Fisher, John S., John D. Ditmars, and Arthur T. Ippen.** MATHEMATICAL SIMULATION OF TIDAL TIME AVERAGES OF SALINITY AND VELOCITY PROFILES IN ESTUARIES. MITSG 72-11. NTIS: COM-73-10053. $4.

**Sa'da Costa, Antonio, and John L. Wilson.** A NUMERICAL MODEL OF SEAWATER INTRUSION IN AQUIFERS. MITSG 79-27. NTIS: PB80-163-363. $8.

**Thatcher, M. Llewellyn, and Donald R.F. Harleman.** A MATHEMATICAL MODEL FOR THE PREDICTION OF UNSTEADY SALINITY INTRUSION IN ESTUARIES. MITSG 72-7. NTIS: COM-72-10670. $5.

**Thatcher, M. Llewellyn, and Donald R.F. Harleman.** PREDICTION OF UNSTEADY SALINITY INTRUSION IN ESTUARIES—MATHEMATICAL MODEL AND USER'S MANUAL. MITSG 72-21. NTIS: COM-73-10543. $4.

**Wilson, John L., and Antonio Sa'da Costa.** FINITE ELEMENT SIMULATION OF A SALTWATER/FRESHWATER INTERFACE WITH INDIRECT TOE TRACKING. MITSG 82-21J. 11pp. No charge.

In this journal reprint vertically integrated equations for two-layered gravity-segregated flow in an aquifer are solved using the finite element method. The transition from two layers to one constitutes a moving boundary which must be calculated as part of the solution. An indirect numerical procedure using a fixed grid is proposed to track the boundary. The procedure is illustrated with an application to the gravity segregation problem. In this example the model performs accurately and is considerably less expensive than equivalent grid regeneration or moving grid schemes. The primary area of application is to the prediction of seawater intrusion in groundwater aquifers using regional, essentially horizontal flow models. Reprinted from *Water Resources Research*, v.18, no.4, August 1982, pp.1069-1080.

## Salt Marshes

**Burke, Roger W., and Keith D. Stolzenbach.** FREE SURFACE FLOW THROUGH SALT MARSH GRASS. MITSG 83-16. 252pp. Photocopy only available. $10.50.

Using salt marshes for activities such as mariculture or waste disposal requires that we know more of how substances move through these areas. A numerical model is presented for predicting the vertical variation of flow through and above large obstructions, with special emphasis on tidally inundated marsh grass. Because the grass may extend through the depth of the water column, thus affecting the stress at the air-water interface, the model has the capability to extend the calculations into the overlying air layer. The model is able to compute the simultaneous vertical distribution of both horizontal velocity components.

**Hemond, Harold F.** A LOW-COST MULTICHANNEL RECORDING PIEZOMETER SYSTEM FOR WETLAND RESEARCH. MITSG 82-7J. 5pp. No charge.

A low-cost system for the continuous recording of piezometric head is described. The system uses inexpensive earphones as sonar transducers, while using the narrow stem of the piezometer as an acoustic waveguide. The system overcomes several of the problems commonly encountered in tidal wetland investigations by providing rapid response, freedom from operator disturbance from peat compression, and essentially continuous automatic data recording in a directly machine-readable medium. Reprinted from *Water Resources Research*, v.18, no.1, February 1982, pp.182-186.

**Hemond, Harold F. and Jayne L. Fifield.** SUBSURFACE FLOW IN SALT MARSH PEAT. MITSG 82-6J. 11pp. No charge.

Subsurface flow within peat in Great Sippewissett Marsh was measured by field tests and mathematical modeling. Tidal influence was found to be slight; the subsurface flow was dominated by an upward flow of groundwater to replace loss from evapotranspiration. This subsurface flow may be typical of much of the marsh, but does not describe conditions near the creekbanks. Sensitivity analyses show that permeability is the most important property of peat influencing subsurface flow in the interior marsh. Reprinted from *Limnology and Oceanography*, v.27, no.1, 1982, pp.126-136.

# Coastal Zone Management

see also CITIZEN'S GUIDE TO SOURCES FOR MARINE AND COASTAL INFORMATION IN MASSACHUSETTS, page 58.

**Acomb, Glenn, Sandy Bodmer-Turner, Gary Gulezian, Jan Taniguchi, Judith Wiegand, John Wieneke and Wesley Worley.** MANAGING GLOUCESTER'S COAST. MITSG 77-23. NTIS: PB-276 443/AS. $2.50.

**Barrington, Kathy, Judith T. Kildow, Deborah Kramer, and Lina Newhouse.** BUILDING PUBLIC/PRIVATE COOPERATION IN THE COASTAL ZONE. MITSG 76-4. NTIS: PB-261 967/AS. $10.

**Devanney, John W., III, Glenn Ashe, and Beth Parkhurst.** PARABLE BEACH—A PRIMER IN COASTAL ZONE ECONOMICS. MITSG 75-11. Out of print.

**Devanney, John W., III, and Robert C. Blumberg.** STUDENT PROJECTS ON COASTAL ZONE AND OFFSHORE RESOURCES MANAGEMENT. MITSG 72-13. NTIS: COM-73-10262. Order from NTIS.

**Devanney, John W., III, Edgardo R. Derbes, William W. Seifert, and W. Wood.** ECONOMIC FACTORS IN THE DEVELOPMENT OF A COASTAL ZONE. MITSG 71-1. NTIS: PB-195 224. Order from NTIS.

**Ducsik, Dennis W.** SHORELINE FOR THE PUBLIC—A HANDBOOK OF SOCIAL, ECONOMIC, AND LEGAL CONSIDERATIONS REGARDING PUBLIC RECREATIONAL USE OF THE NATION'S COASTAL SHORELINE. MITSG 74-16. Out of print.

**Ducsik, Dennis W.** TEACHING COASTAL ZONE MANAGEMENT—AN INTRODUCTORY COURSE SYLLABUS. MITSG 75-1. NTIS: COM-75-10033/AS. Order from NTIS.

**Engellenner, Thomas, Fred Curtis, and William W. Seifert, editors.** THE BOSTON SOUTH SHORE AREA—SOME PROBLEMS AND CONFLICTS. MITSG 75-23. PB 274 646/AS. Order from NTIS.

**Gutman, Andrew L., Michael J. Goetz, Francesca D. Brown, James F. Lentowski, and Wesley N. Tiffney, Jr.** NANTUCKET SHORELINE SURVEY. MITSG 79-7. Out of print.

**Kaminski, Charles, editor.** MODELING AND GAMING FOR REGIONAL PLANNING—A MAINE STUDY. MITSG 74-25. NTIS: COM-75-10188/AS. $8.

**Kildow, Judith T.** BOSTON HARBOR MANAGEMENT STUDY. MITSG 81-15. NTIS: PB82-178-864. 268pp. $10.50.

This final report studies problems with current management of the Boston Harbor and includes recommendations on ways to improve it. Emphasis is on centralizing authority for the development of the harbor and striking a balance between the needs of the public and private sectors. The author compares management of Boston's harbor with that of six other major urban harbors across the nation and analyzes some of the issues, such as public access, marina development, and water quality, with which planners need to deal as Boston Harbor expands.

**McPherson, Roy N., editor.** GLOUCESTER RESOURCE STUDY. MITSG 74-3. NTIS: COM-74-10270. $5.

**Passero, Barbara, and Mary Jane Seale, editors.** COASTAL ZONE MANAGEMENT—FOCUS ON NEW ENGLAND; AN ANNOTATED BIBLIOGRAPHY. MITSG 75-21. NTIS: PB-254 019/AS. Order from NTIS.

**Rosenbaum, Lisa T., editor.** LYNN HARBOR—PLANNING FOR COASTAL DEVELOPMENT. MITSG 78-3. NTIS: PB286-245/AS. $8.

**Rosenbaum, Lisa T., and William W. Seifert, editors.** SUGGESTIONS FOR THE REVITALIZATION OF THE VILLAGE OF HYANNIS. MITSG 79-21. $8.

THE STATE INDUSTRY WORKSHOP ON THE COASTAL ZONE MANAGEMENT ACT OF 1972. MITSG 74-1. NTIS: COM 73-11939. Order from NTIS.

# Energy and Marine Mineral Resources

**Devanney, John W., III.** THE OCS PETROLEUM PIE. MITSG 75-10. NTIS: COM-75-10599/AS. Order from NTIS.

**Devanney, John W., III Joseph B. Lassiter III, et al.** PRIMARY PHYSICAL IMPACTS OF OFFSHORE PETROLEUM DEVELOPMENTS—REPORT TO COUNCIL ON ENVIRONMENTAL QUALITY. MITSG 74-20. NTIS: COM-74-11125/AS. $8.

**Ducsik, Dennis W., and William W. Seifert,** editors. POWER, POLLUTION, AND PUBLIC POLICY. MITSG 71-8. MIT Press, 1971. Out of print.

**Hutton, John.** IMPACTS OF OFFSHORE OIL ON NORTHEAST SCOTLAND. MITSG 75-15. NTIS: COM-75-11026/AS. Order from NTIS.

**Lahman, Howard S., Jr., and Joseph B. Lassiter III.** THE EVOLUTION AND UTILIZATION OF MARINE MINERAL RESOURCES. MITSG 72-9. NTIS: COM-72-11043. $5.

**Lassiter, Joseph B., III, and John W. Devanney, III.** THE ECONOMICS OF ARCTIC OIL TRANSPORTATION. MITSG 71-4. Reprinted from *Schiff und Hafen* 22 (November 1970). pp. 15-21. $1.

**Lassiter, Joseph B., III James E. Soden, and Robert J. Powers.** AN ASSAY OF THE MARINE RESOURCES OF MASSACHUSETTS BAY. MITSG 74-26. NTIS: COM-74-11589/AS. $2.50.

**Moore, Stephen F., Robert L Dwyer, and Arthur M. Katz.** A PRELIMINARY ASSESSMENT OF THE ENVIRONMENTAL VULNERABILITY OF MACHIAS BAY, MAINE, TO OIL SUPERTANKERS. MITSG 73-6. NTIS: COM-73-10564. Order from NTIS.

**Nyhart, J.D., Lance Antrim, Arthur E. Capstaff, Alison D. Kohler, and Dale Leshaw.** A COST MODEL OF DEEP OCEAN MINING AND ASSOCIATED REGULATORY ISSUES. MITSG 78-4. NTIS: PB281-863/AS. $8.

**Nyhart, J.D., Michael S. Triantafyllou, James M. Averback, and Michael A. Gillia.** TOWARD DEEP OCEAN MINING IN THE NINETIES. MITSG 82-1. NTIS: PB82-221151. 31pp. $4.

An MIT Sea Grant team, NOAA's Office of Ocean Minerals and Energy, and three consultants have collaborated to devise a reasonable scenario of events of a hypothetical pioneer deep ocean manganese nodules mining project progressing to commercial production. Detailed descriptions of events in three main project stages are given: pre-production, contract and construction (investment), and commercial production. The narrative describes the projected major events for purposes of cost modelling and analysis.

**Nyhart, J.D., and Michael S. Triantafyllou.** A PIONEER DEEP OCEAN MINING VENTURE. MITSG 83-14. NTIS: PB84-199-645. 255pp. $8.

Using the MIT-NOAA Deep Ocean Mining Model, the authors thoroughly analyze the economic outcomes of a hypothetical pioneer deep ocean manganese nodule mining project. A detailed narrative of likely events leading to full commercial production is provided. Capital and operating costs are estimated, and assumptions necessary to the financial analysis made in the model are described. Finally, a complete financial analysis is detailed based on estimated costs, timing, regulatory policies, etc.

**Offshore Oil Task Group.** THE GEORGES BANK PETROLEUM STUDY. MITSG 73-5. NTIS: VOL. I: COM-73-10922; VOL. II: COM-73-10923; SUMMARY VOL.: COM-73-10924. Order from NTIS.

**Seifert, William W., Mohammed A. Bakr, and M. Ali Kettani.** ENERGY AND DEVELOPMENT—A CASE STUDY. MITSG 72-16. Order from NTIS.

# Alternative Energy Sources

**Carmichael, A. Douglas.** AN EXPERIMENTAL STUDY AND ENGINEERING EVALUATION OF THE SALTER'S CAM WAVE ENERGY DEVICE. MITSG 78-22. NTIS: PB293-603/AS. $4.

**Fay, James A., and Mark A. Smachlo.** SMALL SCALE TIDAL POWER PLANTS, Part 1: Performance, Part 2: Capital Cost. MITSG 82-9/10 . NTIS: PB83-118257. 30pp. and 28pp. $5. Updated journal reprints from *Energy,* November/December 1983, (MITSG 83-28J) will be included upon request. No charge.

Currently in Maine there is interest in considering an integrated system of small tidal power facilities in lieu of one large project. Without taking sides in the large vs. small discussion, this two-part report develops a generic approach to the preliminary design and costing of a small-scale tidal power project. It provides information to help quantify technical performance and capital costs and discusses environmental effects.

**Mynett, Arthur E., Demetrio D. Serman and Chiang C. Mei.** CHARACTERISTICS OF SALTER'S CAM FOR EXTRACTING ENERGY FROM OCEAN WAVES. MITSG 79-12J. Reprinted from *Applied Ocean Research,* Vol. 1, No. 1, 1979. $1.

# Fisheries

## General

**Lozow, Jeffrey B., and John B. Suomala.** THE APPLICATION OF HYDROACOUSTIC METHODS FOR AQUATIC BIOMASS MEASUREMENTS. MITSG 72-8. NTIS: COM-72-10664. $3.

**Pariser, Ernst R.** REDUCING POSTHARVEST LOSSES OF FISH IN THE THIRD WORLD. MITSG 79-11J. NTIS: PB298-341/AS. Reprinted from *Oceanus*, Spring 1979. No charge.

## Fisheries Management

**Devanney, John W., III.** FISHERMAN AND FISH CONSUMER UNDER THE 200-MILE LIMIT. MITSG 75-20. NTIS: PB-253 206/AS. No charge.

**Devanney, John W., III., and G. Mahnken.** THE ECONOMICS OF FISH PROTEIN CONCENTRATE. MITSG 71-3. NTIS: PB-195-226. No charge.

**Devanney, John W., III., Henry W. Simpson, and Yolanda Geisler.** THE MIT SINGLE-SPECIES FISHERY SIMULATOR—APPLICATION TO THE GEORGES BANK YELLOWTAIL. MITSG 77-21. $5.

**Goudey, Clifford A., Kathryn E. Paterson, and Thecla J. Ree, editors.** CONFERENCE PROCEEDINGS—GEAR SELECTIVITY AS A MANAGEMENT TOOL. MITSG 86-18. NTIS: PB88-208632/AS. 57pp. $5.

This proceeding is based on a conference/workshop held at the Massachusetts Institute of Technololgy on 14 and 15 1986. This conference was a part of the ongoing effort to coordinate the fishing gear research done by federal, state and local organizations. This conference set out to answer several specific questions: Does the introduction or even the requirement of more selective gear offer a real alternative to management officials? What has been the experience in other regions and countries with gear-specific regulations? How would such regulations affect fishermen, fishing practices, or gear manufacturers? Speakers from the West Coast and the Gulf Coast shared their experiences with researchers from the New England region. The conference was concluded with presentations on the research plans of the participating organizations and discussions of opportunities for cooperation.

**Marcus, Henry S., James R. Townley, Jr., Alan J. Brown, and Eddie Lee.** USING COOPERATIVES TO AID THE NEW ENGLAND FISHING INDUSTRY. MITSG 75-7. NTIS: COM-75-10474/AS. Order from NTIS.

**Passero, Barbara, editor.** EXTENDED FISHERIES JURISDICTION—A PARTIALLY ANNOTATED BIBLIOGRAPHY WITH SPECIAL REFERENCES TO NEW ENGLAND. MITSG 77-5. NTIS: PB-266 011/AS. No charge.

## Fisheries Gear and Equipment

**Day, Robert W., John W. Zaharadnik, and Arthur B. Clifton.** A LOW-COST IMPROVEMENT FOR ALEWIFE (HERRING) PASSAGEWAYS. MITSG 75-6. No charge.

**Goudey, Clifford A.** DEVELOPMENT OF A SEMI-PELAGIC TRAWL FOR SQUID AND BUTTERFISH. MITSG 87-10J. 4pp. No charge.

Squid and butterfish represent a useful alternative resource to inshore bottom trawlers. However, typical nets used by these vessels cannot attain the vertical height needed to capture these off-bottom species. These vessels have neither the horsepower to tow larger nets, nor the equipment required to switch to mid-water techniques. This report describes a novel rigging arrangement which inserts extended droplines between the sweep and the fishing line to allow the net to fish at prescribed heights. The net and rigging design is detailed, and model tests and commercial trials are reported. Reprinted from *Oceans*, Vol. 2, October 1987, pp. 645-648.

**Goudey, Clifford A.** FISHING VESSEL TOPICS—REPRINTS FROM COMMERCIAL FISHING. MITSG 88-9J. 11pp. $1.

This report is a compilation of seven articles on vessel design, performance and safety. Goudey reports on using bulbous bows to reduce hull resistance, and compares the roll damping effectiveness of paravanes, bilge keels and bilge fins. Also examined are aspects of winch safety, including facts from the 1985 case of Tringali vs. Hathaway Machinery Co., and a discussion of winch types, safety and design.

**Goudey, Clifford A., and Ben Allen.** FLOW TESTS ON CABLES WITH FUZZ FAIRING. MITSG 89-31J. 4pp. $1.

Experimental comparisons were made of the effect of fuzz fairing on the hydrodynamic characteristics of an electro-mechanical tow cable. The tests were done in the David Taylor Research Center circulating water channel. In addition to bare and plain jacketed cables, three different fairing stiffnesses were evaluated, each at three different fairing lengths. Lift, drag and vibration data were taken at nominal angles of attack of 23, 45 and 90 degrees and at speeds from 1.0 to 5.0 knots.

Test results are presented in the form of lift and drag coefficients and also as normal and tangential force coefficients. Faired cables exhibited far less vibration than the unfaired cables, though the fairing stiffness affected the amount of this reduction and the flow speeds at which vibration would reestablish. The effect of the fairing on both the normal and tangential force components was dependent on the stiffness and length of the fairing material. Because of the varying geometry of the faired cable cross-sections due to angle of attack and speed changes, the force coefficients were found to be non-constant. Reprinted from *Proceedings from Oceans '89*, Seattle, Wash., September 18-21, 1989.

**Goudey, Clifford A.** A QUICK-RELEASE HOOK FOR LIFEBOATS AND OFFSHORE RIGGING. MITSG 82-23J. 4pp. No charge.

A quick-release hook has been developed for application in which release-under-load capability is essential. The design, an adaptation of a towing block developed for side trawlers, has proved successful in the launching and retrieval of Coast Guard cutter lifeboats. This paper details design, fabrication and operational tests. Other marine applications are discussed. Reprinted from *Proceedings from Oceans '82* (Washington, D.C.), pp.728-731.

**Goudey, Clifford A., editor.** RUSSIAN TRANSLATIONS—ON TRAWL HYDRODYNAMICS and HYDRODYNAMIC WATER CHANNEL FOR FISHING GEAR RESEARCH. MITSG 83-32. Center for Fisheries Engineering Research, Report 5. 7pp. No charge.

First in a series of MIT Sea Grant reports aimed at disseminating foreign technical work which is generally unavailable. The two translations, translated by Leonid Pukshansky, were selected for their relevance to current work being done in the U.S. *On Trawl Hydrodynamics* concerns extensive full-scale flow measurements in and around a midwater trawl. Research techniques used suggest the Russians have an active and well supported gear research program. The second article describes a USSR facility for hydrodynamic testing of model trawl gear.

**Goudey, Clifford A.** STANDARD SERIES TRAWL TESTS. Center for Fisheries Engineering Research, Report No. 10. MITSG 85-37. NTIS: PB86-217759/XAB. 27pp. $5.

Trawl fishing has become more competitive and the value of proper design, construction and rigging is more evident. Because various design features are interrelated, design changes can present unacceptable risks to both the trawl designer and the fisherman. The report presents test results, with numerous photographs, and analyzes a series of trawl models aimed at understanding better the performance of full sized nets.

**Goudey, Clifford A.** TEST RESULTS FROM THE NEW ENGLAND TRAWL NET TRAINING COURSES. Center for Fisheries Engineering Research, Report No. 11. MITSG 85-33. NTIS: PB86-216504/XAB. 15pp. No charge.

Over the last two years the Fisheries Engineering Center at MIT has helped to organize and run a series of net tests at the David Taylor Naval Ship R&D Center in Bethesda, Md. This publication includes reprints of articles written by Goudey for *Commercial Fisheries News* on model test results from the New England Trawl Net Training Courses which were held from March through September 1985.

**Goudey, Clifford A.** TRAWL GEAR TOPICS—REPRINTS FROM COMMERCIAL FISHERIES NEWS. MITSG 88-10J. 23pp. $1.

*Trawl Gear Topics*, contains 14 articles on fishing gear design and testing. Aided by charts, figures and graphs, Goudey explains how gear efficiency is influenced by headrope flotation, bridle geometry and rigging adjustments. Goudey also reports on several shrimp trawls and details his adaptation of a three-in-one trawl for shrimping. Based on his research at the David Taylor Research Center in Bethesda, Md., Goudey discusses the benefits of tank testing, and presents results from model tests of the Cape May net, Lethal trawl and fishing gear for a 334' factory trawler. *Trawl Gear Topics* also includes

articles on net plan notations, gear selectivity and a new vehicle for underwater gear observation.

**Goudey, Clifford A., and Angelos D. Heliotis.** THE EFFECT OF BULBOUS BOW RETROFITS ON THE RESISTANCE AND SEAKEEPING OF A 50 METER FRESHFISH STERN TRAWLER. Fisheries Engineering Report No. 8. MITSG 85-15. 48pp. No charge.

This report describes research conducted at MIT on bulbous bow retrofits applied to a Canadian trawler 50 meters in length. This vessel is the third in a series of three hulls included in a larger study. The report presents experimental data and analyses, supplemented by results from a motions program and regression model in conjunction with ship model towing tank results.

**Goudey, Clifford A., and Craig A. Holberger.** THE DEVELOPMENT OF FISHING TRAWL TESTING CAPABILITIES AT NSRDC. Center for Fisheries Engineering Research, Report 6. MITSG 84-10. 6pp. No charge.

MIT Sea Grant has developed apparatus to allow the hydrodynamic testing of trawl nets at the David W. Taylor Naval Ship R&D Center in Bethesda, Md. This paper describes the test facilities and instrumentation used in the trawl tests. A list of the nets tested to date is provided along with examples of test results.

**Goudey, Clifford A., and Margaret M. Linskey.** RETROFIT SAIL-ASSIST ON NEW ENGLAND FISHING VESSELS. MITSG 83-12. Center for Fisheries Engineering Research, Report 2. 18pp. No charge.

The predominant method of fishing in New England is trawling, using vessels from 50 to 90 feet long. This report describes a study to determine the feasibility of sail-assist retrofit on these vessels. Preliminary designs, prepared with the cooperation of owners of working trawlers, are reported. In addition, analyses are included of the potential economic effects, local wind conditions and compatibility with fishing activities.

**Goudey, Clifford A., Stephen P. Loutrel, and Arthur B. Clifton.** AN IMPROVED TRAWL DOOR HOOK-UP SYSTEM. MITSG 79-22. NTIS: PB80-127-422. $3.50.

**Goudey, Clifford A., and Robert S. Mant.** FULL SCALE RESISTANCE TESTS OF YANKEE TRAWLS OF BOTH NYLON AND POLYETHYLENE CONSTRUCTION. MITSG 83-11. NTIS: PB84-129-147. Center for Fisheries Engineering Research, Report 1. 12pp. No charge.

This is the first in a series of reports describing the work of the MIT Center for Fisheries Engineering Research. Trawl tests were conducted at the Naval Ship Research and Development Center using that facility's towing carriage and one of its towing basins. The report describes comparisons between Yankee 35 trawls made of nylon and those made of polyethylene.

**Heliotis, Angelos D., and Clifford A. Goudey.** TOW TANK RESULTS OF BULBOUS BOW RETROFITS ON NEW ENGLAND TRAWLER HULLS. Center for Fisheries Engineering Research, Report No. 9. MITSG 85-7. NTIS: PB86-172798/XAB. 45pp. No charge.

Most large ships are designed with blunt bulbous projections on their bows to increase the efficiency of driving a hull through the water. Research in this report applies the rounded, bulbous concept of bow design to New England trawlers 76' and 119' in overall length. Calm water resistance tests were done with 4.5' models. Bare hull results were compared with data gathered when the models were retrofitted with a series of 12 cylindrical bulbous bows. The researchers concluded simple bulb shapes can effectively reduce hull resistance at steaming speeds typical for the trawler hulls studied and thereby reduce horsepower requirements.

**Kellen, Andrew D.** WASTE-HEAT-DRIVEN REFRIGERATION PLANTS FOR FREEZER TRAWLERS. Center for Fisheries Engineering Research, Report No. 12. MITSG 86-9. 52pp. $1.

Recent Sea Grant research has investigated how a high efficiency, gas turbine engine could be designed to provide optimal fishing vessel power. An attractive feature of such an engine would be its ability to provide other shipboard services such as refrigeration. This thesis in the Department of Mechanical Engineering describes design criteria and analyzes several options for an on-board refrigeration plant. The capability of being able to preserve fish for longer times could reduce the number of trips fishermen make, thus saving them fuel and manpower costs.

**Korakianitis, Theodosios P., and David G. Wilson.** IMPROVEMENTS IN PART-LOAD EFFICIENCY BY REDUCING PRESSURE

RATIO IN REGENERATIVE GAS-TURBINE ENGINES. MITSG 85-8J. 8pp. No charge.

To obtain equal thermal efficiencies in gas-turbine engines, designers have the freedom (barring space and mass constraints) to exchange compressor pressure ratio for heat-exchanger effectiveness. The work reported here shows that for similar turbomachinery technology, design-point and part-load efficiencies improve as the design-point pressure ratio decreases and the heat-exchanger thermal ratio increases. Reprinted from *Proceedings of the Gas Turbine Conference and Exhibit*, Houston, Texas, March 1985. American Society of Mechanical Engineers.

**Sutro, Louis L.** STUDY OF AUTOMATIC MEANS OF DETERMINING THE AGE OF FISH. MITSG 72-2. NTIS: COM-72-10326. Order from NTIS.

**Sutro, Louis L.** STUDY OF MEANS OF AUTOMATICALLY CLASSIFYING PLANKTON. MITSG 74-11. NTIS: COM-74-10716. $3.

**Wall, John C., and Stephen P. Loutrel.** A NEW TOWING BLOCK FOR SIDE-TRAWLING. MITSG 75-24. NTIS: PB253-056. Reprinted from *Proceedings from Oceans '75*, the second annual conference sponsored by the Marine Technology Society and the Institute of Electrical and Electronics Engineers. No charge.

**Wilson, David G., P.K. Poole, L.D. Owens Jr., and J. Baglione.** CONVERSION OF DECOMMISSIONED AIRCRAFT GAS TURBINES TO HIGH-EFFICIENCY MARINE UNITS. MITSG 85-9J. 7pp. No charge.

This paper briefly discusses the positive potential for converting existing higher-pressure-ratio gas turbines to a low-pressure-ratio highly regenerated cycle with greatly improved thermal efficiencies. To make it a good candidate for conversion an engine should have either an axial compressor or a two-stage centrifugal compressor in which a pressure ratio of about 3:1 could be reached in the modified engine. Reprinted from *Proceedings of the Gas Turbine Conference and Exhibit*, Houston, Texas, March 1985. American Society of Mechanical Engineers.

**Wilson, David G., and Theodosios P. Korakianitis.** POTENTIAL FOR ADVANCED BRAYTON-CYCLE ENGINES FOR COMMERCIAL VESSELS. MITSG 84-15. Center for Fisheries Engineering Research, Report 7. 14pp. No charge.

The authors propose an engine that is predicted to improve fuel consumption by 10 to 30 percent over the advanced Diesel engine at full and part power, while retaining its advantages of small size, reliability, and potentially lower cost. The engine uses highly effective ceramic heat exchangers, which enable the compressor pressure ratio to be reduced from the common 5-15 range to about 3. The result is an engine in which stresses and speeds can be so reduced as to allow the compressor to be made from a commercial reinforced plastic, while giving outstanding efficiency and range of operation.

**Wilson, David G., and Theodosios P. Korakianitis.** HIGH-EFFICIENCY BRAYTON-CYCLE ENGINES FOR MARINE PROPULSION. MITSG 85-10. 109pp. $5.

Three alternative gas-turbine cycles were examined for their potential to provide greatly improved marine propulsion, particularly for fishing boats. Of the three—the direct-plus-inverted cycle, the intercooled regenerated cycle, and the regenerated cycle—the latter was most attractive. It promised to be more efficient at full and part power, lower in initial cost, have lower mass and volume, and require less maintenance. This report also identifies a baseline fishing vessel, presents a preliminary baseline engine design, looks at the effects on ship design, compares the costs and performance of both low pressure ratio (LPR) and diesel engines, and recommends future research needs.

## Underutilized Species

**Hoff, William B. III, and David G. Wilson.** THE DESIGN, CONSTRUCTION AND DEVELOPMENT OF A PROTOTYPE MACHINE FOR PROCESSING SPINY DOGFISH SHARK. MITSG 80-14. 58pp. Photocopy reprints available. $3.

New food sources require new technology. An example is this advanced prototype machine with pneumatically actuated parts and a solid-state, programmable controller for processing the spiny dogfish shark. The process follows the steps used by hand labor but cuts in half the time required to process a fish, to approximately 12 seconds. With simple developments in future machines, the time could be considerably reduced.

**Kalikstein, Paul H.** THE MARKETABILITY OF SQUID. MITSG 74-24. NTIS: COM-74-11426/AS. Order from NTIS.

**Menjivar, Juan A., Rong Chen, and ChoKyun Rha.** INVESTIGATION OF MECHANICAL PROPERTIES OF RAW FLESH AND SKIN OF SPINY DOGFISH (SQUALUS ACANTHIAS). MITSG 79-30J. NTIS: PB80-164-544. Reprinted from the *Journal of Textural Studies*, Vol. 10, 1979. No charge.

**Patell, James M.** A PRELIMINARY FEASIBILITY STUDY OF IRISH MOSS HARVESTING SYSTEMS. MITSG 72-14. NTIS: COM-73-10152. $4.

## Processing

**Berk, Zeki, and Ernst R. Pariser.** PROCESSING SQUID FOR FOOD. MITSG 74-13. NTIS: COM-74-10820. $2.

**Hultin, Herbert O.** POTENTIAL LIPID OXIDATION PROBLEMS IN FATTY FISH PROCESSING. MITSG 88-15J. 28pp. $2.

Recent evidence suggests fish oils may aid in a heart-healthy diet. But because of the high concentration of polyunsaturated fatty acids in fish muscle, lipid oxidation is an acute problem. Lipid oxidation can lower nutritional quality, produce off-flavors and modify texture and color. In this Sea Grant reprint from a national conference on fatty fish utilization, the author reports on factors within fish muscle and in processing conditions that contribute to oxidation. Temperature, pH, metals, salt and mincing may all contribute to oxidation. The report also discusses several ways processors can control oxidation. Reprinted from *Proceedings from the National Technical Conference* in Raleigh, N.C., December 1987.

# Marine Biology

## Algae and Red Tide

**Anderson, Donald M.** EFFECTS OF TEMPERATURE CONDITIONING ON DEVELOPMENT AND GERMINATION OF GONYAULAX TAMARENSIS (DINOPHYCEAE) HYPNOZYGOTES. MITSG 80-16J. NTIS: PB81-134-876. 7pp. No charge.

Laboratory studies to account for spring and fall red tides examined two growth stages of Gonyaulax tamarensis—intermediate planozygotes, which then form hypnozygotes, dormant "seeds." Comparison of spring and fall hypnozygote formation and temperature conditions found hypnozygotes formed in cold water bloom when water temperature increases; those formed in warmer water bloom when temperature decreases. Observed starch decrease in hypnozygotes and mucilagenous excretions need further study. Reprinted from *Journal of Phycology*, v.16, 1980.

**Anderson, Donald M., Sallie W. Chisholm, and Carl J. Watras.** IMPORTANCE OF LIFE CYCLE EVENTS IN THE POPULATION DYNAMICS OF GONYAULAX TAMARENSIS. MITSG 83-29J. 12pp. No charge.

Life cycle changes that allow populations of the toxic dinoflagellate Gonyaulax tamarensis Lebour to inhabit the benthos and the plankton alternately are important factors regulating the initiation and decline of red tide blooms in embayments. Population monitoring showed that encystment contributed substantially to the decline of the vegetative cell population. The authors conclude that the encystment/excystment cycle temporarily restricts the occurrence of the vegetative population and may not be optimized for bloom formation. Factors that distinguish bloom from non-bloom years appear to be operating on the growth of the planktonic population. Reprinted from *Marine Biology*, v.76, 1983, pp.179-189.

**Anderson, Donald M., and Francois M.M. Morel.** COPPER SENSITIVITY OF GONYAULAX TAMARENSIS. MITSG 78-15J. NTIS: PB290-320/AS. Reprinted From *Limnology and Oceanography*, March 1978. No charge.

**Anderson, Donald M., and Francois M.M. Morel.** THE SEEDING OF TWO RED TIDE BLOOMS BY THE GERMINATION OF BENTHIC GONYAULAX TAMARENSIS HYPNOCYSTS. MITSG 79-26J. NTIS: PB80-125-032. Reprinted from *Estuarine and Coastal Marine Science*, Vol. 8, 1979. No charge.

**Anderson, Donald M. and David Wall.** POTENTIAL IMPORTANCE OF BENTHIC CYSTS OF GONYAULAX TAMARENSIS AND G. EXCAVATA IN INITIATING TOXIC DINOFLAGELLATE BLOOMS. MITSG 78-20J. NTIS: PB289-791/AS. Reprinted from *Journal of Phycology*, Vol. 14, No. 2., 1978. Order from NTIS.

**Ezekiel, Shaoul, William B. Kerfoot, and G. Gregory White.** SPECTROFLOUROMETRIC DIFFERENTIATION OF THE RED TIDE ALGA, GONYAULAX TAMARENSIS, FROM OTHER ALGAE COMMON TO NEW ENGLAND WATERS. MITSG 77-18. NTIS: PB-273 703/AS. $2.

**Morel, Francois M.M., J.G. Rueter, Donald M. Anderson, and R.R.L. Guillard.** AQUIL—A CHEMICALLY DEFINED PHYTOPLANKTON CULTURE MEDIUM FOR TRACE METAL STUDIES. MITSG 79-24J. NTIS: PB80-124-233. Reprinted from *The Journal of Phycology*, Vol. 15, 1979. No charge.

**Quinlan, Alician V.** AN ECODYNAMIC ANALYSIS OF ALGAL BLOOMS FOULING NAHANT BAY BEACHES. MITSG 82-15. 93pp. $8.

Since early 1900s, residents of Nahant and nearby communities have complained about a chronic stench emanating from a brown alga that has washed up on local beaches. This study identified the alga as an abnormal free-living form of the common, attached filamentous, Pilayella littoralis. The foul order is caused by anaerobic wet decomposition of the biomass, buried chiefly during the annual late-winter and early spring natural beach build up process. The report describes the history of the problem, the research methods used to understand the growth, reproduction and transport of the algae, and suggests short-term management and long-term research schemes.

**Swallow, K.C., J.D. Westfall, D.M. McKnight, N.M.L. Morel, and Francois M.M. Morel.** POTENTIOMETRIC DETERMINATION OF COPPER COMPLEXATION BY PHYTOPLANKTON EXUDATES. MITSG 78-19J. Reprinted from *Limnology and Oceanography*, Vol. 23, No. 3, 1978. No charge.

**Watras, Carl J., Sallie W. Chisholm, and Donald M. Anderson.** REGULATION OF GROWTH IN AN ESTUARINE CLONE OF GONYAULAX TAMARENSIS LEBOUR—SALINITY-DEPENDENT TEMPERATURE RESPONSES. MITSG 82-16J. 13pp. No charge.

Batch-culture experiments with Gonyaulax Tamarensis Lebour indicated variations in population growth rate and cell size as a function of temperature and salinity. The data on population growth were used to formulate a simple model which predicts bloom development in the absence of other regulatory factors. The potential use of cell size variability in estimating in situ growth rates, and its role in bloom decline through size-selectivity grazing by zooplankton are considered. Reprinted from *Journal of Experimental Marine Biology and Ecology*, v.62, 1982, pp.25-37.

**Wilce, R.T., C.W. Schneider, Alician V. Quinlan, and K. Van Den Bosch.** THE LIFE HISTORY OF MORPHOLOGY OF FREE-LIVING PILAYELLA LITTORALIS (L.) Kjellm. (Ectocarpaceae, Ectocarpales) IN NAHANT BAY, MASSACHUSETTS. MITSG 82-18J. NTIS: PB83-151-738. 19pp. No charge.

This paper describes a previously unreported free-living form of Pilayella. Drifting clouds of this plant may carpet up to half of the sandy bottom and beaches of Nahant Bay on the north coast of Massachusetts. As the plant decomposes it emits foul odors that keep people from the beach and blow inland through densely populated residential areas. Studies, which show four features distinguishing the atypical free-living form of the Pilayella, are discussed. Reprinted from *Phycologia*, v.21, n.3, pp.336-354.

## Biotechnology

see also BIOTECHNOLOGY AND THE SEA—RECENT ADVANCES AND APPLICATIONS, page 45.

**Averbach, Benjamin L.** THE STRUCTURE OF CHITIN AND CHITOSAN. MITSG 75-17. NTIS: PB-246 876/AS. No charge.

**Averbach, Benjamin L.** THE PROCESSING OF CHITOSAN MEMBRANES. MITSG 78-14. NTIS: PB-292-311/AS. $3.50.

**Barzana, Eduardo.** ENZYME CATALYZED REACTIONS IN THE GAS PHASE. MITSG 89-21TH. 186pp. $45.

**Barzana, Eduardo, Marcus Karel, and Alexander M. Klibanov.** ENZYMATIC OXIDATION OF ETHANOL IN THE GASEOUS PHASE. MITSG 89-19P. 30pp. $2.

The enzymatic conversion of gaseous substrates is a novel concept in bioprocessing. Water activity is critical in such systems. The report discusses the effect of water on alcohol oxidase acting on ethanol vapors. Enzyme activity increases when water is increased, whereas thermostability decreases. Enhanced thermostability causes an increase in the temperature optimum of the gas phase reaction. The reaction appears to occur by direct interaction of the gaseous substrate with the enzyme. Submitted to *Biotechnology and Bioengineering*.

**Barzana, Eduardo, Alexander M. Klibanov, and Marcus Karel.** A CALORIMETRIC METHOD FOR THE ENZYMATIC ANALYSIS OF GASES—THE DETERMINATION OF ETHANOL AND FORMALDEHYDE VAPORS. MITSG 89-18P. 17pp. $2.

This report describes a novel approach to direct determination of ethanol vapors in the gas phase. The system uses dehydrated enzymes and an indicator dye dispersed in avicel. Simple devices are developed for determination of ethanol in the breath. The devices produce a sharp color change at a set time for ethanol concentrations above the legal limit for driving or a stable final color after five minutes. The system can also be used for determination of ethanol or formaldehyde vapors. In addition to determination of ethanol, dehydrated enzymes may be useful for analysis of hazardous gases. Submitted to *Analytical Biochemistry*.

**Hattis, Dale B., and Albert Murray.** INDUSTRIAL PROSPECTS FOR CHITIN AND PROTEIN FROM SHELLFISH WASTES. MITSG 77-3. NTIS: PB-267 527. $5.

**Kahan, Leslie N., Zeki Berk, Sun-de Tong, Ernst R. Pariser, James M. Flink, and Samuel A. Goldblith.** SQUID PROTEIN CONCENTRATES—PART I—EVALUATION OF PROCESSES AND PRODUCT CHARACTERISTICS.
-and-
**Tong, Sun-de, James M. Flink, and Samuel A. Goldblith.** SQUID PROTEIN CONCENTRATES—PART II—EVALUATION OF FUNCTIONAL PROPERTIES. MITSG 75-16J. NTIS: PB-246 931/AS. Reprinted from *Lebensmittel-Wissenschaft und Technologie*, 8(1975). pp. 64-69, and pp. 70-74. No charge.

**Kahan, Leslie N., Zeki Berk, Ernest R. Pariser, Samuel A. Goldblith, and James M. Flink.** SQUID PROTEIN ISOLATE—EFFECT OF PROCESSING CONDITIONS ON RECOVERY YIELDS. MITSG 74-30J. NTIS: COM-74-11403/AS. Reprinted from *Journal of Food Science* 39(1974). pp. 592-595. No charge.

**Karel, Marcus, Alexander M. Klibanov, and Eduardo Barzana.** EFFECTS OF WATER ON ENZYME-CATALYZED REACTION OF GASEOUS SUBSTRATES. MITSG 89-20P. 15pp. $1.50.

Water participates both in maintaining the catalytically active form of enzyme molecules and in their inactivation. New processes in biotechnology that might take advantage of an ability of enzymes to catalyze gas phase reactions make it desirable to understand the role of water in such reactions. This report presents the results of an investigation into high-temperature, gas phase reactions and reviews the effect of water on enzyme activity in non-aqueous environments. Submitted to *Properties of Water on Food Systems*, Marcel Dekker, (address at front of directory).

**Kienzle-Sterzer, Carlos, Dolores Rodriguez-Sanchez, and ChoKyun Rha.** DILUTE SOLUTION BEHAVIOR OF A CATIONIC POLYELECTROLYTE. MITSG 82-24J. 4pp. No charge.

Dilute solution behavior of a cationic polyelectrolyte was studied for acetic acid concentration using chitosan. According to this paper the relationship between intrinsic viscosity and acetic acid suggests no conformation transition of the chitosan molecules and possible formation of intramolecular hydrogen bonds during the shrinking of the hydrodynamic domain of the polyions. Reprinted from *Journal of Applied Polymer Science*, v.27, 1982, pp.4467-4470.

**Kienzle-Sterzer, Carlos A., Dolores Rodriguez-Sanchez, and ChoKyun Rha.** MECHANICAL PROPERTIES OF CHITOSAN FILMS—EFFECT OF SOLVENT ACID. MITSG 82-17J. 7pp. No charge.

Chitosan is capable of forming films, and methods of film preparation have been reported. The mechanical properties of swollen chitosan films have been examined. Ionic strength, chitosan concentration, and the acid used in casting solution, all have important effects on the film's mechanical properties. This study evaluated the effects of chitosan concentration and the type of solvent used in preparation on the elasticity and relaxation response of chitosan films. Reprinted from *Makromolekulare Chemie*, v.183, 1982, pp.1353-1359.

**Kienzle-Sterzer, Carlos, G. Bakis, Dolores Rodriguez-Sanchez, and ChoKyun Rha.** PROPERTIES—COUNTER-ION ACTIVITY IN A CATIONIC POLYELECTROLYTE SOLUTION. MITSG 84-13J. 5pp. No charge.

The counterion transport properties, represented by the chloride ion activity coefficient in cationic polyelectrolyte solutions were studied. The effect of polymer concentration and ionic strength of the media in non-dilute regime were examined. Reprinted from *Polymer Bulletin*, v.11, 1984, pp.185-190.

**Kienzle-Sterzer, Carlos, G. Bakis, Dolores Rodriguez-Sanchez, and ChoKyun Rha.** SOLUTION PROPERTIES OF CHITOSAN—CHAIN CONFORMATION. MITSG 84-14J. 12pp. No charge.

The aim of this paper is to describe the hydrodynamic volume, chain stiffness and local conformational freedom of an isolated chitosan molecule, especially as influenced by the degree of ionization and counterion concentration in the media. The paper was presented at the U.S./Japan Seminar on Chitin, Chitosan, and Related Enzymes, University of Delaware, April 24-27, 1984.

**Kienzle-Sterzer, Carlos, Dolores Rodriguez-Sanchez, Diane Karalekas, and ChoKyun Rha.** STRESS RELAXATION OF A POLYELECTROLYTE NETWORK AS AFFECTED BY IONIC STRENGTH. MITSG 82-12J. 4pp. No charge.

This paper reports on an evaluation of the effect of ionic strength on interchain interactions. A cationic polyelectrolyte, chitosan, was used. Results indicate a rearrangement of the molecular chains in the network under tensile stress and the electrostatic nature of the interactions responsible for the network integrity of the polyelectrolyte films. Reprinted from *Macromolecules*, v.15, 1982, pp.631-634.

**Kildow, Judith T., and John E. Huguenin.** PROBLEMS AND POTENTIALS OF RECYCLING WASTES FOR AQUACULTURE. MITSG 74-27. NTIS: COM-75-10359/AS. Order from NTIS.

**Langer, Robert S.** ISOLATION OF BIOACTIVE COMPOUNDS FROM SHARKS. MITSG 89-16. NTIS: PB89-205603/AS 30pp. $3.

This report details the investigation of an extract from shark cartilage as a potential cancer treatment. Researchers believe one strategy for designing a cancer treatment is to find an inhibitor of the growth of blood vessels that feed tumors. Langer and his colleagues found that an extract from calf cartilage inhibits blood vessel growth. But because it is difficult to get enough extract from calves, the group was unable to produce enough for extensive experiments. Unlike bone-rich mammalian skeletons, shark skeletons are almost entirely cartilage. Not only can the researchers obtain more cartilage from shark than from calf, but shark cartilage is a richer source of the blood vessel growth inhibiting extract.

**Lee, Anne, and Robert S. Langer.** SHARK CARTILAGE CONTAINS INHIBITORS OF TUMOR ANGIOGENESIS. MITSG 84-8J. 5pp. No charge.

Shark cartilage contains a substance that strongly inhibits the growth of new blood vessels toward solid tumors, thereby restricting tumor growth. The abundance of this factor in shark cartilage, in contrast to cartilage from mammalian sources, may make sharks an ideal source for the inhibitor and may help to explain the rarity of neoplasms in these animals. Reprinted from *Science*, Vol. 221, Sept. 16, 1983, pp.1185-1187.

**Lees, Robert S.** THE IMPACT OF DIETARY FAT ON HUMAN HEALTH. MITSG 88-3. PB88-241500. 28pp. No charge.

Almost everyone will agree that eating fish is good for you, but there is little consensus as to why. Recently accumulating evidence suggests that omega-3 fatty acids, in particular the 20 and 22 carbon omega-3 fatty acids present in high concentrations in fish oils, may be part of the healthy heart equation. These compounds may also have therapeutic effects in the treatment of rheumatoid diseases, like arthritis. The key to elucidation of the role of omega-3 fatty acids in health and disease lies in understanding the process of fat metabolism. In this Sea Grant lecture, Dr. Robert Lees, MIT Professor of Cardiovascular Diseases, and Director of Medical Research at the Deaconess Hospital in Boston, summarizes in medical terms the basics of normal human fat metabolism. Dr. Lees then looks at the three major diseases to which dietary fat has been linked—cardiovascular disease, cancer, and arthritis. Reviewing epidemiological, biochemical, physiological, and pathological evidence, Lees concludes that the types and amounts of fat in the human diet are clearly associated with heart disease, less so with cancer, and may have therapeutic effects in the case of rheumatism and arthritis. As to the health benefits of fish oils, he finds the evidence exciting but inconclusive. Shark cartilage contains a substance that strongly inhibits the growth of new blood vessels toward solid tumors, thereby restricting tumor growth. The abundance of this factor in shark cartilage, in contrast to cartilage from mammalian sources, may make sharks an ideal source of the inhibitor and may help to explain the rarity of neoplasms in these animals. Reprinted from *Science*, v.221, Sept. 16, 1983, pp.1185-1187.

**Muzzarelli, R.A.A., and Ernst R. Pariser, editors.** INTERNATIONAL CONFERENCE ON CHITIN/CHITOSAN—PROCEEDINGS (1st. 1978. Cambridge, MA). MITSG 78-7. NTIS: PB285-640/AS. $10.

**Pariser, Ernst R., and Susan L. Bock.** CHITIN AND CHITIN DERIVATIVES—AND ANNOTATED BIBLIOGRAPHY OF SELECTED PUBLICATIONS FROM 1965 THROUGH 1971. MITSG 73-2. NTIS: COM-73-10149. $5.

**Pariser, Ernst R., and Donald P. Lombardi.** THE CHITIN SOURCEBOOK—A GUIDE TO THE CHITIN RESEARCH LITERATURE. MITSG 88-12. 688 pp. $150.

This reference book assembles the most important, contemporary information available today on the commercial applications of chitin,

chitin derivatives and chitin-related enzymes. The result of a five-year effort, the sourcebook contains about 500 cross-referenced listings, including the proceedings of scientific meetings and international conferences, articles from magazines and professional journals, student theses, and some U.S. and foreign patents. The references have been carefully selected and formatted so that specific information is easy to find. Published by John Wiley & Sons, (address at front of directory).

**Rodriguez-Sanchez, Dolores, and ChoKyun Rha.** CHITOSAN GLOBULES. MITSG 85-3J. llpp. No charge.

In many foods, the characteristic textural properties result from a combination of two or more types of structural units. The research described in this paper sought to fabricate a structural unit that could compartmentalize and simulate cellular structure and which would have broad applications in food technology. The units described were granules (or globules) which could be used individually or in aggregation to form a matrix. Reprinted from *Journal of Food Technology*, Vol. 16, 1981, pp. 469-479.

# Pollution

## General

**Cooney, J.J., L. de Rome, O. Laurence, and G.M. Ladd.** EFFECTS OF ORGANOTIN AND ORGANOLEAD COMPOUNDS ON YEASTS. MITSG 90-11J. 10pp. $1.

Four methods were used to screen nine organotin and two organolead compounds for toxicity to 29 yeasts, representing 10 genera. Center well diffusion plates were useful in comparing the sensitivity of yeasts to the most toxic organometals, but were not useful for comparisons between compounds because of differences in diffusion rates and lack of sensitivity. Two layer diffusion plates (density gradient plates) were also of limited use for comparisons between organisms. Two-dimensional diffusion plates were useful for estimating the effect of pH on organometal toxicity. Release of potassium from cell suspensions measured using a potassium electrode provided quantitative information and allowed comparisons between compounds and organisms. The presence of 3 percent NaCl in cell suspensions decreased the rates and extent of organotin-induced potassium release. Yeasts varied in their sensitivity from strain to strain, but tributyltin was the most toxic compound tested. Mono- and di- methyltins were the least toxic. Triphenyltin, dibutyltin, monobutyltin, trimethyltin, triethyltin, diethyllead, diethyltin, and dimethylleads showed intermediate toxicity, but triphenyltin and monobutyltin were the most toxic among the group. Revised from *Journal of Industrial Microbiology*, Vol. 4, 1989, pp. 279-288.

**Cooney, J.J., A.T. Kronick, G.J. Olson, W.R. Blair, and F.E. Brinckman.** A MODIFIED METHOD FOR QUANTIFYING METHYL AND BUTYLTINS IN ESTUARINE SEDIMENTS. MITSG 90-10J. 8pp. $1.

A method is presented for the rapid determination of organotins in aquatic sediments. It employs extraction of sediments with acidic methanol, formation of organotin hydrides, chromatographic separation of individual hydrides, and element specific detection with quartz furnace atomic absorption spectrometry. The method has been applied to sediments from Boston Harbor. Revised from *Chemosphere*, Vol. 17, No. 9, pp.1795-1802, 1988.

**Makkar, N.S., A.T. Kronick, and J.J. Cooney.** BUTYLTINS IN SEDIMENTS FROM BOSTON HARBOR, USA. MITSG 90-9J. 8pp. $1.

Sediments from 12 sites in Boston Harbor were assayed for butylins. The highest levels of tributyltin (TBT) were found at sites where commercial or pleasure boats were moored, where ocean going vessels dock, and at a former shipyard. Little or no TBT was detected at sites which do not have a history of significant boating activity. Dibutyltin and monobutyltin were also detected at most critical sites, indicating that degradation of TBT occurs at these sites. Revised from *Chemosphere*, Vol. 18, Nos. 9/10, pp. 2043-2050, 1989.

## Oil Spills

see also CASE STUDIES OF THE MIT OIL SPILL MODEL, page 45.

**Campbell, Brad, Edward Kern, and Dean A. Horn.** IMPACT OF OIL SPILLAGE FROM WORLD WAR II TANKER SINKINGS. MITSG 77-4. NTIS: PB-265 857/AS. Order from NTIS.

**Devanney, John W., III, S. Protopapa, and R. Klock.** TANKER SPILLS, COLLISIONS, AND GROUNDINGS. MITSG 79-14. NTIS: PB299-204/AS. Order from NTIS.

**Fazal, Riyaz A. and Jerome H. Milgram.** THE EFFECTS OF SURFACE PHENOMENA ON THE SPREADING OF OIL ON WATER. MITSG 79-31. NTIS: PB80-163-629. $4.

**Kondratowicz, Ludwik J. and Harilaos N. Psaraftis.** THE OIL SPILL INCIDENCE SIMULATION MODEL—DESCRIPTION AND USER'S MANUAL. MITSG 80-17. NTIS: PB83-234-088. 72pp. Order from NTIS.

A component of an oil spill computer modeling project, SIMSPIL, the Oil Spill Incidence Simulation Model, simulates random spill incidents of different oil types occurring at various locations from different sources, during a specified period. Regional probabilistic data can be incorporated into the program, and the strategic time scale of events, on the order of months or years, can be adjusted to operate on a real-time, tactical basis.

**Milgram, Jerome H.** BEING PREPARED FOR FUTURE ARGO MERCHANTS. MITSG 77-10. NTIS: PB-269 696/AS. $2.

**Milgram, Jerome H., and Robert J. Van Houten.** A FLUME FOR THE STUDY OF CONTAINED OIL SLICKS. MITSG 77-19. NTIS: PB-272 160/AS. $2.

**Milgram, Jerome H., and Robert J. Van Houten.** MECHANICS OF A RESTRAINED LAYER OF FLOATING OIL ABOVE A WATER CURRENT. MITSG 80-4J. NTIS: PB80-187-214. 16pp. No charge.

This paper determines the relative importance of interfacial shear stress and dynamic pressure in determining the thickness distribution of a layer of floating oil contained by a barrier above a water current, using an equation relating vertical location of the oil-water interface, dynamic pressure, and shear stress. Forward and rear portions of the oil layer relative to wave direction are studied at both low and higher current speeds. Reprinted from *Journal of Hydronautics*, v.12, no.3, July 1978.

**Moore, Stephen F., Gary R. Chirlin, Charles J. Puccia, and Bradley P. Schrader.** POTENTIAL BIOLOGICAL EFFECTS OF HYPOTHETICAL OIL DISCHARGES IN THE ATLANTIC COAST AND GULF OF ALASKA. MITSG 74-19. NTIS: COM-74-11089/AS. Order from NTIS.

**Pollack, Andrew M., and Keith D. Stolzenbach.** CRISIS SCIENCE—INVESTIGATIONS IN RESPONSE TO THE ARGO MERCHANT OIL SPILL. MITSG 78-8. NTIS: PB285-646/AS. $5.

**Psaraftis, Harilaos N., Andrew V. Baird, and J.D. Nyhart.** NATIONAL RESPONSE CAPABILITY TO OIL SPILLS—A SYSTEMS APPROACH. MITSG 80-18J. NTIS: PB81-223-109. 8pp. No charge.

This paper describes a systems approach for the formulation of the overall problem of oil spill pollution response in the United States. The paper discusses objectives of existing and alternative systems for oil spill response, and provides a hierarchical decision framework for optimal oil spill response at strategic, tactical and operational levels. Financial and damage assessments are also presented. Reprinted from *Proceedings from Oceans '80.*

**Psaraftis, Harilaos N., Geverghese G. Tharakan, and Avishai Ceder.** OPTIMAL RESPONSE TO OIL SPILLS—THE STRATEGIC DECISION CASE. MITSG 86-22J. 15pp. No Charge.

The authors develop a model for identifying appropriate response levels and types of oil spill cleanup capability, and allocating such capability among areas of high oil spill potential. The model takes into account frequency of spill occurrence, variability of spill volumes, different cleanup technologies, equipment efficiency and operability, fixed costs, and costs of damage as functions of spill volume and level of response. The model can also accept policy stipulations on response times. The authors present an illustrative application of the model in the New England region and discuss its possible uses within existing and alternative policy environments.

**Psaraftis, Harilaos N., and Babis O. Ziogas.** A TACTICAL DECISION ALGORITHM FOR THE OPTIMAL DISPATCHING OF OIL SPILL CLEANUP EQUIPMENT. MITSG 86-8J. 16pp. No charge.

This paper develops an optimization procedure for assisting decisionmakers in allocating resources for cleaning up a specific oil spill. The inputs include information about oil outflow, the availability and performance of cleanup equipment as well as equipment transport and operational costs. To give the reader insights into the problem's structure, the model is applied to the ARGO MERCHANT spill. Finally, the authors discuss possible uses within existing operations and policy. Reprinted from *Management Science*, Vol. 31, No. 12, December 1985.

**Robbins, Phillips W.** STUDENT PROJECTS ON THE OXIDATION BY MARINE BACTERIA OF AROMATIC COMPOUNDS FOUND IN OIL. MITSG 71-10. NTIS: COM-71-00878. Order from NTIS.

**Stolzenbach, Keith D., Ole S. Madsen, E. Eric Adams, Andrew M. Pollack, and Cortis Cooper.** A REVIEW AND EVALUATION OF BASIC TECHNIQUES FOR PREDICTING THE BEHAVIOR OF OIL SLICKS. MITSG 77-8. NTIS: PB-268 220/AS. Order from NTIS.

**Stewart, Robert J.** THE INTERACTION OF WAVES AND OIL SPILLS. MITSG 75-22. NTIS: PB-262 458/AS. Order from NTIS.

**Trump, John G.** ELECTRIC POWER FOR THE TREATMENT OF WATER AND

WASTEWATER. MITSG 73-8. NTIS: COM-73-11080. Order from NTIS.

**Trump, John G., Kenneth A. Wright, Edward W. Merrill, Anthony J. Sinskey, Dineshchandra Shah, and Steven Sommer.** PROSPECTS FOR HIGH-ENERGY ELECTRON IRRADIATION OF WASTEWATER LIQUID RESIDUALS. MITSG 75-19. NTIS: PB-253 128. Reprinted from the International Atomic Energy Agency, IAEA-SM-194/302. No charge.

**Yeung, Ronald W.** DOCUMENTATION OF FOUR OCEAN-RELATED COMMUTER PROGRAM MODULES. MITSG 76-18. NTIS: PB-264 146/AS. $2.

## Waste Disposal and Treatment

see also WASTEWATER MANAGEMENT—TECHNICAL ALTERNATIVES AND REGULATORY OUTLOOK, and PUBLIC WASTE MANAGEMENT—THE OCEAN CHOICE, page 51.

**Devanney, John W., III, Vassilios Livanos, and James M. Patell.** ECONOMIC ASPECTS OF SOLID WASTE DISPOSAL AT SEA. MITSG 71-2. NTIS: PB-195 225. $3.

**Keays, Keatinge, et al.** HOLBROOK COVE SURVEY—A 1972 STUDENT SUMMER OCEAN ENGINEERING LABORATORY RESEARCH PROJECT. MITSG 72-19. NTIS: COM-73-10621. Order from NTIS.

**Klibanov, Alexander M.** ENZYMATIC REMOVAL OF HAZARDOUS POLLUTANTS FROM INDUSTRIAL AQUEOUS EFFLUENTS. MITSG 83-17. NTIS: PB84-138-155. 18pp. $3.50.

A new method is described for the removal of phenols and aromatic amines from industrial wastewaters. It involves the treatment of wastewater with horseradish peroxidase and hydrogen peroxide. Phenols and aromatic amines are precipitated from water due to their enzymatic crosslinking. The peroxidase treatment has been successfully used to dephenolize samples of real industrial wastewater.

**Myers, Edward P., editor.** OCEAN DISPOSAL OF MUNICIPAL WASTEWATER—IMPACTS ON THE COASTAL ENVIRONMENT. MITSG 83-33. 2 vols. 1115pp. $25.

This two-volume, multi-author publication thoroughly discusses the problem of ocean disposal of municipal wastewater. The organization of chapters essentially follows the life history of a contaminant in coastal waters from its source through physical dilution and transport and chemical conversion, to effects on marine and human life. The final chapters address some socioeconomic, legal/institutional, and management considerations.

**Kolf, Richard C.** SEWAGE DISPOSAL AND THE OCEAN—THE SEA GRANT ROLE. MITSG 85-6. 30pp. No charge.

Disposing of sewage sludge in the ocean is emerging as a viable option among the scientific community. Rather than advocating or excluding any particular disposal alternative, however, this report recommends a flexible policy combining case-by-case decisionmaking with subsequent monitoring, research, and reevaluation. Because general public opinion still condemns ocean disposal and causes serious delays during the permit process, social scientists should concentrate on conflict-avoidance and conflict resolution methods to help resolve socio-political opposition.

## Pollutant Transport

**Kossik, Richard F.** MATHEMATICAL SIMULATION OF POLLUTANT TRANSPORT IN BOSTON HARBOR. MITSG 87-3TN. 35pp. $3.

Two previously developed circulation and transport models were modified and applied with high spatial resolution to Massachusetts Bay and Boston Harbor in order to simulate two-dimensional contaminant concentrations. In addition, a number of halogenated hydrocarbons present in sewage effluent were identified and employed as large-scale tracers of sewage-related contamination. The concentrations of a number of these compounds were measured at their source and throughout Boston Harbor during different seasons. The mathematical models were then calibrated by comparing simulated concentrations in order to evaluate the predative capabilities of the models and quantitatively investigate pollutant transport in the region.

**Kossik, Richard F., Philip M. Gschwend, and E. Eric Adams.** TRACING AND MODELLING POLLUTION TRANSPORT IN BOSTON HARBOR. MITSG 86-16. 227pp. $5.

The harmonic finite element circulation model TEA and the Eulerian-Lagrangian transport model ELA were modified and applied with high spatial resolution to Boston Harbor. The applicability of a number of volatile halogenated organic compounds as tracers in coastal waters was investigated, and complementary tracer experiments were carried out. The transport model was then calibrated to the tracer measurements in order to evaluate model behavior and investigate physical and chemical transport processes in the harbor. Model simulations agree well with measurement, and calibrated parameters have physically realistic values. Comparisons with observations indicate that the models adequately represent the major processes acting in the system, and further validation efforts are justified.

**Wu, Shian-Chee, and Philip M. Gschwend.** NUMERICAL MODELING OF SORPTION KINETICS OF ORGANIC COMPOUNDS TO SOIL AND SEDIMENT PARTICLES. MITSG 88-14J. 11pp. $2.

A numerical model is developed to simulate hydrophobic organic compound sorption kinetics, based on a retarded intraagregate diffusion conceptualization of this solid-water exchange process. This model was used to ascertain the sensitivity of the sorption process for various sorbates to nonsteady solution concentrations and to polydisperse soil or sediment aggregate particle size distributions. Common approaches to modeling sorption kinetics amount to simplifications of our model and appear justified only when (1) the concentration fluctuations occur on a time scale which matches the sorption timescale of interest and (2) the particle size distribution is relatively narrow. Finally, a means is provided to estimate the extent of approach of a sorbing system to equilibrium as a function of aggregate size, chemical diffusivity and hydrophobicity, and system solids concentration. Reprinted from *Water Resources Research*, Vol. 24, No. 8, pages 1373-1383, August 1988.

# Ocean Engineering

## General

**Mollo-Christensen, Erik L., and Craig E. Dorman.** A BUOY SYSTEM FOR AIR-SEA INTERACTION STUDIES—BUOY DESIGN AND OPERATION. MITSG 72-1. NTIS: AD-887 165. $3.

## Arctic and Ice Technology

**Ladd, Charles C., J.S. Weaver, John T. Germaine, and D.P. Sauls.** STRENGTH-DEFORMATION PROPERTIES OF ARCTIC SILT. MITSG 85-22J. 11pp. No charge.

The offshore industry is developing mobile gravity structures to operate in deep Arctic waters. Foundation design depends on complex soil conditions requiring more comprehensive evaluation of strength deformation properties than has been needed for pile supported platforms. Lack of experience in in situ behavior of silts complicates the problem further. This paper summarizes classification and related properties of Arctic silts in Harrison Bay, Alaska and discusses the effect of temperatures on consolidation test results. The main focus is on undrained stress-strain-strength anisotropy of normal consolidated Arctic silt. Reprinted from *Arctic '85*, ASCE, San Francisco, Calif., March 1985.

**Xirouchakis, Paul C.** ON THE RATIONAL SELECTION OF STRENGTHENING CRITERIA FOR NAVIGATION IN ICE. MITSG 85-32TN. NTIS: PB86-172806/XAB. 117pp. $7.

This report summarizes the existing methods for predicting the maximum ice pressure exerted on the side walls of vessels that must travel through ice. Methods are developed defining stiffness and strengthening criteria for the structural design of these structures. Elastic-plastic buckling criteria for transverse frames are developed; these are particularly important since structural damage due to ice loading has been attributed primarily to frame buckling or the crippling of its web, and existing design requirements do not consider this mode of failure.

## Materials and Testing

**Backer, Stanley, and P. Hsu.** STRUCTURES WITH PARTIAL FRICTIONAL CONSTRAINTS. MITSG 87-15J. 8pp. $1.

This paper focuses on the structural mechanics of plied twisted structures with partial frictional constraints. The discussion is limited to the case of tensile deformation, although it can be extended to bending or to twisting deformations as well. The models proposed and developed may be applied to simple plied twisted yarns such as may be used in industrial fabrics or canvasses, to tire cords, or to string, cords, or ropes. The authors' motivation is to understand the mechanical behavior of twisted ropes and to establish a basis for improvements in their design and performance. Reprinted from *Objective Measurement: Applications to Product Design and Process Control, Proceedings of the Third Japan-Australia Joint Symposium on Objective Measurement*, September 1985.

**Backer, Stanley, and M. Seo.** MECHANICS OF DEGRADATION IN MARINE ROPE. MITSG 87-14J. 12pp. $1.

This paper focuses on the factors which cause degradation in marine ropes, and reports on the modes and extent of degradation observed in selected synthetic fiber hawsers over extended periods of use in different deployment situations. Reprinted from *Objective Measurement: Applications to Product Design and Process Control, Proceedings of the Third Japan-Australian Joint Symposium on Objective Measurement*, Sept.ember 1985.

**Bellingham, James G., M.L.A. MacVicar, and M. Nisenoff.** SQUID TECHNOLOGY APPLIED TO THE STUDY OF ELECTROCHEMICAL CORROSION. MITSG 87-6J. 3pp. No charge.

Both the temporal and spatial dependences of the magnetic fields of electrochemical corrosion reactions have been investigated. A comparatively simple metal-electrolyte system, Zn in HCl, was chosen for concentrated study. Design of this corrosion cell, as well as its rationale, are described. The spectral density of the magnetic field generated by corrosion reactions has an inverse dependence on frequency. The overall noise level increases with increased corrosion rate. These preliminary results confirm the great potential of SQUID magnetometry for the study of electrochemical corrosion phenomena. Reprinted from 1986 Applied Superconductivity Conference, Baltimore, Md.

**Bellingham, James G., M.L.A. MacVicar, M. Nisenoff, and P.C. Searson.** DETECTION OF MAGNETIC FIELDS GENERATED BY ELECTROCHEMICAL CORROSION. MITSG 87-7J. 2pp. No charge.

The magnetic fields generated by electrochemical corrosion have been detected. Magnetic fields as large as $10^{-5}$ gauss were measured approximately 2.5 cm above metals immersed in high conductivity electrolytes. It is well known that magnetic fields are associated with current flow; thus electrochemical reactions should have an associated magnetic field. The detectability of the magnetic field will depend on the magnitude and the spatial distribution of the corrosion currents. The current distribution can be determined by inserting probes into the electrolyte, but the presence of such probes may distort the current distribution. Therefore the use of magnetic means provides a non-invasive method which may be capable of monitoring both the magnitude and spatial distribution of the corrosion currents. Reprinted from *Journal of the Electrochemical Society*, August 1986.

**Bishop, William O., John F. Mandell, and Frederick J. McGarry.** NOTCH GEOMETRY AND LAMINATE CONSTRUCTION EFFECTS ON THE FRACTURE TOUGHNESS OF LAMINATES FOR HULL CONSTRUCTION. MITSG 73-15. NTIS: COM-74-10699. $1.50.

**Demchick, Robert P., John F. Mandell, and Frederick J. McGarry.** MARINE ENVIRONMENT EFFECTS ON FATIGUE CRACK PROPAGATION IN GRP LAMINATES FOR HULL CONSTRUCTION. MITSG 73-16. NTIS: COM-74-10534. $2.

**Donnelly, R.G. and R.E. Cohen.** ENHANCEMENT OF THE STABILITY OF COMMON POLYMERIC MATERIALS AGAINST UNDERSEA DEGRADATION. MITSG 81-14. NTIS: PB82-163-015. 216pp. $8.

The report summarizes Sea Grant research on strengthening common polymeric materials against undersea degradation. Several common polymeric materials were subjected to small amplitude cyclic flexure in a simulated marine environment, and changes in molecular weight and crystallinity were monitored. A polyethylene resin was treated by a variety of surface modification techniques and subjected to similar conditions to evaluate these treatments. Each technique was effective in retarding degradation; however, effectiveness varied greatly among them.

**Faulkner, Douglas.** THE OVERALL COMPRESSION BUCKLING OF PARTIALLY CONSTRAINED SHIP GRILLAGES. MITSG 73-10. NTIS: COM-73-11303/AS. $2.50.

**Faulkner, Douglas.** A REVIEW OF EFFECTIVE PLATING TO BE USED IN THE ANALYSIS OF STIFFENED PLATING IN BENDING AND COMPRESSION. MITSG 73-11. NTIS: COM-73-11309. Order from NTIS.

**Kenney, M.C., John F. Mandell, and Frederick J. McGarry.** EFFECTS OF SEA WATER AND CONCENTRATED SALT SOLUTIONS ON THE FATIGUE OF NYLON 6,6 FIBERS. MITSG 87-16J. 11pp. $1.

Cyclic fatigue and creep rupture tests have been run on high tenacity nylon 6,6 single fiber, yarns, and small ropes in air and seawater environments. Fatigue failure in each case is by a creep rupture mechanism; yarns and small ropes show the same fatigue sensitivity as do single fibers. Seawater reduces the strength by approximately 10 percent under most conditions. Concentrated metallic salt solutions which cause environmental stress cracking in bulk nylon do not degrade the fibers beyond the effect of plain water. Tests on oriented nylon specimens show that environmental stress crack sensitivity is greatly reduced by orientation. Reprinted form *Journal of Materials Science*, 1985.

**Kenney, M.C., John F. Mandell, and Frederick J. McGarry.** FATIGUE BEHAVIOR OF SYNTHETIC FIBERS, YARNS, AND ROPES. MITSG 87-17J. 15pp. $2.

S-N fatigue and creep-rupture data have been obtained for nylon 6,6 single fibers, interlaced yarns, and small ropes under a variety of loading conditions. The results show a similar degradation rate at each level of structure, with no apparent influence of inter-fiber effects. Cyclic lifetimes of single fibers of nylon 6,6 as well as polyester and aramid can be predicted from a creep rupture model. Consistent with this model, the time to failure is insensitive to frequency over a broad range. For each level of structure, the strain at failure is the same whether tested in simple tension or under cyclic or creep loading. Failure modes were generally similar in creep rupture and cyclic fatigue tests; no effect of a slack load on each cycle was evident either in the failure mode or specimen lifetime. Reprinted from *Journal of Materials Science*, 1985.

**Klimowski, Robert J., V.J. Papazoglou, and Koichi Masubuchi.** ANALYSIS OF MANUFACTURING PROCESSES OF LARGE ANCHOR CHAINS, PHASE II—DEVELOPMENT OF STRATEGIES FOR IMPROVING THE RELIABILITY TO WELDED CHAINS. MITSG 84-9TN. 247pp. $12.50.

This document reports the results of a study aimed at developing strategies for improving the reliability of flash butt welded anchor chains. The research included a parametric study of factors affecting the quality of flash welded chains, development of strategies for in-process sensing and control of flash welding, and an effort to reduce the possibility of premature failure of a welded chain.

**Mandell, John F.** FATIGUE CRACK PROPAGATION RATES IN WOVEN AND NON-WOVEN FIBERGLASS LAMINATES. MITSG 74-21. NTIS: COM-74-11257/AS. $1.50.

**Mandell, John F.** MODELLING OF MARINE ROPE FATIGUE BEHAVIOR. MITSG 87-18J. 12pp. $1.

Fatigue data for nylon and polyester marine ropes from several testing programs in Europe and the U.S. are compared and analyzed. Failures at loads above 30-40 percent of the new breaking strength for nylon or 60-70 percent for polyester can be predicted by a model based on the creep-rupture behavior of individual fibers and yarns. Failures at lower loads and higher cycles usually occur by external or internal abrasion; an abrasion model is presented that correlates well with these data. Polyester outperforms nylon under wet conditions in both regimes of behavior for a wide range of rope samples. Additional topics discussed are thermal failures from hysteretic heating in dry ropes, and changes during cycling in rope load-extension, hysteresis, and residual properties. Reprinted from *Textile Research Journal*, June 1987.

**Mandell, John F., and Frederick J. McGarry.** FRACTURE OF FIBERGLASS -REINFORCED PLASTICS SUITABLE FOR HULL MATERIALS. MITSG 75-25. NTIS: PB-264 019/AS. Order from NTIS.

**Mandell, John F., and Urs Meier.** FATIGUE CRACK PROPAGATION IN 0°/90° E-GLASS/EPOXY COMPOSITES. MITSG 73-14. NTIS: COM-74-10338. $1.50.

**Mandell, John F., Frederick J. McGarry, Donald S. Barton, and Robert P. Demchick.** EFFECT OF WATER ON THE CRACK PROPAGATION RATE IN FIBERGLASS LAMINATES UNDER STATIC AND DYNAMIC LOADING. MITSG 75-18. NTIS: PB-246 411/AS. Order from NTIS.

**Mandell, John F., Frederick J. McGarry, Reiichiro Kashihara, and William O. Bishop.** ENGINEERING ASPECTS OF FRACTURE TOUGHNESS—FIBER-REINFORCED LAMINATES. MITSG 73-9. NTIS: COM-74-10365. $2.

**Mandell, John F., Frederick J. McGarry, Su-Su Wang, and Jang-hi Im.** STRESS INTENSITY FACTORS FOR ANISOTROPIC FRACTURE TEST SPECIMENS OF SEVERAL GEOMETRIES. MITSG 74-10. NTIS: COM-74-10346. $1.50.

**M.C. Kenney.** FATIGUE AND ENVIRONMENTAL RESISTANCE OF POLYESTER AND NYLON FIBERS. MITSG 89-12J. 7pp. $1.

Marine ropes used in towing and mooring must withstand cyclic loading, abrasion and environmental agents. Rope failures can be sudden and catastrophic. In order to understand the resistance to marine stresses of fibers used in ropes, the authors measured fatigue resistance of individual nylon and polyester fibers both dry and in aqueous solutions. Fiber failure was predictable using simple creep rupture based on theory. Reprinted from *Polymer Engineering and Science*, August 1987.

**Maser, Kenneth R.** AN ANALYSIS OF THE SMALL-SCALE STRENGTH TESTING OF ICE. MITSG 72-6. NTIS: COM-72-10294. $2.50.

**Snyder, Paul G., John F. Mandell, and Frederick J. McGarry.** THE IMPACT RESISTANCE OF MODIFIED FERRO-CEMENT PANELS. MITSG 74-18. NTIS: COM-74-11248/AS. $4.

**Wang, Youjiang, and Stanley Backer.** STRUCTURAL MODELING OF THE TENSILE BEHAVIOR OF EIGHT STRAND ROPES. MITSG 89-28. 48pp. $5.

Synthetic ropes are widely used in marine applications, yet rope breakage can cause injury or economic loss. This report describes structural modeling of load-elongation behavior in eight-stranded rope, providing a basis for predicting internal wear and a foundation for blending fiber components to enhance tensile strength and fatigue life. Rope tensile load, interstrand pressures and strand relative movement are determined based on rope geometries before and after deformation.

**Williams, J.H. Jr., B.R. Felenchak, and R.J. Nagem.** QUANTITATIVE GEOMETRIC CHARACTERIZATION OF TWO-DIMENSIONAL FLAWS VIA LIQUID CRYSTALS AND THERMOGRAPHY.
-and-
**Williams, James H., Jr., and R.J. Nagem.** A LIQUID CRYSTALS KIT FOR STRUCTURAL INTEGRITY ASSESSMENT OF FIBERGLASS WATERCRAFT. MITSG 84-6J. 21pp. No charge for black and white copies. Copies with 2 pages of colored copies are available at $2.

Thermal nondestructive testing (NDT) is a technique for obtaining surface temperature profiles on a structure and subsequently relating this information to some imperfection within the structure. Liquid crystals may be used to reveal the temperature anomaly. The first paper describes experiments conducted on two specimens containing simulated machine flaws. Tests showed that the size and location of the simulated flaws can be determined to within approximately 10 percent. In the second paper, a liquid crystals kit capable of providing quantitative assessments of the structural integrity of fiberglass boats is developed. Reprinted from *Materials Evaluation*, v.41, no.2, pp.190-210, 218.

**Williams, James H., Jr.** THERMAL NONDESTRUCTIVE TESTING OF FIBERGLASS USING LIQUID CRYSTALS. A TWO-PART REPORT. MITSG 81-16. 198pp. $8.

Thermal testing with cholesteric liquid crystals provides a simple nondestructive evaluation technique for detecting interlaminar flaws in fiberglass composite laminates. A one-dimensional model of heat conduction through a flawed laminate has been devised (Part I). A fiberglass laminate with simulated flaws orthogonal to the surface was thermally tested using liquid crystals. Various plots presenting the sensitivity and effectiveness of the liquid crystal thermal nondestructive testing system are presented (Part II).

## Underwater Welding

**Brown, Alan J., Russell T. Brown, Chon-Liang Tsai, and Koichi Masubuchi.** REPORT ON FUNDAMENTAL RESEARCH ON UNDERWATER WELDING. MITSG 74-29. NTIS: COM-74-11821/AS. $5.

**Masubuchi, Koichi.** DEVELOPMENT OF JOINING AND CUTTING TECHNIQUES FOR DEEP-SEA APPLICATION. MITSG 81-2. 227pp. Photocopy reprints available. $14.

This is the final report on four years of research on welding and cutting in deep-sea conditions. During the research program, extensive experiments on arc welding and cutting in deep-sea conditions were performed to study the effects of water pressure on arc welding and on the properties of welds. A prototype of an underwater arc stud welding tool that can attach four studs to the work piece in consecutive order within two seconds was designed. Also, conceptual design of an automatic underwater flux-shielded welding machine for use in the deep sea was completed and a simple automatic welding machine operated merely by pushing a button was constructed and tested.

**Masubuchi, Koichi, V.J. Papazoglou, D.W. Schloerb, and H.L. Gustin.** DEVELOPMENT OF FULLY AUTOMATED AND INTEGRATED "INSTAMATIC" WELDING SYSTEMS FOR MARINE APPLICATIONS. MITSG 84-11. NTIS: PB84-199-611. 61pp. $5.

This reports on a two-year research program, to develop fully automated and integrated welding systems for marine applications. These systems package many welding operations, including feeding the electrode, manipulating the torch, etc., so that welding can be done by a person without welding skill. Following a general discussion on the concept of the instamatic welding system, the report discusses two types of systems which have been built and tested: underwater stud welding and arc welding systems.

**Masubuchi, Koichi, Chon-liang Tsai, Hironori Ozaki, Arnold Moore, Lawrence Zanca, and Subodh Prasad.** DEVELOPMENT OF NEW IMPROVED TECHNIQUES FOR UNDERWATER WELDING. MITSG 77-9. NTIS: PB-268 682/AS. $8.

## Underwater Vehicles

see also MIT underwater vehicles research opportunity briefs, page 47.

**Baggeroer, Arthur B.** ACOUSTIC TELEMETRY—AN OVERVIEW. MITSG 85-11J. 7pp. No charge.

Although it is known that it is possible to communicate in the ocean environment using acoustic telemetry, getting high data rates is difficult. Over the years some acoustic communications have been developed and this paper reviews some of them and indicates how they use various principles to overcome the limitations. Reprinted from *IEEE Journal of Oceanic Engineering*, Vol. OE-9, No. 4, 1984, pp.229-235.

**Bellingham, James G., Robert Beaton, Michael S. Triantafyllou, and Landy Shupe.** AN AUTONOMOUS SUBMERSIBLE DESIGNED FOR SOFTWARE DEVELOPMENT. MITSG 89-30J. 6pp. $1.

An autonomous submersible is being used at MIT Sea Grant as a platform for exploring approaches to mission planning. The vehicle is small, measuring less than three feet long and weighing 62 lbs. Layered control, which has been implemented for land vehicles at the MIT Artificial Intelligence Laboratory, will be used to give the vehicle the capability required to operate in unmapped environments and respond to unanticipated situations. Its repertoire of behaviors will include avoiding collisions, homing on pingers, and investigating interesting phenomena (e.g. sonar targets or magnetic anomalies). A potential mission for the submersible might be rapid response to industrial or natural disasters, for example measuring the characteristics of a chemical spill in a body of water. Reprinted from *Proceedings from Oceans '89*, Seattle, Washington, Sept. 18-21, 1989.

**Brooks, Thurston L., and Thomas B. Sheridan.** SUPERMAN—A SYSTEM FOR SUPERVISORY MANIPULATION AND THE STUDY OF HUMAN/COMPUTER INTERACTIONS. MITSG 79-20. NTIS: PB301-290/AS. $6.

**Carmichael, A. Douglas, Stewart D. Jessup, and Glenn Keller.** A SMALL ROBOT SUBMARINE FOR OCEANOGRAPHIC APPLICATIONS. MITSG 76-15J. NTIS: PB-263 343/AS. Reprinted from *Proceedings from Oceans '76*, the proceedings of the Second Annual Conference sponsored by the marine Technology Society and the Institute of Electrical and Electronic Engineers, 1976.

**Catipovic, J.A., Arthur B. Baggeroer, K. Von Der Heydt, and D.E. Koelsch.** THE DESIGN AND PERFORMANCE ANALYSIS OF A DIGITAL ACOUSTIC UNDERWATER TELEMETRY SYSTEM. MITSG 85-12. NTIS: PB86-156510/XAB. 54pp. $5.

This report discusses the design and performance characteristics of a system for transmitting data between deep sea instruments and surface work stations. The system, Digital Acoustic Telemetry System (DATS), incorporates the current state-of-the-art technology and is capable of reliable data transmission at rates useful for a wide range of tasks. DATS is designed to operate in very reverberant channels. It adaptively monitors the time and frequency dispersion of the channel and uses the measurements to correct the demodulator and decoder. The report presents measurements of the channel used at frequencies centered at 50 kHz and at ranges of up to 1 km in shallow water.

**Doelling, Norman A., Elizabeth T. Gowell, editors.** AUTONOMOUS UNDERWATER SYSTEMS FOR SURVEY OPERATIONS. MITSG 89-4. NTIS: PB89 187397/AS. 83pp. $3.

An undersea robot that can be released at sea, find a harbor, perform a task and return to a designated location could be used for military applications like mine clearing and mine laying, or for oceanographic surveys, mineral exploration, fish population studies and underwater equipment repair. This report summarizes the findings of an interdisciplinary MIT research team assembled in 1987 to develop a vehicle concept and outline a plan of research necessary for its development. Concluding that the best robot is the smallest possible system consistent with payload, power, sensor and computational requirements, the report considers systems for vehicles as small or smaller than torpedoes.

**Doelling, Norman A., and Elizabeth T. Harding, editors.** UNDERSEA TELEOPERATORS AND INTELLIGENT AUTONOMOUS VEHICLES. MITSG 87-1. 233pp. $15.

This book, based on papers presented at a conference on undersea teleoperators held at MIT in October 1986, presents a multidisciplinary look at the evolving fields of teleoperation, robotics and artificial intelligence as they apply to underwater systems. In the first section of the book, the authors present an historical perspective of the current state-of-the-art in teleoperation and the evolution of underwater remotely operated systems. The last section explores the requirements of future systems.

**Goudey, Clifford A., and William B. Coney.** ICARUS—MIT'S HUMAN-POWERED SUBMARINE. MITSG 90-8. 22pp. $1.

In June of 1989, the H.A. Perry Foundation sponsored a race among human powered submarines in West Palm Beach, Fla. Intended as a means of introducing students and young engineers to the challenges and opportunities of applying their skills to the marine environment, the competition attracted 19 entries from across the country.

This paper describes Icarus, MIT's entry into this unusual competition. A team of students banded together to design and build what was hoped to be the winning submarine. The hull form, propulsion system, and control surface geometry are described. Several unusual features of the MIT entry are also explained, including the articulated tail, the automatic buoyancy control system, and the slender propeller blades made of carbon fiber. The numerical techniques used in the propeller design are also covered.

**Kazerooni, Homayoon, and Thomas B. Sheridan.** COMPUTER SIMULATION AND CONTROL OF UNDERWATER VEHICLES. MITSG 82-19. NTIS: PB83-150-532. 150pp. $8.

This report describes the digital simulation of underwater inspection vehicles. Differential equations, which can present the three dimensional motion of the vehicle, have been used to study dynamics and kinematics. Several algorithms are described which bring the motion of the vehicle under the supervisory control of an operator. Digital dynamic models of ALVIN and RCV 150 simulate the control algorithms in performing some complicated tasks such as bottom following.

**Kazerooni, Homayoon, and Thomas B. Sheridan.** WIDE BANDWIDTH POSITIONING SYSTEMS FOR SPACE AND UNDERWATER VEHICLES. MITSG 85-34. NTIS: PB86-157310/XAB. 15pp. $4.

Remotely operated underwater vehicles sometimes must attach themselves to an underwater structure to employ manipulators and other tools for inspection, cleaning and repairing tasks. The interaction of classical control and the constraining attachment systems can result in high forces and possible destruction of equipment. To attack this problem a general technique known as impedance control has been developed. In this report, the concept has been extended to include constraints as a special kind of external load. Thus, it is shown that the controller can be built to work safely with systems having constraints or attachment mechanisms which severely limit motion.

**Kazerooni, Homayoon.** A ROBUST DESIGN METHOD FOR IMPEDANCE CONTROL OF CONSTRAINED DYNAMIC SYSTEMS. MITSG 85-35TN. 140pp. $14.

This report complements MITSG 85-34 abstracted above. It provides considerable detail on the extension of impedance control to include constraints as a special kind of external load. The research reported shows that a controller can be built to work safely with systems having contraints or attachment mechanisms which severely limit motion.

**Landsberger, Samuel E., and Thomas B. Sheridan.** A NEW DESIGN FOR PARALLEL LINK MANIPULATORS. MITSG 85-16J. 3pp. No charge.

This paper describes a new manipulator arm configuration in which six degrees of freedom are obtained through one passive compressive spine and six active tension cables, all position controlled in parallel. The design has the advantage that all motors can be mounted at the base, the mass of the arm can be reduced greatly with greater rigidity and speed and in contrast to conventional designs the inverse Jacobian required for control is easy to calculate. Reprinted from *Proceedings from IEEE International Conference on System, Man & Cybernetics* (1985), Tuscon, Ariz.

**Levi, Carolyn.** DEEP THOUGHTS—ARTIFICIAL INTELLIGENCE IN UNDERWATER VEHICLES. MITSG 90-5. 6pp. $1.

Autonomous underwater vehicles (AUVs) promise to greatly expand access to the ocean for oceanographers as well as marine engineers, but designing AUVs to be both flexible and economic enough for wide use is highly challenging. This article discusses computer and engineering strategies underlying the design of small, inexpensive, and robust artificially intelligent submersibles. Progress in AUV development at two Sea Grant programs is reviewed. Reprinted from *Nor'easter* Vol. 1, No. 2, 1989.

**Morey, Kenneth A., and Erik L. Mollo-Christensen.** DESIGN, DEVELOPMENT, AND FIELD TRIALS OF A TOWED INSTRUMENTED GLIDER. MITSG 76-20. NTIS: AD-A006962. $2.

**Odahara, Tetsuichi and Thomas B. Sheridan.** EXPERIMENTS IN SUPERVISORY CONTROL OF A COMPUTERIZED VEHICLE FOR INSPECTING CURVED SURFACES. MITSG 80-19. NTIS: PB81-178-337. 77pp. $4.

Research in underwater work vehicle support systems has developed a computerized vehicle for inspecting curved surfaces, such as pipelines. The control system uses three kinds of vehicle motion control: manual, automatic approaching, and automatic surface following. The report documents manual control difficulties and the advantage of combined manual and automatic control systems and considers the adaptability of supervisory control concepts to undersea inspection.

**Royer, Thierry.** HUMAN INTERACTIVE SIMULATION AND DISPLAY OF AN UNDERWATER REMOTELY OPERATED VEHICLE. MITSG 85-29TN. 92pp. $5.

As the fleet of unmanned submersibles grows in the next several years, so will the demand for trained human operators who can supervise underwater vehicles using analog controls, computers, and video. This report offers a framework for developing training procedures for the operators through simulation. The simulator, implemented on a PDP 11/34, is made up of four modules which work in parallel: a dynamic model of the vehicle, a static model for the shape and tension of the tether, a graphics display, and a simulator of the environment. The modular concept makes it easy to change or adapt individual elements, and simulation costs can be cut by using a multi-microcomputer system.

**Schneiter, John L.** OBJECTIVE TACTILE SENSING STRATEGY FOR OBJECT RECOGNITION AND LOCALIZATION. MITSG 86-19J. 6pp. No charge.

A theory for scheduling sensor moves to obtain tactile information from objects is presented. In this report, the authors assume that tactile measurements are taken from 2-D planar objects and consist of the point of contact of the sensor with an object's face and the surface normal vector at the contact point, although the theory does not preclude other tactile inputs. The theory is also not limited to 2-D planar objects, and general 3-D objects may be used with a concomitant increase in the complexity of the representation and software development. It is, however, necessary to have a finite number of interpretations of the tactile data. A hardware demonstration system was developed.

**Schneiter, John L.** OPTICAL TACTICAL SENSOR FOR MANIPULATORS. MITSG 87-5J. 7pp. No charge.

A touch sensor for robots was designed, built and demonstrated. It is based on a deformable elastic reflective surface and optical fiber technology. The device is relatively immune to electromagnetic noise and may be used in environments where it is important to protect sensitive electronic equipment from such noise. The sensed touch pattern is easily read and interpreted by a computer using current video technology. The design allows for extremely high spatial resolution (2100 sensitive spots per square inch achieved here). Spatial resolution must be traded off with sensor pad thickness to retain adequate sensitivity. Reprinted from *Robotics and Computer-Integrated Manufacturing*, 1984.

**Sofyanos, Thomas N. and Thomas B. Sheridan.** AN ASSESSMENT OF UNDERSEA TELEOPERATORS. MITSG 80-11. Photocopy reprint available. NTIS: PB81-102-535. 315pp. $15.

This Mechanical Engineering Department thesis assesses undersea teleoperators and competing methods of underwater intervention. The report examines general purpose, remotely controlled work vehicles and discusses representative costs for offshore divers and manned and unmanned submersibles. The role of remotely operated vehicle systems in offshore installation inspection, development trends for teleoperator systems, and federally supported programs are evaluated.

**Stewart, W. Kenneth.** BACKSCATTER FROM SIDESCAN SONAR FOR AUTONOMOUS CLASSIFICATION AND NAVIGATION. MITSG 89-26J. 21pp. $2.

As autonomous underwater vehicles evolve they will need more sophisticated ways to model their environment from sensor data. This report describes several techniques for three-dimensional sonar processing in which seafloor shape is used to reduce geometric and radiometric dependencies in the intensity signal, using bathymetry and sidescan data. Preliminary results are also described for new split-beam sidescan sonars designed for high-resolution seafloor characterization. The processed output is a quantitative model of three-dimensional shape and backscatter characteristics that will

be applied to feature classification and terrain-relative navigation for intelligent underwater vehicles. Reprinted from *Proceedings from the Symposium on Unmanned Untethered Submersible technology*, June 1989.

**Stewart, W. Kenneth.** MODEL BASED APPROACH TO 3-D IMAGING AND MAPPING UNDERWATER. MITSG 88-4J. 12pp. $2.

An approach to multidimensional representation of underwater environments is presented with results of applications in 3-dimensional sonar mapping. A non-deterministic model incorporates information from multiple knowledge sources and creates a framework for real-time processing. Probabilistic methods account for non-ideal sensors while spatial decomposition and numerical techniques treat amorphous underwater features and allow an incremental approach to modeling the surroundings. An emphasis on representational and modeling issues is maintained with examples drawn from computer simulations and field data from profiling and imaging sonars. Reprinted from *Seventh International Conference on Offshore Mechanics and Arctic Engineering-Volume VI.*

**Stewart, W. Kenneth.** MULTISENSOR MODELING OF UNDERSEA TERRAIN. MITSG 89-27J. 11pp. $1.

This paper describes a method of constructing multidimensional models of the undersea environment with real-time multisensor data. The basis of this approach is to divide the space into small cubical units, each of which has a multisensor feature vector that represents the properties within the region. New sensor data is merged to continuously update the image. Reprinted from *Proceedings from MTS ROV '89*, San Diego, CA., March 1989.

**Stewart, W. Kenneth.** MULTISENSOR MODELING UNDERWATER WITH UNCERTAIN INFORMATION. MITSG 89-29TH. 172pp. $48. Michrofiche copies free.

This thesis develops an approach for constructing multidimensional models of an underwater environment from sensor data. The model operates within real-time constraints using high-bandwidth sensors providing redundant, overlapping coverage. It provides for lack of prior knowledge about the environment and for inherent inaccuracy or ambiguity in sensing and interpretation. A numerical approach is derived from an incremental adaptation of the summation method for image reconstruction. Computer simulations show the model can be used for navigation. The method has been applied to real sonar data from bathymetric surveys, acoustic imagery and high-resolution scanning sonar.

**Triantafyllou, Michael S., and A.M. Amzallag.** A NEW GENERATION OF UNDERWATER UNMANNED TETHERED VEHICLES CARRYING HEAVY EQUIPMENT AT LARGE DEPTHS. MITSG 85-30TN. 243pp. $14.

The offshore industry and deep ocean mining companies operating in deep water will require unmanned vehicles which can perform heavy duty tasks. This report describes in detail a rational process for designing an appropriate tethered submersible for those conditions. Simulations of the submersibles are presented to evaluate performance and power requirements, with and without payload. These are then repeated with a control methodology which uses LQG/LTR.

**Triantafyllou, Michael S., and Franz Hover.** CABLE DYNAMICS FOR TETHERED UNDERWATER VEHICLES. MITSG 90-4. NTIS: PB90 200049/AS. 30pp. $3.

Tethered underwater vehicles find many uses in underwater exploration. Yet, although tethers provide safety, power and control, they can complicate movement of these submersibles, especially in deep water, because of hydrodynamic drag and inertial on the tether. This paper provides a numerical scheme for studying the dynamics of tethered vehicles. The Woods Hole Oceanographic Institution's vehicles ARGO and JASON are used to confirm the validity of the numerical predictions.

## Hydrodynamics

### General

**Halkyard, John E.** WAVE FORCES ON A SUBMERGED OBJECT. MITSG 72-4. NTIS: COM-72-10126. Order from NTIS.

**Karniadakis, G., and George S. Triantafyllou.** FREQUENCY SELECTION AND ASYMPTOTIC STATES IN LAMINAR WAKES. MITSG 89-13J. 29pp. $3.

A better understanding of the transition process in open flows can be obtained through identification of the possible asymptotic response states in the

flow. In this paper, the authors investigate the asymptotic states in laminar wakes behind circular cylinders at low supercritical Reynolds numbers. Direct numerical simulation of the flow is performed, using spectral-element techniques. Naturally produced wakes, and periodically forced wakes are considered separately. It is found that naturally produced wakes are periodic, but under forcing they undergo a series of transitions leading to chaos. Reprinted from *Journal of Fluid Mechanics*, Vol. 199.

**Triantafyllou, George S.** INSTABILITY IN THE WAKE OF A STEADILY ADVANCING SHIP. MITSG 89-8. 14pp. $1.

This paper studies the instability of the viscous wake of a ship. The viscous wake leaves a persistent trace of a ship's passage in the ocean, detectable by satellite surveillance. The researcher found that the wake is unstable and the instability is convective. The instability exhibits a staggered pattern of hills and valleys, antisymmetric about the axis of the wake. For low Froude numbers, the frequency and phase-velocity is determined by the characteristics of the shear flow in the wake.

**Triantafyllou, George S., and C. Chryssostomidis.** THE DYNAMICS OF TOWED ARRAYS. MITSG 89-32J. 6pp. No charge.

Towed arrays of hydrophones are used for bottom exploration and target detection. The hydrophones are attached to a long, slender, flexible cylinder, which is towed horizontally. Since motions of the cylinder can induce uncertainties in the measurements of the hydrophones, the hydroelasticity of the cylinder is an important consideration. This report details a procedure for calculating the response of an array to a harmonic excitation at the upstream end. It is found that, when the separation drag is included, the array exhibits the behavior of an over-damped system, responding only to low-frequency excitations. Reprinted from *Journal of Offshore Mechanics and Arctic Engineering*, August 1989.

**Triantafyllou, George S., and Athanasios Dimas.** THE LOW FROUDE NUMBER WAKE OF FLOATING BLUFF OBJECTS. MITSG 89-5P. 12 pp. $1.

The stability of the wake of an object, such as a ship, floating on the ocean surface is an important consideration in satellite sensing of the ocean surface. An important aspect of this problem is the effect of free surface of the object on the stability and pattern of the wake. It is shown that the presence of the free surface has a stabilizing effect suppressing the unsteadiness in the wake. Submitted to *The Physics of Fluids*.

**Triantafyllou, George S., K. Kupfer, and A. Bers.** ABSOLUTE INSTABILITIES AND SELF-SUSTAINED OSCILLATIONS IN THE WAKES OF CIRCULAR CYLINDERS. MITSG 88-6J. 4pp. $1.

The von Karman vortex street in the wake of a circular cylinder is shown to be due to an instability in the flow in the near wake. A new means of instability analysis is used, involving mappings from the complex $\kappa$ plane to the complex $\omega$ plane. Reprinted from *Physical Review Letters*, Vol. 59, No. 17, Oct. 26, 1987.

## Ship Hydrodynamics

**Goudey, Clifford A., and Madan Venugopal.** ROLL DAMPING ON A 76 FOOT NEW ENGLAND TRAWLER—AN EXPERIMENTAL INVESTIGATION. MITSG 87-13. 70pp. $5.

The damping effects of bilge keels, bilge fins and paravanes on the roll motions of a fishing vessel are studied experimentally using model tests in a towing tank. A 1:17.03 scale model of a 76 ft. New England trawler was fitted with the different damping devices and excited by a moment generator. The roll amplitudes were measured at trawling and steaming speeds and with no forward speed, and the roll damping ratios were calculated. The model resistance was measured at trawling and steaming speeds. Comparisons of the effects of the different damping devices are made. The effects of circular cutouts on the damping action of a fin and a bilge keel are also studied.

**Noblesse, Francis.** ALTERNATE EXPRESSIONS FOR THE GREEN FUNCTION OF THE THEORY OF SHIP WAVE RESISTANCE. MITSG 79-23. $4.

**Noblesse, Francis.** FINAL REPORT ON A STUDY OF SHIP WAVE RESISTANCE. MITSG 81-13. NTIS: PB82-160-953. 24pp. $3.50.

Sea Grant researchers have examined a new analytical theory for predicting wave resistance of a ship in rectilinear motion at constant speed in a calm sea. One objective of the project was to test the theory using various idealized geometrical ship forms. Towards that objective, this report proves the convergence of the sequence

of slender-ship approximations defined in Noblesse's slender-ship theory of wave resistance.

**Venugopal, Madan, and Clifford A. Goudey.** ROLL DAMPING ON A 119 FOOT NEW ENGLAND TRAWLER—AN EXPERIMENTAL INVESTIGATION. MITSG 87-12. 61pp. $5.

The damping effects of bilge keels, bilge fins and paravanes on the roll motions of a fishing vessel are studied experimentally using model tests in a towing tank. A 1:26.53 scale model of a 119 ft. long New England trawler was fitted with the different devices and excited in roll by a moment generator. The roll amplitudes and resistance at steaming and trawling speeds were measured and roll damping ratios calculated. Comparisons of the effects of the different damping devices are made.

## Offshore Structures

### General

**Chryssostomidis, Marjorie.** OFFSHORE PETROLEUM ENGINEERING—A BIBLIOGRAPHIC GUIDE TO PUBLICATIONS AND INFORMATION SOURCES. MITSG 78-5. $5.

### Risers and Cables

**Chryssostomidis, C., and Nicholas M. Patrikalakis.** THEORETICAL AND EXPERIMENTAL PREDICTION OF THE RESPONSE OF A MARINE RISER MODEL—REPORT SERIES. MITSG 83-2, 3, 4, 5, 6, 15, 18, 19, 20, 21, 22, 23. Individual reports—$5., series of 12 reports—$50.

A marine riser model, made up of an aluminum tube covered externally with a sealing material, has been developed. The length between ball joints (L) = 3.000 m; the aluminum tube I.D. ($D_i$) = 10.92 mm; the aluminum tube O.D. ($D_o$) = 12.61 mm; external sealing diameter or effective diameter ($D_e$) = 15.3 mm; average mass per unit length (M) = 0.327 kg/m; average effective weight per unit length (We) = 1.378 N/m; effective overpull at the lower ball joint (Pe(0)) = 1.72 N; and bending stiffness of a cross section (EI) = 35.4 $Nm^2$. Each report in this series describes the THEORETICAL AND EXPERIMENTAL PREDICTION OF THE RESPONSE OF A MARINE RISER MODEL...

MITSG 83-2
...SUBJECTED TO SINUSOID EXCITATION OF ITS TOP END WITH AMPLITUDE EQUAL TO TWO DIAMETERS (co-author E. Vrakas). NTIS: PB83-210-575. 86pp.

MITSG 83-3
...SUBJECTED TO SINUSOID EXCITATION OF ITS TOP END WITH AMPLITUDE OF TWO DIAMETERS PARALLEL TO A UNIFORM STREAM OF SPEED EQUAL TO 120 mm/s. 66pp.

MITSG 83-4
...SUBJECTED TO SINUSOID EXCITATION OF ITS TOP END WITH AMPLITUDE OF TWO DIAMETERS PARALLEL TO A UNIFORM STREAM OF SPEED EQUAL TO 240 mm/s. NTIS: PB83-210-567. 66pp.

MITSG 83-5
...SUBJECTED TO SINUSOID EXCITATION OF ITS TOP END WITH AMPLITUDE OF TWO DIAMETERS ORTHOGONAL TO A UNIFORM STREAM OF SPEED EQUAL TO 120 mm/s. NTIS: PB83-210-559. 85pp.

MITSG 83-6
...SUBJECTED TO SINUSOID EXCITATION OF ITS TOP END WITH AMPLITUDE OF TWO DIAMETERS ORTHOGONAL TO A UNIFORM STREAM OF SPEED EQUAL TO 240 mm/s. NTIS: PB-210-583. 86pp.

MITSG 83-15
...IN A UNIFORM STREAM. 318pp.

MITSG 83-18
...SUBJECTED TO SINUSOID EXCITATION OF ITS TOP END ORTHOGONAL TO A UNIFORM STREAM OF SPEED EQUAL TO 42 mm/s. 209pp.

MITSG 83-19
...SUBJECTED TO SINUSOID EXCITATION OF ITS TOP END PARALLEL TO A UNIFORM STREAM. 261pp.

MITSG 83-20
...SUBJECTED TO SINUSOID EXCITATION OF ITS TOP END. 181pp.

MITSG 83-21
...SUBJECTED TO SINUSOID EXCITATION OF ITS TOP END ORTHOGONAL TO A UNIFORM STREAM. 299pp.

MITSG 83-22
...SUBJECTED TO NARROW BANK RANDOM EXCITATION OF ITS TOP END PARALLEL TO A UNIFORM STREAM **(co-author E. Vrakas)**. 280pp.

MITSG 83-23
...SUBJECTED TO SURFACE WAVE EXCITATION **(co-author E. Vrakas)**. 114pp.

**Chryssostomidis, C., and Nicholas M. Patrikalakis.** AN EXPERIMENTAL PROCEDURE FOR THE PREDICTION OF THE DYNAMIC BEHAVIOR OF RISER TYPE SYSTEMS. MITSG 85-14J. 33pp. No charge.

This paper describes a study of a set of model scale experiments that permitted the evaluation of the role of fluid/structure interaction and the force correlation along the length of a riser model in the global behavior or riser kinds of systems. A 3m scale riser model was built with support through ball joints and with the capability of being tensioned. Reprinted from *Proceedings: International Conference on the Behavior of Offshore Structures:* Boss: 1982

**Chryssostomidis, C., and Nicholas M. Patrikalakis.** COMPLIANT RISER ANALYSIS. MITSG 85-23J. 9pp. No charge.

This paper presents a general mathematical model which describes the global behavior of a compliant riser idealized as a slender, non-rotationally uniform rod with bending, extensional and torsional degrees of freedom in three dimensions. In addition the embedding technique used to solve the two-dimensional static problem is developed. The researchers explain the selection of the initial approximation needed to start the solution process which makes the algorithm very efficient. Reprinted from *Ocean Space Utilization* '85, Tokyo, Vol. 1, pp.401-410.

**Harichandran, Ronald S. and H. Max Irvine.** A STATIC ANALYSIS TECHNIQUE FOR MULTI-LEG CABLE-BUOY SYSTEMS. MITSG 82-13. NTIS: PB83-137745. 78pp. $5.

Submerged buoys and their moorings used to support scientific instrumentation, such as current meters and sensors, must be controlled from moving in a dynamic ocean environment. Sea Grant research, described in this report, has explored static analysis as a method to be used for developing design procedures to properly locate anchor points on the seabed and to determine cable locations for multi-leg, cable-buoy systems.

**Patrikalakis, Nicholas M., and C. Chryssostomidis.** A MATHEMATICAL MODEL FOR COMPLIANT RISERS. MITSG 85-17. 79pp. $5.

To date compliant risers have been used successfully in protected waters for tanker buoy loading stations. Now the offshore industry believes that as alternatives to conventional production risers they could simplify offshore production systems. This report provides a general non-linear mathematical model describing the global behavior of a compliant riser idealized as a slender non-rotationally uniform rod with bending, extensional and torsional degrees of freedom in three dimensions. It also includes the internal fluid's pressure and speed effects on the system.

**Patrikalakis, Nicholas M., and C. Chryssostomidis.** NONLINEAR STATICS OF NONROTATIONALLY UNIFORM RODS WITH TORSION. MITSG 85-18. 80pp. $5.

This report describes research which extends the model presented in MITSG 85-17. The authors in this work have allowed for the computation of static responses and present an embedding technique to solve the general two-dimensional and three-dimensional static problems of a buoyant compliant riser. Configurations are presented in the presence and the absence of external currents.

**Patrikalakis, Nicholas M., and C. Chryssostomidis.** LINEAR DYNAMICS OF COMPLIANT RISERS. MITSG 85-19. 154pp. $5.

This report derives the governing equations for linear dynamics of a compliant riser idealized as a slender non-rotationally uniform rod with bending, extensional and torsional degrees of freedom. In addition it analyses a novel combination of efficient embedding and asymptotic techniques used to solve the three dimensional linear dynamic problem of a riser with a planar static configuration. It then presents numerical examples for linear dynamic analysis of a buoyant compliant riser in the presence and absence of external current.

**Patrikalakis, Nicholas M., and C. Chryssostomidis.** VORTEX INDUCED RESPONSE OF A FLEXIBLE CYLINDER IN A SHEARED CURRENT. MITSG 85-25J. 6pp. No charge.

This paper outlines a method for the approximate prediction of the static and lift responses of a flexible cylinder in an undirectional variable stream. The prediction is based on information from experimental results involving rigid cylinders forced to oscillate sinusoidally orthogonally to a uniform stream. A numerical example that assumes bimodal solutions is included to illustrate the method used for the geometry of a single-tube marine riser. Reprinted from *Journal of Energy Resources Technology*, ASME, March 1986, Vol. 108, pp.59-64.

**Patrikalakis, Nicholas M., and C. Chryssostomidis.** VORTEX INDUCED RESPONSE OF A FLEXIBLE CYLINDER IN A CONSTANT CURRENT. MITSG 85-26J. 6pp. No charge.

The paper describes a method to theoretically predict the static and lift responses of a flexible cylinder in an undirectional constant current. The approach used allows the authors to predict a number of independently determined, monochromatic, and multimode dynamic solutions. Numerical examples assuming monomodal solutions are included to allow comparison of the theoretical predictions with experimental and other published theoretical results. Reprinted from *Journal of Energy Resources Technology*, ASME, Vol. 107, No. 2, June 1985, pp. 244-249.

**Patrikalakis, Nicholas M., and George A. Kriezis.** THREE-DIMENSIONAL NON-LINEAR DYNAMICS OF COMPLIANT RISERS. MITSG 87-11. NTIS: PB88-205488/AS. 88pp. $6.

A mathematical model is presented for the three-dimensional non-linear static and frequency domain dynamic analysis of non-rotationally uniform sing leg multitube compliant risers with torsion in the presence of: unidirectional monochromatic surface gravity waves traveling at an arbitrary angle; arbitrary monochromatic motions and rotations of the upper and lower ends, of the same frequency and the waves; and arbitrary currents.

The effects of riser-ocean bottom interaction, present in some catenary configurations, and of non-linear hydrodynamic drag are taken into account, using an equivalent harmonic linearization technique. The governing non-linear ordinary differential equations are subsequently solved using an adaptive non-uniform grid finite difference method, an embedding technique, and Newton's iteration. Good initial approximations of the solution are also provided allowing fast convergence of the iterative scheme.

The proposed riser analysis methodology is compared with a cable dynamic analysis and two time domain finite element analysis of compliant risers. Three riser configurations are used for these comparisons; a riser configuration idealized as a cable, a catenary riser configuration, and a steep wave riser configuration.

Additional numerical examples are also presented to examine the effects of various excitation conditions on the performance of different types of risers. The riser configurations examined include a shallow water buoyant riser, a shallow water catenary riser under the presence of two-dimensional and three-dimensional excitation and a deep water catenary riser experiencing riser-ocean bottom interaction.

**Triantafyllou, George S., and C. Chryssostomidis.** STABILITY OF A STRING IN AXIAL FLOW. MITSG 85-24J. 5pp. No charge.

The equation of motion of a long slender beam submerged in an infinite fluid moving with constant speed is derived using Hamilton's

principle. The upstream end of the beam is pinned and the downstream end is free to move. The resulting equation of motion is then used to perform the stability analysis of a string, i.e., a beam with negligible bending stiffness. Reprinted from *Journal of Energy Resources Technology*, ASME, December 1985, Vol 107, pp.421-425.

**Triantafyllou, Michael S.** DYNAMICS OF TAUT INCLINED CABLES. MITSG 85-1J. 19pp. No charge.

This paper provides a mathematical framework for studying taut cable dynamics. Inelastic change of configuration and stretching or a combination of the two mechanisms result when a taut cable moves. Each has a different effect which is particularly interesting in the case of inclined cables since different parts have different curvature and static tension, thus creating hybrid modes, a mixture of taut-wire and inelastic-chain dynamics. Reprinted from *Q. J. Mech. Appl. Math.* Vol. 37, Pt.3, 1984 pp 421-440

**Triantafyllou, Michael S.** THE DYNAMICS OF TRANSLATING CABLES. MITSG 85-38J. 12pp. No charge.

The dynamics of a translating catenary are studied. The static and linearized dynamic governing equations are derived along the local tangential and normal directions. It is shown that in this form two simpler equations can be derived and solved asymptotically for both small and large sag cables. Reprinted from *The Journal of Sound and Vibration*, 1985, Vol. 103(2), pp. 171-182.

**Triantafyllou, Michael S., Antoine Bliek, Jim Burgess, and Hyunkyoung Shin.** MOORING DYNAMICS FOR OFFSHORE APPLICATIONS. MITSG 86-1, Part 1, Theory/MITSG 86-2, Part 2, Applications. NTIS: Part 1, PB86-157252; Part 2, PB86-157260. $12.each; $20 for the set.

The use of mooring systems in offshore waters of 2,000 feet or more cause a design problem in that the natural frequency of the cables lie within the wave spectrum and are thus vulnerable to dynamic amplification. At the same time, longer lines are required, thereby increasing self weight and reducing the available margin for dynamic effects. The study described in these reports reveal the effect of some non-linearities for vibrating cables. A new method was developed by the research to couple the dynamics of several mooring lines, based on the principle of dynamic impedance.

**Triantafyllou, Michael S., Antoine Bliek, and Hyunkyoung Shin.** STATIC AND FATIGUE ANALYSIS OF MULTI-LEG MOORING SYSTEM. MITSG 86-21. 75pp. $5.

The report describes all theoretical developments for evaluating the fatigue life of multi-leg mooring systems. It is a continuation of previous, detailed research on the statics and dynamics of a mooring line. In the previous work, the authors concluded that the quasi-static approach to cable design becomes increasingly inapplicable in deeper waters, since the dynamic tension, although caused by small amplitude motions, is as important as the quasi-static tension caused by the large amplitude, slowly varying excursions of the vessel. This creates the distinct possibility of cable fatigue. One major decision was made at the beginning of the present study: drag nonlinearity was to be linearized stochastically and the dynamic cable code was to employ frequency domain techniques by iterating with respect to the nonlinear drag effect until convergence was achieved. This decision led to the development of very efficient computational methods to treat the very complex problem of long-term cable fatigue.

**Vanmarcke, Erik H., and Richard N. Iascone.** ESTIMATION OF DYNAMIC CHARACTERISTICS OF DEEP OCEAN TOWER STRUCTURES. MITSG 72-12. NTIS: COM-72-10919. Order from NTIS.

## Soils and Foundations

**Azzouz, Amr S., Mohsen M. Baligh, and Charles C. Ladd.** CONE PENETRATION AND ENGINEERING PROPERTIES OF THE SOFT ORINOCO CLAY. MITSG 82-11. 53pp. $5.

Construction of an offshore platform design requires knowledge of sea floor soils: their ability to support gravity loads and to resist horizontal forces from waves, currents and seismic activities. This report discusses methods for identifying soil characteristics. The emphasis is on comparing the relative advantages of in situ versus conventional and sophisticated laboratory tests. Observations have been made at two widely separated borings in 40 m thick deposits of soft, plastic, Orinoco clay, a sediment found extensively offshore Venezuela.

**Azzouz, Amr S., Mohsen M. Baligh, and Andrew J. Whittle.** SHAFT RESISTANCE OF PILES IN CLAY. MITSG 90-7J. 18pp. $1.

A new method is proposed for elucidating, formulating, and predicting the axial capacity of friction piles in moderately overconsolidated clays ($1 \le OCR \le 4$) within a systematic and rational framework. The paper focuses on single, vertical, rigid, and cylindrical piles driven in deep deposits which exhibit normalized behavior. The normalized limiting skin friction, $\beta$ ($=f_s/\sigma'_{vo}$), during rapid monotonic undrained axial loading is written as the product of a lateral earthpressure coefficient, $K_c$ ($=\sigma'_{hc}/\sigma'_{vo}$) at the end of soil consolidation, which follows pile installation, and a skin-friction ratio, $\rho$ ($=f_s/\sigma'_{hc}$). Important factors affecting $K_c$ are shown to include the overconsolidation ratio (OCR) of the clay and its sensitivity. The friction ratio, $\rho$, is not sensitive to the in situ OCR of the deposit and corresponds to the normalized peak-strength ratio, $c_u/\sigma'_{vc}$, in undrained direct simple shearing of the clay at

an OCR=1.2 (±0.1). Reprinted from *Journal of Geotechnical Engineering*, Vol. 116, No. 2, February 1990.

**Baecher, Gregory B., Mark Chan, Thomas S. Ingra, Thomas Lee, and Louis A. Nucci.** GEOTECHNICAL RELIABILITY OF OFFSHORE GRAVITY PLATFORMS. MITSG 80-20. NTIS: PB81-224-438. 271pp. Order from NTIS.

Current techniques of risk and reliability analysis provide a strong analytical framework for handling many offshore design uncertainties rationally. This report describes existing methods and combines them into a unified analytical approach. An important part of the study discusses the uncertainties introduced by modeling and the relationship of those uncertainties to parameter estimation.

**Baecher, Gregory B., and Thomas S. Ingra.** STOCHASTIC FEM IN SETTLEMENT PREDICTIONS. MITSG 85-2J. 14pp. No charge.

Foundation design requires predictions of total and differential settlement. However, as soil strata are spatially variable and exploration effort is limited, these predictions cannot be made with certainty. This paper reports the results of two-dimensional second-moment settlement analyses using finite element methods and compares these results with one-dimensional uncertainty analyses already in the

literature. Reprinted from *Journal of the Geotechnical Engineering Division*, April 1981, pp. 449-463.

**Baligh, Mohsen M., and Amr S. Azzouz.** CONE PENETRATION TESTS OFFSHORE THE VENEZUELAN COAST. MITSG 80-21. NTIS: PB81-182-560. 164pp. $8.

This report publishes results of a soils testing program offshore Venezuela using a Dutch cone and pore pressure probe. Theoretical and empirical correlation procedures, and information about in situ undrained stress-strain-strength behavior in test sites and in known characteristic soils were compared. Researchers developed theoretical models for interpreting cone penetration and pore pressure data, with guidelines for using cone penetrometers to estimate in situ properties for foundation design.

**Baligh, Mohsen M., Amr S. Azzouz, Z.E. Wissa, R.T. Martin, and M.J. Morrison.** THE PIEZOCONE PENETROMETER. MITSG 81-10. NTIS: PB82-147-505. 21pp. $3.50.

A Sea Grant team has developed a piezocone penetrometer capable of measuring simultaneously cone resistance, pore water pressure, and skin friction during soil penetration. The piezocone was tested in a marine clay deposit from which extensive penetration data already are available. Results indicate that the penetrometer is reliable and extremely useful in identifying soils and determining soil stratification. Measurements of pore pressure dissipation when penetration stops can be used to estimate the consolidation and/or permeability of soils.

**Baligh, Mohsen M. and Jaques-Noel Levadoux.** PORE PRESSURE DISSIPATION AFTER CONE PENETRATION. MITSG 80-13. NTIS: PB81-102-485. 368pp. Order from NTIS.

This report describes rapid response conical piezometers used to evolve new analytical methods of determining soil properties directly at offshore sites. The methods of estimating consolidation and permeability characteristics of clays from measurements of the pore pressure decay after cone penetration is interrupted are evaluated, using extensive dissipation measurements in two clay deposits. The predicted profiles provide good agreement with laboratory data and full-scale performance.

**Baligh, Mohsen M., Vitoon Vivatrat, and Charles C. Ladd.** EXPLORATION AND EVALUATION OF ENGINEERING PROPERTIES FOR FOUNDATION DESIGN OF OFFSHORE STRUCTURES. MITSG 79-8. NTIS: PB298-292/AS.

**Lee, Lep S., and Gregory B. Baecher.** ACOUSTIC DATA AND UNCERTAINTY IN GEOTECHNICAL SITE CHARACTERIZATION OFFSHORE. MITSG 83-13. NTIS: PB84-100-908. 188pp. $8.

Acoustical profiling provides a flexible, convenient method to study the characteristics of ocean soils, but to date the reliability of this information has not been firmly established. This report discusses methods of determining the velocity parameter. Correlations of acoustical properties, physical properties and sediment geotechnical elastic properties provide an indirect means of correlating acoustical and elastic properties. Then the reliability of predicting the state of regions outside and

between parallel seismic profile lines are examined. The last chapter looks at the government's role in leasing the Outer Continental Shelf lands and discusses a policy model for leasing.

**Levadoux, Jaques-Noel, and Mohsen M. Baligh.** PORE PRESSURES DURING CONE PENETRATION IN CLAYS. MITSG 80-12. NTIS: PB81-100-661. 310pp. Order from NTIS.

In situ and laboratory analyses of cone penetration and pore pressure estimation in clays are discussed. Test results are combined with special soil behavior models and known soil element strain paths which determine deviatoric stresses and sheer-induced pore pressures. The comparisons attempt to explain test differences in different deposits and apply questions about soil stability and compressibility with deep penetration, pile installation and undrained loading problems in offshore construction.

**Malek, Azziz M., Amr S. Azzouz, Mohsen M. Baligh, and John T. Germaine.** UNDRAINED CYCLIC SIMPLE SHEAR BEHAVIOR OF CLAY WITH APPLICATIONS TO PILE FOUNDATIONS SUPPORTING TENSION LEG PLATFORMS. MITSG 87-20. NTIS: PB88-209036/AS. 381pp. $18.

This study seeks to develop a basic understanding of the behavior of clays under combined static and cyclic loading conditions with particular application to deep water compliant offshore structures. In order to develop more reliable methods for analyzing and predicting the behavior of pile shafts supporting Tension Leg Platforms (TLPs), this report attempts to identify and evaluate the effects of important factors on the behavior of clay elements subjected to the complex loading history typical of a TLP foundation system. Results of a lab testing program on resedimented samples of Boston Blue Clay are compared with other clays and generalizations made. An hypothesis is presented that provides good predictions of the number of cycles to failure as well as evolution of shears strains during undrained cyclic direct simple shearing. One of a series of Sea Grant reports on offshore piles and marine soils, this study lists related MIT Sea Grant reports and unpublished MIT theses.

**Urzua, Alfredo M., and W. Allen Marr.** ANALYSIS OF PERMANENT DISPLACEMENT FROM CYCLIC LOADING OF FOUNDATIONS. MITSG 81-9. NTIS:PB83-113753. 343pp. $8.

An analytical method is described for predicting the permanent displacement of soils resulting from cyclic loading under drained conditions. The technique uses the finite element method with a linear viscoelastic stress-strain relation that accounts for cumulative strain by using data from stress path cyclic tests. In the one-dimensional case permanent strains predicted using parameters from triaxial tests agree with measured strains, both in magnitude and rate. Predicted horizontal stress considerably exceeds the measured stress.

## Hydrodynamic Loading and Structural Response

**Chryssostomidis, C., and Nicholas M. Patrikalakis.** SEAKEEPING CALCULATIONS FOR SWATH SHIPS USING A NEW MODIFIED VERSION OF CAT-5. MITSG 86-7TN. 116pp. $4.

This study modifies an existing seakeeping program, CAT-5, developed for catamarans to allow seakeeping computations for swath ships. Comparisons of modified program results are presented for both kinds of vessels and are accompanied by experimental and other theoretical results. The research was undertaken with passthrough funds from the Naval Sea Systems Command, the U.S. Coast Guard.

**Chan, E.S., and W.K. Melville.** DEEPWATER BREAKING WAVE FORCES ON SURFACE PIERCING STRUCTURES. MITSG 85-5J. 6pp. No charge.

A preliminary experimental study of deep water breaking wave forces on a flat plate was conducted in a wave channel. Pressures were measured simultaneously at six vertical locations, for different horizontal locations of the plate relative to the break point, and for three inclinations to the vertical. Reprinted from *Proceedings from Oceans '84.*

**De Oliveira, Joao G.** THE BEHAVIOR OF STEEL OFFSHORE STRUCTURES UNDER ACCIDENTAL COLLISIONS. MITSG 82-22J. 12pp. No charge.

In order to design steel offshore structures against impact loads due to accidental collisions by ships, it is necessary to evaluate the plastic energy absorption capability of the structure's members. In this paper, the local energy absorbed at the point of impact and in its immediate vicinity is first considered. Then the overall energy absorption capability of a tubular member

is studied when it deforms in bending. A simple method for estimating the extent of damage from collision with a typical supply vessel is suggested, and a specific application is discussed. Reprinted from *Proceedings from the Offshore Technology Conference* (1981: Houston, Texas).

**Marshall, James G.** BEHAVIOR OF DELAMINATED COMPOSITE CYLINDERS SUBJECT TO HYDROSTATIC PRESSURE. MITSG 89-15TH. 101pp. $30.75. Microfiche copies free.

Composite materials have been increasingly employed in automobile, aerospace, and maritime industries over the past decade. One reason they have not been used as extensively as they might be for construction of deep-diving vessels is a lack of experience with composite ocean structures. This research attempts to quantify manufacturing defects and in-service impact loads on the critical load-bearing capacity of cylindrical pressure vessels subjected to external pressure.

**Mavrikios, Yianni, and Joao G. de Oliveira.** DESIGN AGAINST COLLISION FOR OFFSHORE STRUCTURES. MITSG 83-7. NTIS: PB83-210-468. 164pp. $8.

The possibility of accidental collision between supply boats and offshore platforms increases with stepped-up offshore development. To aid in developing better design criteria this report describes a simple method of estimating the structural damage to a platform from a minor platform-ship collision. The force deflection curve for a rigid-plastic circular cylinder subjected to transverse loading applied by a wedge is derived following an energy approach. The curve combined with the equivalent curve for a ship's bow and the foundation stiffness of a platform are used for a simplified two-mass dynamic model which determines numerically the plastic deformation of one platform member damaged by a ship collision. The final chapter outlines a cost-benefit analysis of a minor collision versus strength of platform.

**Mei, Chiang C.** NUMERICAL METHODS IN WATER WAVE DIFFRACTION AND RADIATION. MITSG 78-17J. Reprinted from *The Annual Review of Fluid Mechanics*, Vol. 10, 1978. No charge.

**Shum, K.T., and W.K. Melville.** ESTIMATES OF THE JOINT STATISTICS OF AMPLITUDES AND PERIODS OF OCEAN WAVES USING AN INTEGRAL TRANSFORM TECHNIQUE. MITSG 85-4J. 10pp. No charge.

An integral transform method is used to obtain continuous time series of wave amplitude and period from ocean wave measurements. The joint statistics of these two variables are determined and directly compared with the theoretical probability densities predicted by Longuet-Higgins (1975, 1983). Good agreement is found for data from both calm and hurricane sea states. This method avoids the ambiguities in the definitions of wave amplitude and period found in earlier comparisons of field data with theory. Reprinted from *Journal of Geophysics Research*, v.89, No. C4, July 20, 1984.

**Vandiver, J. Kim.** PREDICTION OF THE DAMPING-CONTROLLED RESPONSE OF OFFSHORE STRUCTURES TO RANDOM WAVE EXCITATION. MITSG 80-9J. 10pp. No charge.

This paper introduces a simple procedure for estimating a structure's dynamic response at each of its natural frequencies to random wave excitation. For many structures, a simple expression may be derived for the wave force spectrum in terms of radiation damping and the prescribed wave amplitude spectrum. In this method explicit calculation of wave forces is not required. Example calculations are presented. Reprinted from *Society of Petroleum Engineers Journal*, 1980.

**Vandiver, J. Kim, and Shuhei Mitome.** EFFECTS OF LIQUID STORAGE TANKS ON THE DYNAMIC RESPONSE OF OFFSHORE PLATFORMS. MITSG 79-9J. NTIS: PB80-186-414. Reprinted from *Applied Ocean Research*, Vol. 1, No. 2, 1979. Order from NTIS.

**Wierzbicki, Tomasz, and Myung Sung Suh.** DENTING ANALYSIS OF TUBES UNDER COMBINED LOADINGS. MITSG 86-5. 105pp. $5.

Tubular members of offshore platforms and pipes which transport oil and gas from production fields are vulnerable to human damage from supply boats, dropped objects or launch mishandling and to natural causes such as ice scouring in the Arctic. In the case of platforms, distortion of shape or loss of axial and bending strength and stiffness could lead to catastrophic collapse. For purposes of design it is important to be able to predict loading and behavior of tubes. This report presents insights into the mechanisms of plastic tube deformation undergoing large shape distortion and sectional collapse. The

understanding of these processes is a prerequisite for solving the whole class of boundary value problems in using tubes for industrial applications.

**Wierzbicki, Tomasz, C. Chryssostomidis, and C. Wiernicki.** RUPTURE ANALYSIS OF SHIP PLATING DUE TO HYDRODYNAMIC WAVE IMPACT. MITSG 85-13J. 19pp. No charge.

A large percentage of marine vessel casualties caused by extreme loading is attributed to hydrodynamic impact forces in severe seas. In this paper a new analytical procedure for predicting the damage of stiffened ship structures under hydrodynamic impact loads is developed. Reprinted from *Proceedings of Ship Structure Symposium '84*, Arlington, VA..

## Marine Architecture

**Chryssostomidis, C., C. Graham, M. Meyers, and P.V. Prakash.** EQUIPMENT ARRANGEMENT USING INTERACTIVE COMPUTER GRAPHICS. MITSG 86-3TN. 37pp. $2.40.

This study produced a methodology for managing computer arrangements and a program for transferring equipment arrangment locations via ASCII file to the ship's Integrated Data Base (IDB). The program is written in VARPRO2 computer language for a Computer Vision (CV) 200X CGP minicomputer with the ComputerVision CADDS 4X CAD/CAM application program installed. The research was undertaken with passthrough funds from the Naval Sea Systems Command, the U.S. Navy.

**Chryssostomidis, C., and Nicholas M. Patrikalakis.** GEOMETRIC MODELING ISSUES IN COMPUTER-AIDED DESIGN OF MARINE STRUCTURES. MITSG 89-14J. 29pp. $3.

This work discusses the application of geometric modeling in computer-aided engineering systems such as ships and offshore structures. Methods of shape representation and interrogation in the computer are identified and their salient features are analyzed to allow understanding of their strengths and limitations in the context of different applications. Issues of data exchange between systems of different inherent capabilities are also discussed. Finally, some other open problems in this field are identified. Reprinted from *Marine Technology Society Journal*, Vol. 22, No. 2, 1989.

**Patrikalakis, Nicholas M.** APPROXIMATE CONVERSION OF RATIONAL SPLINES. MITSG 89-10J. 11pp. $1.

The exchange of data between different geometric modeling systems frequently requires approximate conversions of rational Bezier and B-spline curves and surfaces to lower degree integral B-spline representations. The objective of this paper is to present an algorithm to approximate non-uniform rational B-spline curves with non-uniform integral B-spline curves of lower degree. A global error bound which guarantees the precision of approximation at all points is derived. Reprinted from *Computer-Aided Geometric Design*, Vol. 6, No. 2, 1989.

**Patrikalakis, Nicholas M., and George A. Kriezis.** PIECEWISE CONTINUOUS ALGEBRAIC SURFACES IN TERMS OF B-SPLINES. MITSG 88-5. 73pp. $8.

Because of the importance of intersection, blending, and offset problems in geometric modeling applications and the promise of implicit polynomials in providing solutions to these problems, a number of investigators have suggested the use of algebraics, especially low-order algebraics, in computer-aided design. Modelling with low-order algebraic B-spline patches bounded by rectangular boxes is investigated and reported in this work. Motivations behind the development of a method to represent sculptured shapes in the B-spline form are: the degree reduction in the resulting representation, the capability for piecewise continuous shape representation, and the geometrical significance of the coefficients in this representation. Using Bernstein polynomials, this paper describes a method of representing a finite portion of an algebraic surface within a rectangular box. The method is extended to handle piecewise continuous algebraic surfaces within rectangular boxes defined in terms of triple products of B-spline basis function. Various techniques for shape creation using the above formulation are developed and several interrogation techniques used in the creation and analysis of the formulation are described. Results are summarized and possible applications given. A highlight of this paper are color illustrations of sculptured shapes created in the computer with this method.

**Patrikalakis, Nicholas M., and P.V. Prakash.** COMPUTATION OF ALGEBRAIC AND POLYNOMIAL PARAMETRIC SURFACE

INTERSECTIONS. MITSG 87-19. NTIS: PB88-208277. 106pp. $6.

Computer programs that can describe all features of an unknown implicit polynomial (algebraic) are essential tools for computer engineering. Naval architects use such programs to represent and interrogate the external and internal shape of complex engineering objects during different phases of design, analysis, and fabrication. This report presents the basic elements of a new algorithm allowing automatic interrogation of planar algebraic curves within a rectangular parallelogram, arising in the context of intersections of algebraic surfaces and piecewise continuous rational polynomial parametric surface patches. The report, which focuses primarily on robustness issues of the proposed algorithm, addresses the problem of reliable derivation of the correct connectivity of the curve in the presence of singularities and small isolated loops. Both of the latter are very common features of algebraic curves arising in a geometric modeling context and significantly affect the reliability and overall performance of current state-of-the-art algorithms. Representative results from the application of the new method in tracing known curves and in computing surface intersections are also presented.

**Prakash, P.V., and Nicholas M. Patrikalakis.** SURFACE-TO-SURFACE INTERSECTIONS FOR GEOMETRIC MODELING. MITSG 88-8. NTIS: PB89 145650/AS. 85pp. $6.

Computer programs that can describe all features of unknown implicit polynomial curves are essential tools for computer engineering. Engineers use such programs to represent and interrogate the external and internal shape of complex engineering objects during different phases of design, analysis, and fabrication. This report deals with singularities and small isolated features, which present common problems in handling the intersections of algebraic surfaces with piecewise continuous rational polynomial parametric surface patches, such as B-splines, with presently available algorithms. Such problems can be reduced to tracing a planar algebraic curve within a rectangular domain. The authors present the basic components of a new method of handling these intersecting surfaces by combining the advantageous features of analytic representation of the governing equation of the algebraic curve in the Bernstein basis within a rectangular domain, the computation of border, turning and singular points, and adaptive subdivision and polyhedral faceting techniques to provide the basis for a reliable solution procedure.

**Wozny, Michael J.** AUTOMATION OF DESIGN AND MANUFACTURING IN HEAVY INDUSTRIES. Rensselaer Polytechnic Institute. MITSG 89-22P. 34pp. No charge.

The automation of design and manufacture for the purpose of achieving increased manufacturing competitiveness is a very complex and multidimensional research problem. In this paper, presented as the 1988 Sea Grant Lecture, the author presents a brief overview of the research trends and opportunities in design and manufacturing. The paper addresses the state of research in design and manufacturing, an overview of research thrusts, the historical perspective of design automation, and research directions in computer-aided design. Submitted to *Proceedings of Automation in the Design and Manufacture of Large Marine Systems*, Hemisphere Publishing Corp., (address at front of directory).

# Marine Policy

**Devanney, John W., III.** MARINE DECISIONS UNDER UNCERTAINTY. MITSG 71-7. Out of print.

**Frankel, Ernst G.** THE FUTURE OF ATLANTIC PORTS. MITSG 72-18. NTIS: COM 73-11834/AS. Order from NTIS.

**Frankel, Ernst G., editor.** PORT DESIGNS AND ANALYSIS METHODOLOGY. MITSG 74-31. NTIS: COM-75-10264/AS. $2.

**Frankel, Ernst G., and Henry S. Marcus.** OCEAN TRANSPORTATION. MITSG 72-17. Out of print.

**Kildow, Judith T., et al.** INTERNATIONAL TRANSFER OF MARINE TECHNOLOGY—A THREE-VOLUME STUDY. MITSG 77-20. NTIS: PB-275 353/AS. $8.

**Padelford, Norman J.** OCEAN COMMERCE AND THE PANAMA CANAL. MITSG 73-13J. NTIS: COM-73-11423. Reprinted from *The Journal of Maritime Law and Commerce* 4(April 1973):397-423. No charge.

**Padelford, Norman J.** PROSPECTS FOR A NEW REGIME OF THE SEAS—INTERNATIONAL POLITICAL CONSIDERATIONS. MITSG 72-5. NTIS: COM-72-10522. $1.50.

**Padelford, Norman J., and Jerry E. Cook.** NEW DIMENSIONS OF U.S. MARITIME POLICY. MITSG 71-5. Out of print.

**Padelford, Norman J., and Stephen R. Gibbs.** MARITIME COMMERCE AND THE FUTURE OF THE PANAMA CANAL. MITSG 74-28. $12.50.

# ADVISORY SERVICES

## MIT Marine Industry Collegium

**Doelling, Norman A.** THE MIT MARINE INDUSTRY ADVISORY SERVICE--A CRITICAL REVIEW. MITSG 79-10. NTIS: PB299-113/AS. Order from NTIS.

**Horn, Dean A., and Norman A. Doelling.** THE MIT SEA GRANT MARINE INDUSTRY COLLEGIUM—A TECHNOLOGY TRANSFER PARTNERSHIP OF INDUSTRY, ACADEMIA AND GOVERNMENT. MITSG 84-7J. 4pp. No charge.

Technology transfer among industry, academia, and government is difficult to accomplish effectively and efficiently. The authors describe the special features of the Sea Grant College Program which facilitate technology transfer. Also described is how the MIT Sea Grant Marine Industry Collegium was implemented under the guidelines of the Sea Grant College Program Act. Two examples of successful technology transfer efforts are given. Reprinted from *Proceedings from American Society of Mechanical Engineers Winter Annual Meeting* (1982), paper no. 82-WA/TS-3.

# Opportunity Briefs

The MIT Marine Industry Collegium Opportunity Briefs are concise descriptions of research in progress. Most, but not all projects, have been sponsored by Sea Grant at MIT or another Sea Grant institution—and all have been presented and discussed with user groups at a Collegium workshop. Information on how to join the Collegium and participate in these workshops is available through the Sea Grant Information Service.

MIT Marine Industry Collegium. ADVANCES IN UNDERWATER WELDING—OPPORTUNITY BRIEF #4. MITSG 76-8. NTIS: PB-262 560/AS. $2.50.

MIT Marine Industry Collegium. APPLICATIONS OF MARINE ACOUSTIC SYSTEMS—OPPORTUNITY BRIEF #33. MITSG 83-10. NTIS: PB84-141-381. 52pp. $4.

This report examines three ocean applications of new and powerful communication technologies that were developed initially for application in other scientific disciplines. Ocean acoustic tomography, similar to the CAT (computer aided tomography) scan which uses x-rays for imaging parts of the body, deploys underwater sound waves to produce a picture of the inner ocean. The Digital Ocean Bottom Hydrophone (DOBH) is a self-contained instrument that can be left on the sea floor to collect acoustic and seismic data. The Digital Acoustic Telemetry System (DATS) applies modern communication techniques to communicate digital information from underwater vehicles or instruments without a cable.

MIT Marine Industry Collegium. BIOTECHNOLOGY AND THE SEA—RECENT ADVANCES AND APPLICATIONS—OPPORTUNITY BRIEF #43. MITSG 86-13. 18pp. $4.

Derivatives from seaweed, shark, crustaceans and other marine biomaterials are finding their way into the food and pharmaceutical industries. Research projects at the Collegium meeting include the isolation of a tumor growth inhibitor from shark cartilage, a DNA-hybridization probe to detect microorganisms in seawater, use of marine biopolymers for controlled release of pharmaceuticals and food preservatives, and prospects for commercial production and applications of chitins and chitosans.

MIT Marine Industry Collegium. CAPACITY OF OFFSHORE FRICTION PILES IN CLAY—OPPORTUNITY BRIEF #44. MITSG 86-14. 13pp. $4.

Tension leg platforms represent the transition in offshore structures from depending on compression members to relying on tension members. Over the past decade a major geotechnical study at MIT has probed the interaction between friction piles used to support offshore structures and their underlying soils. Large scale load tests have verified the MIT approach which combines analytical methods with measurements obtained by the new Piezo-Lateral Stress cell to analyze and predict the behavior of friction piles.

MIT Marine Industry Collegium. CASE STUDIES OF THE MIT OIL SPILL MODEL—OPPORTUNITY BRIEF #35. MITSG 84-2. 20pp. $4.

This report is a follow-up to opportunity brief #25, "Oil Spill Clean-up: An Economic and Regulatory Model." The earlier document described a computer-based model useful to policymakers as a strategic tool for responding to accidental oil spills under varying assumptions and conditions. The evolution of the research project, a detailed description of the model, and three applications are presented in this second report. The model has been applied to examine what actually happened in the 1976 Argo Merchant oil spill and to analyze a worst case situation. Another application has been to help a Canadian petroleum company decide where to stockpile chemical dispersants in case of an offshore spill.

MIT Marine Industry Collegium. CHITIN AND CHITIN DERIVATIVES—OPPORTUNITY BRIEF #1. MITSG 76-5. NTIS: PB-262 557/AS. $2.50.

MIT Marine Industry Collegium. CLOSED-CYCLE AQUACULTURE—OPPORTUNITY BRIEF #7. MITSG 77-15. NTIS: PB-272 582/AS. $2.50.

MIT Marine Industry Collegium. COMPUTER-AIDED PRELIMINARY DESIGN OF SHIPS—OPPORTUNITY BRIEF #13. MITSG 78-13. NTIS: PB286-238/AS. $4.

MIT Marine Industry Collegium. COMPUTER MODELS FOR ENVIRONMENTAL ENGINEERING AND RESEARCH IN NEAR-COASTAL ENVIRONMENTS—OPPORTUNITY BRIEF #8. MITSG 77-16. NTIS: PB-272 583/AS. $2.50.

MIT Marine Industry Collegium. DEEP OCEAN MINING—A COMPUTER MODEL FOR INVESTIGATING COSTS, RATES OF RETURN, AND ECONOMIC IMPLICATIONS OF SOME POLICY OPTIONS—OPPORTUNITY BRIEF #12. MITSG 78-12. NTIS: PB286-847/AS. $4.

MIT Marine Industry Collegium. DESIGN CONSIDERATIONS FOR THE USE OF ROPES AND CABLES IN THE MARINE ENVIRONMENT—OPPORTUNITY BRIEF #42. MITSG 86-12. 16pp. $4.

Mooring systems have always played an important role in offshore engineering. Engineers currently do not have the tools to study dynamic loads in cables, so they design cables for static load conditions. Ropes sometimes reveal the first signs of damage when they snap. These major problems of ropes and cables, along with future research topics, are discussed by a panel of MIT investigators.

MIT Marine Industry Collegium. DIRECTIONS FOR MIT RESEARCH IN UNMANNED UNDERWATER WORK SYSTEMS—OPPORTUNITY BRIEF #29. MITSG 82-4. NTIS: PB83-117499. 7pp. $4.

MIT Sea Grant research in unmanned underwater work systems is described. Projects include vehicle simulation (a sophisticated simulator has been developed); manipulator systems (towards a working demonstration of a digitally driven, force-reflecting manipulator servo-system using brushless D.C. motors, and computer-graphic display aids for the operator of a remote work vehicle); relative motion of manipulator to work object (a demonstration system using a passive, lightweight six-degree-of-freedom arm has been completed); and touch sensing (using fiber optics).

MIT Marine Industry Collegium. DYNAMIC RESPONSE OF MARINE RISERS, TENSION LEGS, CABLES AND MOORINGS—OPPORTUNITY BRIEF #30. MITSG 82-5. NTIS: PB83-148-817. 8pp. $4.

A major research effort is described to obtain experimental data on the drag forces and dynamic response of riser-like systems subject to steady currents, and to steady currents and surface platform motion. Investigations are concerned with drag coefficients found when the cylindrical system vibrates in response to vortex shedding forces; "in-line" alternating displacements; and alternating displacements perpendicular to the current flow.

MIT Marine Industry Collegium. THE ECONOMICS AND ENGINEERING OF LARGE-SCALE ALGAE BIOMASS ENERGY SYSTEMS—OPPORTUNITY BRIEF #11. MITSG 78-11. NTIS: PB287-868/AS. $4.

MIT Marine Industry Collegium. ELECTRON IRRADIATION, SEWAGE SLUDGE AND AQUACULTURE—OPPORTUNITY BRIEF #6. MITSG 77-14. NTIS: PB-272 581/AS. $2.50.

MIT Marine Industry Collegium. THE ENGINEERING AND ECONOMICS OF COAL-FIRED SHIP PROPULSION—OPPORTUNITY BRIEF #26. MITSG 81-7. NTIS PB82-151-895. 28pp. $4.

This report discusses the problems and benefits of coal as a fuel for ships, including the problems of pollution and the need for facilities for storing coal at port. The report examines how coal is handled and burned aboard ship. A discussion of the economic feasibility of coal conversion concludes that there is economic incentive to convert from oil to coal if the ship meets specified criteria of size and speed of travel.

MIT Marine Industry Collegium. GEOTECHNICAL RESEARCH AT MIT—SPRING SEMINAR (1988—HOUSTON). OPPORTUNITY BRIEF #50. MITSG 88-1. 24pp. $4.

As offshore oil exploration and resource recovery moves farther from shore and into increasingly deeper waters, more designers are turning to the use of Tension Leg Platforms (TLPs). But design engineers need to know what kind of critical loads that supporting friction piles will bear. Such loads occur during storms, for example, when the pile-soil interface encounters large cyclic shear stresses. By understanding the loading conditions placed upon a pile during a storm and being able to determine the stresses encountered at the pile-soil interface, the design engineer can perform a more accurate design analysis for a TLP. Recent research at MIT has led to the development of a model for predicting pile-soil interaction based on soil characteristics. This opportunity brief abstracts presentations that

were made to members at the Spring 1988 workshop of the MIT Marine Industry Collegium in Houston, Texas. Discussions summarize recently completed work on piles and TLPs, and explore some of MIT's current geotechnical research on field testing of soils

MIT Marine Industry Collegium. MARINE CORROSION AND BIOFOULING—OPPORTUNITY BRIEF #37. MITSG 84-5. 50pp. $4.

With support from the National Sea Grant Office, a group of eight marine materials scientists from five universities and one industrial research lab have coordinated their efforts to solve selected marine corrosion problems. Two broad problem areas were addressed: the relation between calcareous deposits and cathodic protection of structural steel, and the localized corrosion of aluminum and stainless alloys.

MIT Marine Industry Collegium. MEASUREMENT AND PREDICTION OF VIBRATION RESPONSE OF DEEPWATER OFFSHORE STRUCTURES—OPPORTUNITY BRIEF #22. MITSG 81-3. NTIS: PB82-148-305. 19pp. $4.

In this report a new method based on the engineering concept of reciprocity is described for predicting displacement of a structure battered by waves. The new method predicts displacement without explicit calculation of the wave forces. The report also describes new ways to measure dissipation of energy, or damping, and current experiments in predicting damping of structures in the ocean environment.

Marine Industry Collegium. MIT UNDERWATER TECHNOLOGY RESEARCH—TELEMANIPULATOR DEVELOPMENTS. OPPORTUNITY BRIEF #40. MITSG 85-27. NTIS: PB86-157302/XAB. 17pp. $4.

Several laboratories at MIT are conducting research on the use of manipulator systems for undersea and outer space environments, as well as for factory automation. Projects in the Space Systems Laboratory, Man-Machine Systems Laboratory, and Artificial Intelligence Laboratory, as well as the Deep Submergence Laboratory at the Woods Hole Oceanographic Institution, are summarized in this report. The projects described include touch sensing, parallel link manipulator, impedance control of manipulators, underwater teleoperators for space simulation, and development of a supervisory controlled telemanipulator for the ARGO/JASON vehicle system.

MIT Marine Industry Collegium. MIT UNDERWATER VEHICLE RESEARCH—RECENT ADVANCES AND FUTURE PROGRAMS—OPPORTUNITY BRIEF #36. MITSG 84-3. $4.

Underwater technology research at MIT has been accelerating with industrial demand for less expensive, safer, more reliable, and more capable undersea vehicles. This report gives brief descriptions of Sea Grant research in supervisory control for remotely operated systems, the effect of tethers on underwater vehicles, and an underwater welding system for remotely operated vehicles. In the area of supervisory control, projects include underwater vehicle control systems incorporating mechanical constraints, touch sensing for underwater manipulators, and a novel manipulator design.

MIT Marine Industry Collegium. MODELING OF COASTAL PROCESSES—CIRCULATION, DISPERSION, AND WAVES—OPPORTUNITY BRIEF #38. MITSG 84-4. $4.

In the mid-1970s two computer models, CAFE and DISPER, dealing with circulation and dispersion in coastal environments, were developed by MIT Sea Grant. These models have been widely distributed and used in many academic and industrial applications. This report describes some substantial modifications in CAFE and DISPER that will enable users to model circulation at much lower cost. The report also discusses two methods for modeling design wave heights in nearshore environments. University of Maine researchers have developed a method for modeling steady-state wave spectra and significant wave heights in bays with complicated bathymetry, and MIT researchers have built a model which incorporates the dissipation effects of finite water depth in predicting wind generated waves.

MIT Marine Industry Collegium. NEW TECHNIQUES FOR OCEAN MEASUREMENT. OPPORTUNITY BRIEF #52. MITSG 88-13. 17pp. $4.

This collection of synopses presented at a November 1988 MIT Sea Grant Marine Industry Collegium meeting describes new developments in marine instrumentation devices at MIT, Woods Hole Oceanographic Institution, and the University of Minnesota. Devices, such as a

portable mass spectrometer under development at MIT and an instrument for in-itu ocean chemical analysis under development at WHOI, are mentioned. Speakers also outlined instrumentation applied to aquatic ecology, remote sensing of waves and the upper ocean, an autonomous telemetry system, and biogeochemical measurements using a manned submersible.

MIT Marine Industry Collegium. A NEW UNDERWATER COMMUNICATION SYSTEM—OPPORTUNITY BRIEF #19. MITSG 80-6. NTIS: PB81-108-128. 17pp. $4.

This opportunity brief presents a joint acoustical telemetry communications project for untethered underwater work vehicles at MIT and Woods Hole Oceanographic Institution.Because of microprocessor advances, the system of transforming digital data to "chords" can be adapted through programmable software changes and satisfy a variety of uses requiring trade-offs among key parameters of data rate, range, and error rates.

MIT Marine Industry Collegium. NONDESTRUCTIVE EVALUATION OF FIBER COMPOSITES—OPPORTUNITY BRIEF #21. MITSG 80-8. NTIS: PB81-108-144. 20pp. $4.

Inherently nonhomogeneous, fiber composites can contain hard-to-detect internal flaws. A process of nondestructive thermal testing for flaws involves coating the material with a cholesteric liquid crystal compound. Applying heat causes the crystals to change color, and anomalies in color indicate internal flaws. This project provides quantitative interpretation of surface temperature patterns and underlying flaws, and mentions acoustic and ultrasonic testing.

MIT Marine Industry Collegium. NOVEL APPLICATIONS OF MARINE BIOPOLYMERS. OPPORTUNITY BRIEF #54. MITSG 89-7. NTIS: PB89 182950/AS. 20pp. $4.

This collection of synopses presented at an April 1989 MIT Sea Grant Marine Industry Collegium meeting describes new applications for polymers produced by marine plants and animals. These polymers have long been used as food and industrial ingredients, but recent developments in biotechnology, enzyme technology, and food and biochemical engineering have created new uses for marine biopolymers. These synopses focus on the use of biopolymers for encapsulation processes with application to drug delivery systems, cell transplantation and industrial food processing.

MIT Marine Industry Collegium. OCEANOGRAPHIC INSTRUMENTATION AT WOODS HOLE OCEANOGRAPHIC INSTITUTION—OPPORTUNITY BRIEF #45. MITSG 86-15. 20pp. $4.

Six new instruments for gathering data faster, more conveniently and more accurately are discussed. The POPUP profiler releases a series of probes to track vertical current profiles, while the Fast Profiler collects CTD data and returns to its support ship. A tiny digital recording voltmeter measures sediment temperature from within the walls of a hydraulic piston corer. Sea Duct performs in situ sediment transport experiments. A custom data acquisition system monitors fixed and drifting hydrophone arrays in the Arctic, and an Arctic Remote Autonomous Measurement Platform serves as a semi-permanent data station to collect and transmit or store information.

MIT Marine Industry Collegium. OFFSHORE GEOTECHNICAL EVALUATION—OPPORTUNITY BRIEF #27. MITSG 82-3. NTIS: PB83-118265. 16pp. $4.

Important advances have been made in geotechnical analysis for designing offshore structures. Existing in situ testing procedures have been improved and a "piezocone penetrometer" has been developed which provides simultaneous measurement of cone resistance and pore pressure. Variability of soil property estimates gathered by field measurement can be quantified and integrated into a comprehensive, quantitative analysis of the geotechnical risk in offshore structures.

MIT Marine Industry Collegium. OFFSHORE MINING OF SAND AND GRAVEL—OPPORTUNITY BRIEF #2. MITSG 76-6. NTIS: PB-262 558/AS. Order from NTIS.

MIT Marine Industry Collegium. OIL SPILL CLEAN-UP, AN ECONOMIC AND REGULATORY MODEL—OPPORTUNITY BRIEF #25. MITSG 81-6. NTIS: PB82-147-489. 24pp. $4.

Sea Grant research is described to integrate a set of computer models to help policymakers respond effectively to oil spills. The models will be tools for identifying and evaluating alternatives and trade-offs involved in cleaning up oil spills. Three features characterize the models: decisions

are categorized in three hierarchical levels, strategic, tactical, and operational; components of the models are modular to allow maximum flexibility; and an analysis of parameters is incorporated to determine the importance of each parameter to the overall problem.

MIT Marine Industry Collegium. OIL SPILLS—PROBLEMS AND OPPORTUNITIES—OPPORTUNITY BRIEF #9. MITSG 77-17. NTIS: PB-272 584/AS. $2.50.

MIT Marine Industry Collegium. POWER SYSTEMS FOR SMALL UNDERWATER VEHICLES. OPPORTUNITY BRIEF #51. MITSG 88-11. NTIS: PB89 148043/AS. 34pp. $4.

To date, electrical storage batteries have been used almost exclusively to meet the energy needs of small underwater vehicles. Although these batteries are easy, relatively safe, and convenient, their size and weight severely limit options for vehicle design. New developments in power systems, however, may enhance designers' abilities to develop small vehicles capable of performing missions ranging from antisubmarine warfare and surveillance to pipeline inspection and oceanographic data collection. This opportunity brief abstracts presentations made by representatives of industry and academia at the fall 1988 workshop of the MIT Sea Grant Marine Industry Collegium. Summarized are: recent developments and applications for high-density power systems, such as silver-zinc, silver-cadmium, and pressure compensated batteries; developments in artificial gills, aluminum-air batteries, and rechargeable lithium batteries; and applications of the Stirling engine for underwater use. Related published papers are abstracted.

MIT Marine Industry Collegium. PROGRESS IN CONTROLLED ENVIRONMENT AQUACULTURE AND ALGAE HUSBANDRY. OPPORTUNITY BRIEF #24. MITSG 81-5. NTIS: PB82-148-271. 26pp. $4.

Two University of Delaware research projects discussed in this report suggest profitable business opportunitites. An experiment with a closed-cycle aquaculture system for growing oysters may have significant value in growing seed oysters up to one centimeter. The system recycles oyster wastes, keeping costs of nutrients down, enhancing the ability of the oysters to use a larger fraction of their food, and reducing the amount of energy needed to heat water in the system.

MIT Marine Industry Collegium. PROGRESS IN UNDERWATER TELEMANIPULATOR RESEARCH—OPPORTUNITY BRIEF #23. MITSG 81-4. NTIS: PB82-148-651. 23pp. $4.

The long-term goal of research at MIT and the Naval Ocean Systems Center (NOSC) in underwater telemanipulators is construction and operation of an underwater, unmanned, untethered telemanipulator. The report describes improvements in the NOSC submersible vehicle, EAVE WEST, the NOSC manipulator and its supervisory control system, and experiments and improvements in hardware and software for the supervisory control system of MIT's laboratory manipulators. Also described is an experimental vehicle (EV) being developed as the first step in simulation of an undersea vehicle.

MIT Marine Industry Collegium. PROTECTION OF MATERIALS IN THE MARINE ENVIRONMENT—OPPORTUNITY BRIEF #20. MITSG 80-7. NTIS: PB81-110-454. 9pp. $4.

A collaborative presentation of the Sea Grant programs of Louisiana State University (LSU) and MIT, this opportunity brief discusses aspects of LSU marine materials protection research: long lasting antifouling marine coatings, characterization and environmental impact; hydrogen embrittlement, including cathodic protection concentration of environmental hydrogen; and titanium-based metallic coatings. Also discussed are two LSU projects: remote sensing and interpretation of data with a TIROS satellite, and creative computer-aided ship design tools.

Marine Industry Collegium. REMOTE SENSING AND OCEANOGRAPHIC EQUIPMENT TECHNOLOGY—SOME PRESENT SYSTEMS AND FUTURE NEEDS. OPPORTUNITY BRIEF #41. MITSG 85-21. NTIS: PB86-156502/XAB. 21pp. $4.

This report describes projects focused on the interdependence of satellite measurements, in situ measurements, and modelling for understanding the dynamics of the ocean. Projects include remote sensing of large-scale ocean processes; the value of in situ measurements for modeling the dynamics of warm core rings; and the scientific program of the world ocean circulation experiment (WOCE). A description of a new moored current and density profiler is also given.

Marine Industry Collegium. RISKS AND COSTS FOR OCEAN STRUCTURES—OPPORTUNITY BRIEF #17. MITSG 79-18. NTIS: PB299-852/AS. $4.

MIT Marine Industry Collegium. SATELLITE IMAGE ANALYSIS FOR MARINE APPLICATIONS. OPPORTUNITY BRIEF #53. MITSG 89-3. PB89 187330/AS. 18pp. $4.

Future research efforts to gain a greater understanding of the ocean and its processes will rely increasingly on the use of satellite data. New and more sophisticated satellites will dramatically increase the types and amount of satellite imagery data sets available to the marine community. This collection of summaries for a March 1989 MIT Sea Grant/Marine Industry Collegium meeting addresses dissemination of the vastly increased data by NASA and NOAA, artificial intelligence under development to assist in data review, and research into data assimilation coupled to the development of ocean circulation models. The final summary looks at future satellite systems to be deployed.

MIT Marine Industry Collegium. SOME FEDERALLY SPONSORED RESEARCH PROGRAMS FOR UNMANNED UNDERWATER VEHICLES—OPPORTUNITY BRIEF #18. MITSG 80-5. NTIS: PB81-108-110. 34pp. $4.

This opportunity brief reviews unmanned underwater vehicle research: MIT's untethered search and survey vehicle; the Naval Ocean Systems Center's free-swimming submersible using direct and supervisory control; and the University of New Hampshire experimental autonomous vehicle with five degrees of freedom of motion, developed by UNH, NOSC, and the U.S. Coast Guard.

MIT Marine Industry Collegium. STRUCTURAL ACOUSTICS—AN APPLIED SCIENCE WITH MANY APPLICATIONS. OPPORTUNITY BRIEF #56. MITSG 89-33. NTIS: PB90 182933/AS. 18pp. $4.

This report is a compilation of abstracts of presentations and related publications for an MIT Collegium workshop held Jan 9, 1990, in Cambridge, MA. Topics discuss current research at MIT in acoustic transmission properties of fluid storage tanks within marine vessels, recent developments in analytical models of machine systems for noise and vibration, minimization, techniques to combine analytically and experimentally derived acoustic parameters for model definition, and application of active and passive control techniques to minimize structural acoustic wave propagation. This report also contains a listing of recently completed theses that address structural acoustic research at MIT.

MIT Marine Industry Collegium. TELEMANIPULATORS FOR UNDERWATER TASKS—OPPORTUNITY BRIEF #3. MITSG 76-7. NTIS: PB-262 559/AS. $2.50.

MIT Marine Industry Collegium. TELEOPERATORS UNDER THE SEA—OPPORTUNITY BRIEF #14. MITSG 79-15. NTIS: PB299-883/AS. $4.

MIT Marine Industry Collegium. TOWARDS IMPROVED TECHNIQUES FOR PREDICTING SOIL STRENGTH—OPPORTUNITY BRIEF #16. MITSG 79-17. NTIS: PB299-960/AS. $4.

MIT Marine Industry Collegium. UNTETHERED ROBOT SUBMERSIBLE INSTRUMENTATION SYSTEMS—OPPORTUNITY BRIEF #5. MITSG 76-9. NTIS: PB-262 561/AS. $2.50.

MIT Marine Industry Collegium. VEHICLE DESIGN—MOTORS AND PROPULSORS. OPPORTUNITY BRIEF #55. MITSG 89-24. NTIS: PB90 114133/AS. 32pp. $4.

This report is a compilation of presentations from an MIT Collegium workshop held October 4 and 5, 1989, in Cambridge, Mass. Topics include propeller design and analysis, autonomous underwater vehicle propulsion, oscillating hydrofoils, AUV development, ducted propellers, propulsive efficiency, a brushless thruster drive, superconducting homopolar motors, DC brushless motor design, hydraulic systems for propulsion, control of noise, incorporating thruster dynamics in control and propulsion design for small underwater vehicles.

MIT Marine Industry Collegium. VIBRATION RESPONSE AND THE STRUCTURAL INTEGRITY OF DEEPWATER STRUCTURES—OPPORTUNITY BRIEF #10. MITSG 78-10. NTIS: PB286-846/AS. $4.

MIT Marine Industry Collegium. WASTEWATER MANAGEMENT—TECHNICAL ALTERNATIVES AND REGULATORY OUTLOOK—OPPORTUNITY BRIEF #32. MITSG 83-9. NTIS: PB84-141-373. 21pp. $4.

Although ocean disposal of sewage sludge is against current national policy, new methods of ensuring protection of the marine environment and increasing its fertility could make ocean

disposal not only acceptable but desirable in the future. At MIT two important technical areas related to wastewater management have been studied. The first part of this report discusses research in the use of enzymes to precipitate phenols and related chemicals from industrial wastewater. The second section describes developments in the electron irradiation process for treating municipal wastewaters. Finally, a discussion of new trends in financing water and wastewater projects in light of decreasing federal subsidies and strict regulation is presented.

Marine Industry Collegium. WAVE AND ICE IMPACT LOADING AND RESPONSE OF OCEAN STRUCTURES—OPPORTUNITY BRIEF #39. MITSG 85-20. NTIS: PB86-156494/XAB. 21pp. $4.

The report summarizes several MIT research projects on environmental damage to ships and offshore structures, including: deepwater wavebreaking forces on ocean structures; local response of marine structures to hydrodynamic impact loads; slow drift motion of ocean structures; and selection of strengthening criteria for navigation in ice.

Marine Industry Collegium. WAVE POWER SYSTEMS—OPPORTUNITY BRIEF #15. MITSG 79-16. NTIS: PB299-851/AS. $4.

# EDUCATION

## Fisheries Education

**Hall-Arber, Madeleine.** SURVEY OF MASSACHUSETTS FISHERIES PROGRAM. MITSG 83-26. 34pp. No charge.

In an effort to better fulfill the needs of the commercial fishing industry, MIT Sea Grant and the Massachusetts Maritime Academy (MMA) began a commercial fisheries training program in 1976. This survey documents the financial benefits of the program as estimated by the participants. The value of the training courses is summarized in the areas of employment, equipment (construction, use, and repair), and safety. A note on the methodology of the survey is given by the author.

# Lectures and Seminars

## Sea Grant Lecture and Seminar Series

BOUNTIFUL GRANTS OF THE SEA—proceedings of the annual MIT Sea Grant College Program Lecture (1st: 1972: Cambridge, MA). **By Athelstan Spilhaus.** MITSG 73-1. NTIS: COM-73-10052. Order from NTIS.

WORLD ENERGY AND THE OCEANS—proceedings of the annual MIT Sea Grant College Program Lecture (2nd: 1973: Cambridge, MA). **By William E. Shoupp, John W. Devanney III, and Donald R.F. Harleman.** MITSG 74-7. NTIS: COM-74-10197. Order from NTIS.

THE OCEANS—PLANETARY ENGINEERING AND INTERNATIONAL MANAGEMENT—proceedings of the annual MIT Sea Grant College Program Lecture (3rd: 1974: Cambridge, MA). **By Robert A. Frosch, Judith T. Kildow, and Richard R. Baxter.** MITSG 75-3. NTIS: COM-75-10086/AS. No charge.

THE SCIENCE, ENGINEERING, ECONOMICS, AND POLITICS OF OCEAN HARD MINERAL DEVELOPMENT—proceedings of the annual MIT Sea Grant College Program Lecture (4th: 1975: Cambridge, MA) **By Roger B. Burns, Martin A. Dubs, Ira Dyer, John E. Flipse, Leigh S. Ratiner, and Sergio M. Thompson-Flores.** MITSG 76-1. NTIS: PB-253 548. Order from NTIS.

THE UNITED STATES AND THE OCEANS—OPPORTUNITIES FOR INDEPENDENCE—proceedings of the annual MIT Sea Grant College Program Lecture (5th: 1976: Cambridge, MA). **By Alfred A.H. Keil, J. Herbert Holloman, George F. Mechlin, and Marvin Pitkin.** MITSG 77-1. NTIS: PB-261 991/AS. Order from NTIS.

THE SEAS AND THE WATERWAYS—THE NEW FRONTIER—proceedings of the annual MIT Sea Grant College Program Lecture (6th: 1977: Cambridge, MA). **Presented by Yvonne B. Burke and Panelists Paul E. Atkinson, A. Douglas Carmichael, Irling D. Naess, and John P. Sheffey.** MITSG 78-1. NTIS: PB277-765/AS. 36pp. Order from NTIS.

At the sixth annual Sea Grant Lecture and Symposium, California Congresswoman Yvonne B. Burke discussed the consequences of passage of the now ratified Panama Canal Treaty, with special emphasis on issues of ship registry, tanker safety, and international shipping rights. The Congresswoman also discussed oil tanker safety in light of the high incidence of oil spills in recent years, and the importance of maritime strength to the security and eminence of the United States. Symposium panelists responded to Mrs. Burke's remarks with their own views on waterways management issues and opportunities for international cooperation using the seas.

OIL POLLUTION OF THE OCEANS—A TANKER OWNER'S PERSPECTIVE—proceedings of the annual MIT Sea Grant College Program Lecture (7th: 1978: Cambridge, MA). **By Irling D. Naess and Panelists William M. Benkert, James A. Cole, Jr., Jerome H. Milgram, and Evelyn F. Murphy.** MITSG 79-1. NTIS PB297-771/AS. No charge.

GEORGES BANK—FISH AND FUEL—proceedings of the annual Sea Grant College Program Lecture (9th: 1980: Cambridge, MA). **By Ronald C. Lassiter, Morris A. Adelman, Douglas I. Foy, Paul M. Jacobs, and Don E. Kash.** MITSG 81-1. 36pp. No charge.

Ronald C. Lassiter, president of Zapata Corporation, examined objections to oil drilling on Georges Bank at the ninth annual Sea Grant Lecture and Symposium. Panelists debating how the petroleum and fishing industries might resolve their differences included Morris A. Adelman, Professor of Economics, MIT; Douglas I. Foy, Executive Director, Conservation Law Foundation; Paul M. Jacobs, Managing Partner, Basic Development Services; and Don E. Kash, Chief, Conservation Division, U.S. Geological Survey.

BIOTECHNOLOGY IN THE MARINE SCIENCES—proceedings of the annual MIT Sea Grant College Program Lecture and Seminar (1st: 1982: Cambridge, MA). **Edited by Rita R. Colwell, Ernst R. Pariser, Anthony J. Sinskey.** MITSG 82-25. Available through John Wiley & Sons, (address at front of directory).

The March 1982 MIT Sea Grant lecture and seminar, Biotechnology in the Marine Sciences, responded to increasing interest in the application of biotechnology to solve marine problems and create new opportunities for using

marine resources. The lecture and selected seminar papers are published in these proceedings. Seminar papers cover four main

topics: biotechnology in aquaculture, marine pharmaceuticals and bioproducts, marine biofouling, and marine pollution control. The lecture was presented by Rita R. Colwell, a noted marine microbiologist from the University of Maryland.

ARCTIC TECHNOLOGY AND POLICY—AN ASSESSMENT AND REVIEW FOR THE NEXT DECADE—proceedings of the annual MIT Sea Grant College Program Lecture and Seminar (2d: 1983: Cambridge, MA) and the third annual Robert Bruce Wallace Lecture, Department of Ocean Engineering. **Edited by Ira Dyer and C. Chryssostomidis.** MITSG 83-1. NTIS: PB84-154-806. 290pp. Available from Hemisphere Publishing Corp., (address at front of directory).

Recently, petroleum has been discovered in the Arctic, and exploration by oil companies has already begun. Experts believe that the Arctic's resources will one day rival those of the Persian Gulf. As a result, nations bordering the Arctic have intensified their efforts to resolve national and international policy questions, to develop new technologies, and to understand the characteristics of the ice and other elements of the environment that make working in the region costly and dangerous. Papers were presented on three main topics—Arctic Policy, Arctic Technology, and Arctic Science and Engineering.

BIOTECHNOLOGY OF MARINE POLYSACCHARIDES—proceedings of the annual Sea Grant College Program Lecture and Seminar (3rd: 1984: Cambridge, MA). **Rita R. Colwell, Ernst R. Pariser, and Anthony J. Sinskey.** MITSG 84-1. 559pp. $40. Available through Hemisphere Publishing Corp., (address at front of directory).

Among the chemicals that have recently shown great promise in biotechnological processes are the polysaccharides. These are biopolymers that include cellulose, chitin, and a host of other compounds which represent the most abundant naturally renewable resource of organic chemicals. This book contains a collection of papers dealing with the occurrence, nature, function, production and use of marine polysaccharides. The papers were originally developed for presentation at the April 1984 MIT Sea Grant Lecture/Seminar on the Biotechnology of Marine Polysaccharides.
Essays include the significance of polysaccharides in biofouling, drag reduction, enhanced oil recovery and pharmaceuticals.

PUBLIC WASTE MANAGEMENT AND THE OCEAN CHOICE: proceedings of the annual MIT Sea Grant Lecture Seminar Series (4th: 1985: Cambridge, MA). **Keith D. Stolzenbach, Judith T. Kildow, and Elizabeth T. Harding, editors.** MITSG 85-36. 280pp. $15.

Although extensive documentation indicates that the oceans can assimilate large volumes of sewage, sludge and dredge spoils, there is also evidence that in a few cases environmental thresholds have been reached. Today, the public demands greater assurance that the oceans and coastal waters are not seriously degraded by future waste disposal.

This volume examines these issues and places ocean disposal within the context of other waste management options. Experience and planning in Philadelphia, Chicago and New York illustrate the technical, economic and institutional aspects that communities face in disposing of toxic wastes.

OMEGA-3 FATTY ACIDS IN HEALTH AND DISEASE–proceedings of the annual Sea Grant College Program Lecture and Seminar (6th: 1987: Cambridge, MA). **Robert S. Lees and Marcus Karel, editors.** MITSG 89-2. 240pp. $99.75.

An increasing body of data suggests that fish oil, in particular the omega-3 fatty acids found in fish oil, have beneficial effects on human health. This volume covers the proceedings of the 6th annual Sea Grant Lecture/Seminar held in 1987. It is divided into two sections, the first of which discusses several major aspects of the relationship between fish oil and human health, including the effects of fish oil on disease and on cellular and metabolic processes. Contributors to the second section discuss the technology, economics, and legal aspects of public consumption of omega-3 fatty acids.

AUTOMATION IN THE DESIGN OF LARGE MARINE SYSTEMS–proceedings of the annual Sea Grant College Program Lecture and Seminar (7th: 1988: Cambridge, MA). **Chryssostomidis, C., editor.** MITSG 89-1. 298pp. $50. Published by Hemisphere Publishing Co., (address at front of directory).

This volume covers the proceedings of a conference held at MIT in 1988. The conference provided a forum for the coherent examination and exchange of ideas on aspects of automation in the design and manufacture of complex systems important in heavy industries. Subjects covered

involved aspects of sculptured shape representation and interrogation in a computer environment, automated analysis, procedural modeling of objects for design and fabrication, tolerances, forming of metal shells, and adaptive controls. Also discussed were issues of design and fabrication of composite materials.

NASA BUT NOT NOAA? FUNDING FOR OCEAN RESEARCH IN THE 1990s—proceedings of the annual Sea Grant College Program Lecture (17th: 1989: Cambridge, MA). **By Lowell Weicker.** MITSG 90-2. 12pp. No charge.

Throughout the Reagan Administration, funding for marine research suffered erosion. In this 17th annual Sea Grant Lecture, former Sen. Lowell Weicker of Connecticut says that while space exploration was championed by NASA, ocean research lacks a constituency ready to communicate the priority of oceans to Congress. Among other examples, Weicker notes the failure of the marine research community to capitalize on anti-pollution sentiment in wake of recent beach foulings. Weicker say the research community must take the initiative for pushing funding with individual effort and strong communication.

## Robert Bruce Wallace Lectures

THE ALEXANDER L. KIELLAND ACCIDENT—proceedings from the Robert Bruce Wallace Lecture (1st: 1981: Cambridge, MA). **Presented by Torgeir Moan.** MITSG 81-8. NTIS PB82-160-987. 20pp. Order from NTIS.

The collapse of the oil rig, Alexander L. Kielland, in the North Sea March 27, 1980, is the largest offshore platform accident to date. The proceedings from this lecture present the findings of a commission appointed by the Norwegian government to investigate the accident. The report gives a detailed account of the accident and its causes and a description of the evaluation and rescue operation. The Commission's evaluations of the structural integrity, floatability, and stability of the platform and of the evacuation and rescue operation are detailed, along with its recommendations for improving the safety of offshore structures.

ENGINEERING EDUCATION—A NATIONAL AGENDA—proceedings from the Robert Bruce Wallace Lecture (8th: 1989: Cambridge, MA). **By Gerald L. Wilson.** MITSG 89-9. 17pp. No charge.

Many analysts say American manufacturing is in crisis because it is failing to produce internationally competitive products and because the public is increasingly wary of the social impact of science and technology. In this 8th annual Robert Bruce Wallace lecture, MIT Dean of Engineering Gerald L. Wilson places much of the responsibility for both problems on poor engineering and the way engineers are educated. Education should emphasize the synthesis of ideas, not just analysis; laboratories should nurture design and building skills, but not distance students from common-sense understanding. In addition, he says, engineers need to learn how their products affect society at large. In this publication, Wilson proposes a "new agenda" for engineering education and describes two MIT programs that address the issues he raises.

## Other Lectures

PROCEEDINGS OF THE FIRST INTERNATIONAL CONFERENCE ON TOXIC DINOFLAGELLATE BLOOMS. Massachusetts Science and Technology Foundation and the MIT Sea Grant Program. MITSG 75-8. Order from NTIS.

STRENGTHENING OCEAN ENGINEERING IN THE SEA GRANT PROGRAM. **Presented by Alfred A.H. Keil.** MITSG 79-3. NTIS: PB298-338/AS. No charge.

COASTAL ZONE AND CONTINENTAL SHELF CONFLICT RESOLUTION—IMPROVING OCEAN USE AND RESOURCE DISPUTE MANAGEMENT. **Nyhart, J.D., editor.** Proceedings (1984: MIT: Cambridge, MA). MITSG 85-28. NTIS: PB86-173283/XAB. 159pp. $15.

With advancing technology opening up greater opportunities for using the oceans, conflicts are arising over such differing uses as oil drilling and fishing or sewage disposal and recreation. Traditionally, remedies for such conflicts have been sought in the courts, but this route is costly both in terms of time and money, and often results in outcomes unsatisfactory to at least one of the parties. In response, non-adjudicatory processes have sprung up, including mediation and facilitation to settle cases out of court. An MIT Sea Grant conference focused on these alternative methods of dispute resolution as they applied to conflicts in the coastal zone and outer continental shelf. Papers presented at the conference are published in these proceedings.

# Engineering Education

**Carmichael, A. Douglas.** OCEAN ENGINEERING POWER SYSTEMS. MITSG 74-15. Out of print.

**Carmichael, A. Douglas., and David B. Wyman.** OCEAN ENGINEERING SUMMER LABORATORY 1973—MASSACHUSETTS INSTITUTE OF TECHNOLOGY AND MAINE MARITIME ACADEMY. MITSG 74-12. NTIS: COM-74-10963/AS. Order from NTIS.

**Carmichael, A. Douglas., and David B. Wyman.** OCEAN ENGINEERING SUMMER LABORATORY 1974—MASSACHUSETTS INSTITUTE OF TECHNOLOGY AND MAINE MARITIME ACADEMY. MITSG 75-12. NTIS: COM-75-10888/AS. $5.

**Carmichael, A. Douglas, and David B. Wyman.** OCEAN ENGINEERING SUMMER LABORATORY, 1975. MITSG 76-3. NTIS: PB-256 095/AS. $3.

**Carmichael, A. Douglas, Keatinge Keays, and Donald A. Small.** OCEAN ENGINEERING SUMMER LABORATORY, 1976. MITSG 77-22. NTIS: PB-277 260/AS. $4.

**Craven, John P., John R. Mittleman, T. Gray Curtis, and James M. Patell.** OCEAN ENGINEERING SYSTEMS. MITSG 71-6. Out of print.

**Cummings, Damon E., and David B. Wyman.** OCEAN ENGINEERING SUMMER LABORATORY, 1971. MITSG 72-3. NTIS: COM-72-10327. Order from NTIS.

**Keays, Keatinge, et al.** THE SEARCH FOR *DEFENCE* AND OTHER OCEAN ENGINEERING PROJECTS. MITSG 72-20. NTIS: COM-73-10622. Order from NTIS.

**Keil, Alfred A.H.** STATUS OF ENGINEERING IN THE OCEAN ENVIRONMENT TODAY. MITSG 74-6. NTIS: COM-74-10142. Order from NTIS.

# GUIDES AND DIRECTORIES

CITIZEN'S GUIDE TO SOURCES FOR MARINE AND COASTAL INFORMATION IN MASSACHUSETTS. **Fifth revised edition compiled and edited by Madeleine Hall-Arber and Karen Hartley.** MITSG 90-3. 179pp. $5. Previous editions 86-6 and 77-13 may be ordered from NTIS.

The 1990 edition lists more than 175 Massachusetts agencies, information centers, and organizations concerned with 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 organization. A subject index provides easy reference by area of interest.

DIRECTORY OF MIT SEA GRANT COLLEGE PROGRAM PUBLICATIONS. Vol. 3, 1971-1990 MITSG 90-12. No charge. **Compiled by Hilary Thornton.** Vol. 1, 1971-1977 MITSG 78-6 (out of print). Vol. 2, 1978-1986 MITSG 86-11 (out of print)

Since 1971 MIT Sea Grant has issued a variety of publications on marine-related research and the use of ocean resources. These reports, abstracted in these directories, cover the entire range of Sea Grant research–coastal processes, coastal zone management, ocean mining, alternative energy sources, fisheries, marine biology and biotechnology, pollution and ocean engineering, including offshore structures and underwater vehicles. Author, subject/title and numerical indexes are included.

MARINE-RELATED RESEARCH AT MIT 1990-1991. **Compiled by John Moore, Jr. and Karen Hartley.** MITSG 90-13. Earlier editions 1978-1988 (MITSG 74-22 (Order from NTIS), 75-14 (Order from NTIS), 76-13, 77-12 (Order from NTIS), 78-9, 79-6, 80-10, 81-11, 82-14, 83-31, 85-31, 86-10, 88-2) are also available. No charge.

Interested in finding out what current marine-related research is going on at MIT? Each year Sea Grant issues this directory to describe the full range of marine-related studies at the Institute. Projects from the departments of Civil Engineering; Earth, Atmospheric, and Planetary Sciences; Ocean Engineering; Mechanical Engineering; and Electrical Engineering and Computer Science are covered. Topics include studies on pollution, oceanography, ocean engineering, ship design and operation, shipping and transportation, and marine education. Short descriptions pinpoint major research objectives and list the names of the principal investigators. Indexes are by subject area and principal investigator. The directory of *Marine-Related Research at MIT* is a valuable guide for anyone interested in keeping up-to-date on the latest research in marine-related disciplines.

MIT SEA GRANT THESES LIST 1980-1983. MITSG 83-8. 30pp. No charge.

The MIT Sea Grant Information Center has made available a list of theses and reports from Undergraduate Research Opportunities Program (UROP) projects sponsored in 1980-83. The papers are organized in the same subject categories as the program's two research report directories (MITSG 84-16 and MITSG 78-6). Each citation lists the thesis title, author, supervising faculty, and MIT department.

SEA GRANT PUBLICATIONS FOR THE FISHING INDUSTRY. **Edited by Lynne M. Newman.** MITSG 82-20. Revised 1984. NTIS: PB83-151-886. 119pp. No charge.

This directory is a compilation of publications that have been written and produced from throughout the Sea Grant network for the fishing industry. The topics are organized under five major headings: fish harvesting; fishing vessel design and operation; fish handling, preservation, and processing; fishing economics and management; fish ecology and aquaculture. Prices and ordering information are included.

# NEWSLETTERS & BROCHURES

MIT SEA GRANT QUARTERLY REPORT. **Carolyn Levi, editor.**

Each issue of the Quarterly Report includes three to four short articles on current MIT Sea Grant projects, as well as abstracts of new research reports. No charge. Directories for the contents of all issues are available.

CURRENT AFFAIRS. **Carolyn Levi, editor.**

This two-page publication features brief, non-technical stories covering recent advances in MIT Sea Grant research, advisory and education activities. Published twice yearly.

MIT SEA GRANT COLLEGE PROGRAM BROCHURE. Out of print.

This brochure briefly describes MIT Sea Grant's current focus and lists those research project funded during the 1985-86 cycle. A summary of program services and the names and phone numbers of people responsible for them have been included. No charge.

## Advisory Reports and Factsheets

CHOLESTEROL IN FINFISH—MARINE AND COASTAL FACTS. Factsheet #3. No charge.

A COASTAL HAZARD—SALTWATER INTRUSION—MARINE AND COASTAL FACTS. Factsheet. **By Bronwyn L. Davies.** Cooperative Extension Service, University of Massachusetts and Massachusetts Institute of Technology Sea Grant College Program. 1981. 4pp. No charge.

This factsheet describes saltwater intrusion and the threat it poses to coastal communities, in particular, Cape Cod. Suggestions for mitigating the problem are given.

ESTABLISHING NEW SALT MARSHES—MARINE AND COASTAL FACTS. Factsheet #7. **By Arnold C. Lane.** Cooperative Extension Service, University of Massachusetts and Massachusetts Institute of Technology Sea College Grant Program. 1979. No charge.

LANDSCAPING THE SEASHORE COTTAGE—MARINE AND COASTAL FACTS. Factsheet #4. **By Ralph H. Goodno.** Cooperative Extension Service, University of Massachusetts and Massachusetts Institute of Technology Sea Grant College Program. 1978. No charge.

LOW COST SHORELINE PROTECTION IN MASSACHUSETTS. **By Andrew L. Gutman.** MITSG 79-19J. NTIS: PB80-112-923. 1979. 13pp. Reprinted from the *Proceedings of the Specialty Conference on Coastal Structures '79*, ASCE, Alexandria VA. No charge.

MARPOL ANNEX V: NO MORE DUMPING PLASTICS IN THE OCEAN. Brochure. MITSG 89-11. 2pp. No charge.

NEW ENGLAND RED TIDE— MARINE AND COASTAL FACTS. Factsheet #6. **By Liza Williams.** Cooperative Extension Service, University of Massachusetts and Massachusetts Institute of Technology Sea Grant College Program. 1979. No charge.

THE SPINY DOGFISH SHARK, A SEAFOOD SPECIALTY—MARINE AND COASTAL FACTS. Factsheet #7. **By Anna M. Warrock.** Cooperative Extension Service, University of Massachusetts and Massachusetts Institute of Technology Sea Grant College Program. 1981. 4pp. No charge.

Some commercial fishermen, searching for new species of fish to bring onto the market, have begun to catch and sell the dogfish shark in the United States and abroad. The fish is an excellent source of protein and the fillets are white and flaky when cooked and free of small bones. This factsheet compares the dogfish nutritionally to other popular seafoods and describes how to dress and cook it.

STABILIZATION OF BARRIER DUNES BY VEGETATION—MARINE AND COASTAL FACTS. Factsheet #2. No charge.

SURVIVAL IN COLD WATER—MARINE AND COASTAL FACTS. Factsheet #1. No charge.

THEFT-PROOFING BOATS—MARINE AND COASTAL FACTS. Factsheet #5. Cooperative Extension Service. University of Massachusetts and Massachusetts Institute of Technology Sea Grant College Program. 1978. No charge.

# PROGRAM MANAGEMENT

MIT Sea Grant Program issues annual reports that describe the Program's projects and achievements during the completed fiscal year. The reports, in addition to describing each project and its results, include budget tables and sources of matching funds.

A REPORT ON THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY SEA GRANT COLLEGE PROGRAM— 1 JULY 1978 to 30 JUNE 1979. MITSG 80-2. NTIS: PB80-183-718. 48pp. No charge.

ANNUAL REPORT—1 JULY 1973 TO 30 JUNE 1974. MITSG 75-4. NTIS: COM-75-10269/AS. Order from NTIS.

ANNUAL REPORT—1 JULY 1974 TO 30 JUNE 1975. MITSG 76-2. Out of print.

ANNUAL REPORT—1 JULY 1975 TO 30 JUNE 1976. MITSG 77-2. NTIS: PB-264 262/AS. Order from NTIS.

ANNUAL REPORT—1 JULY 1976 TO 30 JUNE 1977. MITSG 78-2. Out of print.

ANNUAL REPORT—1 JULY 1977 TO 30 JUNE 1978. MITSG 79-2. NTIS: PB80-294-582. Order from NTIS.

ANNUAL REPORT—1 JULY 1978 TO 30 JUNE 1979. MITSG 80-2. NTIS: PB80-183-718. No charge.

MIT SEA GRANT—TEN YEARS OF OCEAN DEVELOPMENT. A REPORT ON THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY SEA GRANT COLLEGE PROGRAM 1970-1980. MITSG 80-15. 80pp. No charge.

MIT SEA GRANT—HELPING TO MANAGE A NATION'S INVESTMENT. A REPORT ON THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY SEA GRANT COLLEGE PROGRAM 1981-1984. MITSG 84-18. 40pp. No charge.

TRIENNIAL REPORT OF THE MIT SEA GRANT COLLEGE PROGRAM. **Karen Hartley, editor.** MITSG 90-1. NTIS: PB90 183187/AS. 30pp. No charge.

The Triennial Report is a comprehensive look at the MIT Sea Grant College Program and its activities over the past three years. The report includes overviews of the research theme areas—automation in the manufacture of marine systems, coastal processes, marine biotechnology, ocean engineering, technology development and unmanned underwater systems. Each theme area includes a capsule description of sample research programs. Administrative, advisory and educational services, program budgets and staff and committee listings are also included.

# Author Index 1971-1990


Acomb, Glenn 8
Adams, Eric E. 22, 23
Adelman, Morris A. 53
Allen, Ben 12
Amzallag, A.M. 32
Anderson, Donald M. 16, 17
Antrim, Lance 9
Ashe, Glenn 8
Atkinson, Paul E. 53
Averbach, Benjamin L. 17
Averback, James M. 9
Azzouz, Amr S. 37-39
Backer, Stanley 25, 27
Baecher, Gregory B. 38
Baggeroer, Arthur B. 28, 29
Baglione, J. 14
Baird, Andrew V. 22
Bakis, G. 18
Bakr, Mohammed A. 9
Baligh, Mohsen M. 37-39
Barrington, Kathy 8
Barton, Donald S. 27
Barzana, Eduardo 17, 18
Baxter, Richard R. 53
Beardsley, Robert C. 6
Beaton, Robert 29
Bellingham, James G. 25, 26, 29
Benkert, William M. 53
Berk, Zeki 15, 18
Bers, A. 33
Bishop, William O. 26, 27
Blair, W.R. 21
Bliek, Antoine 37
Blumberg, Robert 8
Bock, Susan L. 19
Bodmer-Turner, Sandy 8
Briggs, Douglas A. 4
Brinckman, F.E. 21
Brooks, Thurston L. 29
Brown, Alan J. 11, 28
Brown, Francesca D. 8
Brown, Russell T. 28
Burgess, Jim 37
Burke, Roger W. 6
Burke, Yvonne B. 53
Burns, Roger B. 53
Campbell, Brad 21
Capstaff, Arthur E. 9
Catipovic, J.A. 29
Ceder, Avishai 22
Carmichael, A. Douglas 10, 29, 53, 56
Chan, E.S. 39
Chan, Mark 38
Chen, H.S. 4
Chen, Rong 15
Chirlin, Gary R. 22
Chisholm, Sallie W. 16, 17
Christodoulou, George C. 4, 6
Chryssostomidis, C. 33-36, 39, 41, 54
Chryssostomidis, Marjorie 34
Clifton, Arthur B. 11, 13
Cohen, R.E. 26
Cole, James A., Jr. 53
Colwell, Rita R. 53, 54
Connor, Jerome J. 4, 6
Coney, William B. 29
Cook, Jerry E. 43
Cooney, J.J. 21
Cooper, Cortis 22
Craven, John P. 56
Cummings, Damon E. 56
Curtis, Fred 8
Curtis, T. Gray 56
Dailey, James E. 4
Davies, Bronwyn L. 58
Day, Robert W. 11
De Oliveira, Joao G. 39, 40
Demchick, Robert P. 26, 27
Derbes, Edgardo R. 8
Devanney, John W. 8, 9, 11, 21, 23, 43, 53
Dimas, Athanasios 33
Ditmars, John D. 6
Doelling, Norman A. 29, 44
Dommeruth, Douglas G. 4
Donnelly, R.G. 26
Doret, Stephen C. 4
Dorman, Craig E. 25
Dubs, Martin A. 53
Ducsik, Dennis W. 8, 9
Dwyer, Robert L. 9
Dyer, Ira 53, 54
Engellenner, Thomas 8
Ezekiel, Shaoul 16
Faulkner, Douglas. 26
Fay, James A. 10
Fazal, Riyaz A. 21
Felenchak, B.R. 28
Fifield, Jayne L. 7
Fisher, John S. 6
Flink, James M. 18
Flipse, John E. 53
Foy, Douglas I. 53
Frankel, Ernst G. 43
Frankel, Sheila M. 4
Frosch, Robert A. 53
Geisler, Yolanda 11
Germaine, John T. 25, 39
Gibbs, Stephen R. 43
Gillia, Michael A. 9
Goetz, Michael J. 8
Goldblith, Samuel A. 18
Goodno, Ralph H. 58
Goudey, Clifford A. 11-13, 29, 33, 34
Gowell, Elizabeth T. 29
Graber, Hans C. 5
Graham, C. 41
Greer, Matthew N. 5
Gschwend, Philip M. 23, 24
Guillard, R.R.L. 16
Gulezian, Gary 8
Gustin, H.L. 28
Gutman, Andrew L. 8, 58
Halkyard, John E. 32
Hall-Arber, Madeleine 52, 57
Harding, Elizabeth T. 29, 54
Harichandran, Ronald S. 35
Harleman, Donald R.F. 4, 6, 53
Hartley, Karen 57, 59
Hattis, Dale B. 17
Heliotis, Angelos D. 13
Hemond, Harold F. 7
Hoff, William B. 14
Holberger, Craig A. 13
Holloman, J. Herbert 53
Horn, Dean A. 21, 44
Houten, Robert J. 22
Hover, Franz 32
Hsu, P. 25
Huguenin, John E. 19
Hultin, Herbert O. 15
Hutton, John. 9
Iascone, Richard N. 37
Im, Jang-hi 27
Ingra, Thomas S. 38
Ippen, Arthur T. 4, 6
Irvine, H. Max 35
Jacobs, Paul M. 53
Jessup, Stewart D. 29
Joglekar, Nitindra R. 4
Kahan, Leslie N. 18
Kalikstein, Paul H. 14
Kaminski, Charles 8
Karalekas, Diane 18
Karel, Marcus 17, 18, 54
Karniadakis, G. 32
Karpen, Joseph 6
Kash, Don E. 53
Kashihara, Reiichiro 27
Katz, Arthur M. 9
Kazerooni, Homayoon 30
Keays, Keatinge 23, 56
Keil, Alfred A.H. 53, 55, 56
Kellen, Andrew D. 13
Keller, Glenn 29
Kenney, M.C. 26, 27
Kerfoot, William B. 16
Kern, Edward 21
Kettani, M. Ali 9
Kienzle-Sterzer, Carlos A. 18
Kildow, Judith T. 8, 19, 43, 53, 54
Klibanov, Alexander M. 17, 18, 23
Klimowski, Robert J. 27
Klock, R. 21
Koelsch, D.E. 29
Kohler, Alison D. 9
Kolf, Richard C. 23
Kondratowicz, Ludwik J. 21
Korakianitis, Theodosios P. 13, 14
Kossik, Richard F. 23
Kramer, Deborah 8
Kriezis, George A. 36, 41
Kronick, A.T. 21
Kupfer, K. 33
Ladd, Charles C. 25, 37-39
Ladd, G.M. 21
Lahman, Howard S., Jr. 9
Landsberger, Samuel E. 30
Lane, Arnold C. 58

Langer, Robert S. 19
Lassiter, Joseph B. 9
Lassiter, Ronald C. 53
Laurence, O. 21
Lee, Anne 19
Lee, Eddie 11
Lee, Lep S. 38
Lee, Thomas 38
Lees, Robert S. 19, 54
Leimkuhler, William F. 4
Lentowski, James F. 8
Leshaw, Dale 9
Levadoux, Jaques-Noel 38, 39
Levi, Carolyn 30, 58
Linskey, Margaret M. 13
Livanos, Vassilios 23
Lombardi, Donald P. 19
Loutrel, Stephen P. 13, 14
Lozow, Jeffrey B. 11
MacVicar, M.L.A. 25, 26
Madsen, Ole S. 4-6, 22
Mahnken, G. 11
Makkar, N.S. 21
Malek, Azziz M. 39
Mandell, John F. 26, 27
Manohar-Maharaj, Veshpati 6
Mant, Robert S. 13
Marcus, Henry S. 11, 43
Marr, W. Allen 39
Marshall, James G. 40
Martin, R.T. 38
Masubuchi, Koichi 27, 28
Maser, Kenneth R. 27
Mavrikios, Yianni 40
McGarry, Frederick J. 26, 27
McKnight, D.M. 17
McPherson, Roy N. 8
Mechlin, George F. 53
Mei, Chiang C. 4, 10, 40
Meier, Urs 27
Melville, W.K. 39, 40
Menjivar, Juan A. 15
Merrill, Edward W. 23
Meyers, M. 41
Milgram, Jerome H. 6, 21, 22, 53
Mitome, Shuhei 40
Mittleman, John R. 56
Moan, Torgeir 55
Mollo-Christensen, Erik L. 6, 25, 30
Moore, Arnold 28
Moore, John, Jr. 57
Moore, Stephen F. 9, 22
Morel, Francois M.M. 16, 17
Morel, N.M.L. 17
Morey, Kenneth A. 30
Morrison, M.J. 38
Murphy, Evelyn 53
Murray, Albert 17
Muzzarelli, R.A.A. 19
Myers, Edward P. 23
Mynett, Arthur E. 10
Naess, Irling D. 53
Nagem, R.J. 28
Newhouse, Lina 8
Newman, Lynne M. 57
Nisenoff, M. 25, 26
Noblesse, Francis 33
Nucci, Louis A. 38
Nyhart, J.D. 9, 22, 55
Odahara, Tetsuichi 31
Offshore Oil Task Group 9
Oliveira, Joao G. de 39
Olson, G.J. 21
Ostendorf, David W. 5, 6
Owens, L.D., Jr. 14
Ozaki, Hironori 28
Padelford, Norman J. 43
Pagenkopf, James R. 4, 6
Papazoglou, V.J. 27, 28
Pariser, Ernst R. 11, 15, 18, 19, 53, 54
Parker, Bruce B. 6
Parkhurst, Beth 8
Passero, Barbara 8, 11
Patell, James M. 15, 23, 56
Paterson, Kathryn E. 11
Patrikalakis, Nicholas M. 34-36, 39, 41, 42
Pierce, Brian R. 4, 6
Pitkin, Marvin 53
Pollack, Andrew M. 22
Poole, P.K. 14
Poon, Ying-Keung 5
Powers, Robert J. 9
Prakash, P.V. 41, 42
Prasad, Subodh 28
Protopapa, S. 21
Psaraftis, Harilaos N. 21, 22
Puccia, Charles J. 22
Quinlan, Alician V. 16, 17
Ratiner, Leigh S. 53
Ree, Thecla 11
Reyman, Andrea S. 5
Rha, ChoKyun 15, 18, 20
Robbins, Phillips W. 22
Rodriguez-Sanchez, Dolores 18, 20
Rome, L. de 21
Rosenbaum, Lisa T. 8
Rosengaus, Michael M. 5
Royer, Thierry 31
Rueter, J.G. 16
Sa'da Costa, Antonio 6
Sauls, D.P. 25
Schloerb, D.W. 28
Schneider, C.W. 17
Schneiter, John L. 31
Schrader, Bradley P. 22
Seale, Mary Jane 8
Searson, P.C. 26
Seifert, William W. 8, 9
Seo, M. 25
Serman, Demetrio D. 10
Shah, Dineshchandra 23
Sheffey, John P. 53
Sheridan, Thomas B. 29-31
Shin, Hyunkyoung 37
Shoupp, William E. 53
Shum, K.T. 40
Shupe, Landy 29
Simpson, Harry W. 11
Sinskey, Anthony J. 23, 53, 54
Smachlo, Mark A. 10
Small, Donald A. 56
Snyder, Paul G. 27
Soden, James E. 9
Sofyanos, Thomas N. 31
Sommer, Steven 23
Spilhaus, Athelstan 53
Stewart, Robert J. 22
Stewart, W. Kenneth 31, 32
Stolzenbach, Keith D. 6, 22, 54
Suh, Myung Sung 40
Suomala, John B. 11
Sutro, Louis L. 14
Swallow, K.C. 17
Taniguchi, Jan 8
Tharakan, Geverghese G. 22
Thatcher, M. Llewellyn 6
Thompson-Flores, Sergio M. 53
Thornton, Hilary 57
Tiffney, Wesley N. 8
Tong, Sun-de 18
Townley, James R. 11
Triantafyllou, George S. 32, 33, 36
Triantafyllou, Michael S. 9, 29, 32, 36, 37
Trump, John G. 22, 23
Tsai, Chon-Liang 28
Urzua, Alfredo M. 39
Van Houten, Robert J. 22
Van Den Bosch, K. 17
Vandiver, J. Kim 40
Vanmarcke, Erik H. 37
Venugopal, Madan 33, 34
Vivatrat, Vitoon 38
Von Der Heydt, K. 29
Vrakas, E. 34, 35
Wall, David 16
Wall, John C. 14
Wang, John D. 4, 6
Wang, Su-Su 27
Wang, Youjiang 27
Warrock, Anna M. 58
Watras, Carl J. 16, 17
Weaver, J.S. 25
Weicker, Lowell 55
Westfall, J.D. 17
White, G. Gregory 16
Whittle, Andrew J. 37
Wiegand, Judith 8
Wieneke, John 8
Wiernicki, C. 41
Wierzbicki, Tomasz 40, 41
Wilce, R.T. 17
Williams, James H., Jr. 28
Williams, Liza 58
Wilson, David G. 13, 14
Wilson, Gerald L. 55
Wilson, John L. 6
Wissa, Z.E. 38
Wood, W. 8
Worley, Wesley 8
Wozny, Michael 42
Wright, Kenneth A. 23
Wu, Shian-Chee 24
Wyman, David B. 56
Xirouchakis, Paul C. 25
Yeung, Ronald W. 23
Yue, Dick K.P. 4
Zaharadnik, John W. 11
Zanca, Lawrence 28
Ziogas, Babis O. 22

# Subject and Title Index 1971-1990


ABSOLUTE INSTABILITIES AND SELF-SUSTAINED OSCILLATIONS IN THE WAKES OF CIRCULAR CYLINDERS 33
Accidental collisions 40
ACOUSTIC DATA AND UNCERTAINTY IN GEOTECHNICAL SITE CHARACTERIZATION OFFSHORE 38
ACOUSTIC TELEMETRY—AN OVERVIEW 28
Acoustics 7, 11, 29, 32, 39, 45, 48, 50
Addresses of publishing companies 2
ADVANCES IN UNDERWATER WELDING—OPPORTUNITY BRIEF #4 45
Air-sea boundary layer 25
Alaska, Gulf of 9, 22
Alewife fisheries 11
ALEXANDER L. KIELLAND ACCIDENT—PROCEEDINGS FROM THE FIRST ROBERT BRUCE WALLACE LECTURE 55
Algae biomass energy 46
Algae control 16, 17, 54
Algae culture 8, 15, 45, 49
ALTERNATE EXPRESSIONS FOR THE GREEN FUNCTION OF THE THEORY OF SHIP WAVE RESISTANCE 33
Alternative energy sources 10, 46, 51
Aluminum, corrosion 47
ANALYSIS OF LONGSHORE CURRENTS AND ASSOCIATED SEDIMENT TRANSPORT IN THE SURF ZONE 6
ANALYSIS OF MANUFACTURING PROCESSES OF LARGE ANCHOR CHAINS 27
ANALYSIS OF PERMANENT DISPLACEMENT FROM CYCLIC LOADING OF FOUNDATIONS 39
ANALYSIS OF THE SMALL-SCALE STRENGTH TESTING OF ICE 27
Anchor chains 27
Angiogenesis inhibitors 19
ANNUAL REPORTS 1973-1979 59
Anti-fouling 49
Antrim, Lance 9
APPLICATION OF ESTIMATION THEORY TO DESIGN OF SAMPLING PROGRAMS FOR VERIFICATION OF COASTAL DISPERSION PREDICTIONS 4
APPLICATION OF HYDROACOUSTIC METHODS FOR AQUATIC BIOMASS MEASUREMENTS 11
APPLICATIONS OF MARINE ACOUSTIC SYSTEMS—OPPORTUNITY BRIEF #33 45
APPROXIMATE CONVERSION OF RATIONAL SPLINES 41
Aquaculture 15, 19, 45, 46, 49, 53, 56, 58
Aquifers 6
AQUIL—A CHEMICALLY DEFINED PHYTOPLANKTON CULTURE MEDIUM FOR TRACE METAL STUDIES 16
Arc welding 28
Arctic 9, 25, 53
ARCTIC TECHNOLOGY AND POLICY—AN ASSESSMENT AND REVIEW FOR THE NEXT DECADE 54
Argo merchant 22, 45, 49
Artificial intelligence 30
ASSAY OF THE MARINE RESOURCES OF MASSACHUSETTS BAY 9
ASSESSMENT OF UNDERSEA TELEOPERATORS 31
Atlantic coast 8, 9, 11, 21, 22, 43
AUTOMATION IN THE DESIGN OF LARGE MARINE SYSTEMS 54
AUTOMATION OF DESIGN AND MANUFACTURING IN HEAVY INDUSTRIES 42
AUTONOMOUS SUBMERSIBLE DESIGNED FOR SOFTWARE DEVELOPMENT 29
AUTONOMOUS UNDERWATER SYSTEMS FOR SURVEY OPERATIONS 29
BACKSCATTER FROM SIDESCAN SONAR FOR AUTONOMOUS CLASSIFICATION AND NAVIGATION 31
Bacteria, marine 22
Bayesian decision theory 43
Bays 6
Beaches 8, 60
BEHAVIOR OF DELAMINATED COMPOSITE CYLINDERS SUBJECT TO HYDROSTATIC PRESSURE 40
BEHAVIOR OF STEEL OFFSHORE STRUCTURES UNDER ACCIDENTAL COLLISIONS 39
BEING PREPARED FOR FUTURE ARGO MERCHANTS 22
Bibliographies 8, 11, 19, 28, 34, 58
Biofouling 49
Biomass 11, 46
Biotechnology 17, 18, 19, 20, 23, 45, 53
BIOTECHNOLOGY AND THE SEA—RECENT ADVANCES AND APPLICATIONS—OPPORTUNITY BRIEF #43 45
BIOTECHNOLOGY IN THE MARINE SCIENCES 53
BIOTECHNOLOGY OF MARINE POLYSACCHARIDES 54
Boat hulls 26, 27, 28
Boston Harbor 4, 8, 23, 43
BOSTON HARBOR MANAGEMENT STUDY 8
BOSTON SOUTH SHORE AREA—SOME PROBLEMS AND CONFLICTS 8
Boundary layers 5, 25
BOUNTIFUL GRANTS OF THE SEA 53
Brayton-cycle engines 14
Breakwaters 56
BUILDING PUBLIC/PRIVATE COOPERATION IN THE COASTAL ZONE 8
Bulbous bows 13
BUOY SYSTEM FOR AIR-SEA INTERACTION STUDIES—BUOY DESIGN AND OPERATION 25
BUTYLTINS IN SEDIMENTS FROM BOSTON HARBOR, USA 21
CABLE DYNAMICS FOR TETHERED UNDERWATER VEHICLES 32
Cables 12, 32, 35, 36, 37, 46
CAFE-1—A TWO DIMENSIONAL FINITE ELEMENT CIRCULATION MODEL 4
CALORIMETRIC METHOD FOR THE ENZYMATIC ANALYSIS OF GASES—THE DETERMINATION OF ETHANOL AND FORMALDEHYDE VAPORS 17
CAPACITY OF OFFSHORE FRICTION PILES IN CLAY—OPPORTUNITY BRIEF #44 45
Cape Cod 8
CASE STUDIES OF THE MIT OIL SPILL MODEL—OPPORTUNITY BRIEF #35 45

Catamarans 39
Cathodic protection 47
Center for Fisheries Engineering Research 12-14
CHARACTERISTICS OF CONDENSER WATER DISCHARGE ON THE SEA SURFACE 4
CHARACTERISTICS OF SALTER'S CAM FOR EXTRACTING ENERGY FROM OCEAN WAVES 10
CHITIN AND CHITIN DERIVATIVES—AND ANNOTATED BIBLIOGRAPHY OF SELECTED PUBLICATIONS FROM 1965 THROUGH 1971 19
CHITIN AND CHITIN DERIVATIVES—OPPORTUNITY BRIEF #1 45
CHITIN SOURCEBOOK—A GUIDE TO THE CHITIN RESEARCH LITERATURE 19
Chitin/Chitosan 17-20, 45, 53
CHITOSAN GLOBULES 20
CHOLESTEROL IN FINFISH—MARINE AND COASTAL FACTS 58
CITIZEN'S GUIDE TO SOURCES FOR MARINE AND COASTAL INFORMATION IN MASSACHUSETTS 57
Clay 37, 39
CLOSED-CYCLE AQUACULTURE—OPPORTUNITY BRIEF #7 45
COASTAL HAZARD—SALTWATER INTRUSION—MARINE AND COASTAL FACTS 58
Coastal processes 5-7, 45, 47
COASTAL ZONE AND CONTINENTAL SHELF CONFLICT RESOLUTION—IMPROVING OCEAN USE AND RESOURCE DISPUTE MANAGEMENT 55
Coastal zone management 8, 9, 21-23, 53-55, 62
COASTAL ZONE MANAGEMENT—FOCUS ON NEW ENGLAND 8
Cockerell raft 51
COMPLIANT RISER ANALYSIS 35
Composites 40
Compounds, aromatic 22
COMPUTATION OF ALGEBRAIC AND POLYNOMIAL PARAMETRIC SURFACE INTERSECTIONS 41
Computer graphics 41
COMPUTER MODELS FOR ENVIRONMENTAL ENGINEERING AND RESEARCH IN NEAR-COASTAL ENVIRONMENTS—OPPORTUNITY BRIEF #8 46
COMPUTER SIMULATION AND CONTROL OF UNDERWATER VEHICLES 30
Computer-aided design 41, 42, 53
COMPUTER-AIDED PRELIMINARY DESIGN OF SHIPS—OPPORTUNITY BRIEF #13 45
CONE PENETRATION AND ENGINEERING PROPERTIES OF THE SOFT ORINOCO CLAY 37
CONE PENETRATION TESTS OFFSHORE THE VENEZUELAN COAST 38
CONFERENCE PROCEEDINGS—GEAR SELECTIVITY AS A MANAGEMENT TOOL 11
Continental shelf 9
CONVERSION OF DECOMMISSIONED AIRCRAFT GAS TURBINES TO HIGH-EFFICIENCY MARINE UNITS 14
Copper 16
COPPER SENSITIVITY OF GONYAULAX TAMARENSIS 16
Corrosion 25, 26, 47
COST MODEL OF DEEP OCEAN MINING AND ASSOCIATED REGULATORY ISSUES 9
Council on Environmental Quality 9, 22
CRISIS SCIENCE—INVESTIGATIONS IN RESPONSE TO THE ARGO MERCHANT OIL SPILL 22
CURRENT AFFAIRS 58
Decision-making 8, 21, 43
DEEP OCEAN MINING—A COMPUTER MODEL FOR INVESTIGATING COSTS, RATES OF RETURN, AND ECONOMIC IMPLICATIONS OF SOME POLICY OPTIONS—OPPORTUNITY BRIEF #12 46
DEEP THOUGHTS—ARTIFICIAL INTELLIGENCE IN UNDERWATER VEHICLES 30
DEEPWATER BREAKING WAVE FORCES ON SURFACE PIERCING STRUCTURES 39
Deer Island wastewater treatment plant 46
Defence (shipwreck) 23, 56
DENTING ANALYSIS OF TUBES UNDER COMBINED LOADINGS 40
DESIGN AGAINST COLLISION FOR OFFSHORE STRUCTURES 40
DESIGN AND PERFORMANCE ANALYSIS OF A DIGITAL ACOUSTIC UNDERWATER TELEMETRY SYSTEM 29
DESIGN CONSIDERATIONS FOR THE USE OF ROPES AND CABLES IN THE MARINE ENVIRONMENT—OPPORTUNITY BRIEF #42 46
Design wave heights in the nearshore 47
DESIGN, CONSTRUCTION AND DEVELOPMENT OF A PROTOTYPE MACHINE FOR PROCESSING SPINY DOGFISH SHARK 14
DESIGN, DEVELOPMENT, AND FIELD TRIALS OF A TOWED INSTRUMENTED GLIDER 30
DETECTION OF MAGNETIC FIELDS GENERATED BY ELECTROCHEMICAL CORROSION 26
DETERMINATION OF WATER QUALITY PARAMETERS IN THE MASSACHUSETTS BAY (1970-1973) 4
Developing countries 11, 43
DEVELOPMENT OF A SEMI-PELAGIC TRAWL FOR SQUID AND BUTTERFISH 11
DEVELOPMENT OF FISHING TRAWL TESTING CAPABILITIES AT NSRDC 13
DEVELOPMENT OF FULLY AUTOMATED AND INTEGRATED "INSTAMATIC" WELDING SYSTEMS FOR MARINE APPLICATIONS 28
DEVELOPMENT OF JOINING AND CUTTING TECHNIQUES FOR DEEP-SEA APPLICATION 28
DEVELOPMENT OF NEW IMPROVED TECHNIQUES FOR UNDERWATER WELDING 28
Digital Acoustic Telemetry System 29, 45
DILUTE SOLUTION BEHAVIOR OF A CATIONIC POLYELECTROLYTE 18
Dinoflagellates 16, 55
DIRECTIONS FOR MIT RESEARCH IN UNMANNED UNDERWATER WORK SYSTEMS—OPPORTUNITY BRIEF #29 46
Directories 58
DIRECTORY OF MIT SEA GRANT COLLEGE PROGRAM PUBLICATIONS 57
DISPER-1—A TWO-DIMENSIONAL FINITE ELEMENT DISPERSION MODEL 4
Dispersion 4, 45
Diving 56
DOCUMENTATION OF FOUR OCEAN-RELATED COMMUTER PROGRAM MODULES 23
Dogfish shark 14, 15
Dredging 4, 56
Dutch cone penetrometer 38, 50
DYNAMIC RESPONSE OF MARINE RISERS, TENSION LEGS, CABLES AND MOORINGS—OPPORTUNITY BRIEF #30 46
DYNAMICS OF TAUT INCLINED CABLES 36
DYNAMICS OF TOWED ARRAYS 33
DYNAMICS OF TRANSLATING CABLES 37
Echo sounders 11
ECODYNAMIC ANALYSIS OF ALGAL BLOOMS

FOULING NAHANT BAY BEACHES 16
ECONOMIC ASPECTS OF SOLID WASTE DISPOSAL AT SEA 23
ECONOMIC FACTORS IN THE DEVELOPMENT OF A COASTAL ZONE 8
Economics 8, 9, 11, 17, 22, 23, 46, 50, 54, 55
ECONOMICS AND ENGINEERING OF LARGE-SCALE ALGAE BIOMASS ENERGY SYSTEMS—OPPORTUNITY BRIEF #11 46
ECONOMICS OF ARCTIC OIL TRANSPORTATION 9
ECONOMICS OF FISH PROTEIN CONCENTRATE 11
Education 8, 52, 54-56
EFFECT OF BULBOUS BOW RETROFITS ON THE RESISTANCE AND SEAKEEPING OF A 50 METER FRESHFISH STERN TRAWLER 13
EFFECT OF WATER ON THE CRACK PROPAGATION RATE IN FIBERGLASS LAMINATES UNDER STATIC AND DYNAMIC LOADING 27
EFFECTS OF LIQUID STORAGE TANKS ON THE DYNAMIC RESPONSE OF OFFSHORE PLATFORMS 40
EFFECTS OF ORGANOTIN AND ORGANOLEAD COMPOUNDS ON YEASTS 21
EFFECTS OF SEA WATER AND CONCENTRATED SALT SOLUTIONS ON THE FATIGUE OF NYLON 6,6 FIBERS 26
EFFECTS OF SURFACE PHENOMENA ON THE SPREADING OF OIL ON WATER 21
EFFECTS OF TEMPERATURE CONDITIONING ON DEVELOPMENT AND GERMINATION OF GONYAULAX TAMARENSIS (DINOPHYCEAE) HYPNOZYGOTES 16
EFFECTS OF WATER ON ENZYME-CATALYZED REACTION OF GASEOUS SUBSTRATES 18
Effluents 4, 6, 19, 23
Ekman boundary layer 5
ELECTRIC POWER FOR THE TREATMENT OF WATER AND WASTEWATER 22
Electric power generation 9
Electron irradiation treatment 22, 23, 46, 50
ELECTRON IRRADIATION, SEWAGE SLUDGE AND AQUACULTURE—OPPORTUNITY BRIEF #6 46
Energy 9, 10, 46, 55
ENERGY AND DEVELOPMENT—A CASE STUDY 9
ENGINEERING AND ECONOMICS OF COAL-FIRED SHIP PROPULSION—OPPORTUNITY BRIE #26 46
ENGINEERING ASPECTS OF FRACTURE TOUGHNESS—FIBER-REINFORCED LAMINATES 27
Engineering education 30, 55, 56
ENGINEERING EDUCATION: A NATIONAL AGENDA–8TH ANNUAL ROBERT BRUCE WALLACE LECTURE 55
Engines 14, 49, 50
ENHANCEMENT OF THE STABILITY OF COMMON POLYMERIC MATERIALS AGAINST UNDERSEA DEGRADATION 26
Environment 4-6, 8, 9
Environmental law 54
ENZYMATIC OXIDATION OF ETHANOL IN THE GASEOUS PHASE 17
ENZYMATIC REMOVAL OF HAZARDOUS POLLUTANTS FROM INDUSTRIAL AQUEOUS EFFLUENTS 23
ENZYME CATALYZED REACTIONS IN THE GAS PHASE 17
Enzymes 17, 18
Epoxy 27
EQUIPMENT ARRANGEMENT USING INTERACTIVE COMPUTER GRAPHICS 41
Erosion 8, 60
ESTABLISHING NEW SALT MARSHES—MARINE AND COASTAL FACTS 58
ESTIMATES OF THE JOINT STATISTICS OF AMPLITUDES AND PERIODS OF OCEAN WAVES USING AN INTEGRAL TRANSFORM TECHNIQUE 40
ESTIMATION OF DYNAMIC CHARACTERISTICS OF DEEP OCEAN TOWER STRUCTURES 37
Estuaries 4, 6
EVOLUTION AND UTILIZATION OF MARINE MINERAL RESOURCES 9
EXPERIMENTAL PROCEDURE FOR THE PREDICTION OF THE DYNAMIC BEHAVIOR OF RISER TYPE SYSTEMS 35
EXPERIMENTAL STUDY AND ENGINEERING EVALUATION OF THE SALTER'S CAM WAVE ENERGY DEVICE 10
EXPERIMENTS IN SUPERVISORY CONTROL OF A COMPUTERIZED VEHICLE FOR INSPECTING CURVED SURFACES 31
EXPLORATION AND EVALUATION OF ENGINEERING PROPERTIES FOR FOUNDATION DESIGN OF OFFSHORE STRUCTURES 38
EXTENDED FISHERIES JURISDICTION—A PARTIALLY ANNOTATED BIBLIOGRAPHY WITH SPECIAL REFERENCES TO NEW ENGLAND 11
Factsheets 60
Fat, dietary 19
FATIGUE AND ENVIRONMENTAL RESISTANCE OF POLYESTER AND NYLON FIBERS 27
FATIGUE BEHAVIOR OF SYNTHETIC FIBERS, YARNS, AND ROPES 26
FATIGUE CRACK PROPAGATION IN 0°/90° E-GLASS/EPOXY COMPOSITES 27
FATIGUE CRACK PROPAGATION RATES IN WOVEN AND NON-WOVEN FIBERGLASS LAMINATES 27
Fatigue life 26, 27
Ferro-cement 27
Fiberglass 26-28, 48
FINAL REPORT ON A STUDY OF SHIP WAVE RESISTANCE 33
FINITE ELEMENT SIMULATION OF A SALTWATER / FRESHWATER INTERFACE WITH INDIRECT TOE TRACKING 6
FINITE-DEPTH WIND-WAVE MODEL. PART I—MODEL DESCRIPTION 5
Fish as food 15, 18, 19, 54
Fish handling 11, 58
Fish harvesting 58
Fish ladders 11
Fish Marketing 11, 15
Fish oils 19
Fish processing 15, 54
Fish protein concentrate 11
Fish, age determination 14
fish-oils 15, 54
Fisheries 8, 9, 11-15, 43, 52, 55
Fisheries education and training 12, 52
FISHERMAN AND FISH CONSUMER UNDER THE 200-MILE LIMIT 11
Fishing cooperatives 11
Fishing gear 11-14
Fishing industry 54, 58
FISHING VESSEL TOPICS—REPRINTS FROM COMMERCIAL FISHING. REPRINTS FROM COMMERCIAL FISHERIES NEWS 11
FLOW TESTS ON CABLES WITH FUZZ FAIRING 12

FLUME FOR THE STUDY OF CONTAINED OIL SLICKS 22
Food chain 14
Food technology 15, 17, 18, 45
Fouling 49
Foundations 25, 37, 38, 39, 45
Fracture mechanics 26, 27
FRACTURE OF FIBERGLASS -REINFORCED PLASTICS SUITABLE FOR HULL MATERIALS 27
FREE SURFACE FLOW THROUGH SALT MARSH GRASS 6
Freezer-trawlers 13
FREQUENCY SELECTION AND ASYMPTOTIC STATES IN LAMINAR WAKES 32
Fuel efficient engines 14
FULL SCALE RESISTANCE TESTS OF YANKEE TRAWLS OF BOTH NYLON AND POLYETHYLENE CONSTRUCTION 13
Funding for ocean research 54
FUTURE OF ATLANTIC PORTS 43
Game techniques 8
Gas-turbine engines 14
Gases 17, 18
GEOMETRIC MODELING ISSUES IN COMPUTER-AIDED DESIGN OF MARINE STRUCTURES 41
Georges Bank 9, 11, 54
GEORGES BANK PETROLEUM STUDY 9
GEORGES BANK—FISH AND FUEL 53
GEOTECHNICAL RELIABILITY OF OFFSHORE GRAVITY PLATFORMS 38
GEOTECHNICAL RESEARCH AT MIT—SPRING SEMINAR (1988—HOUSTON). OPPORTUNITY BRIEF #50 46
Geotechnical risk 38, 48, 50
Gloeocystis gigas 16
GLOUCESTER RESOURCE STUDY 8
Gloucester, MA 8
Gonyaulax excavata 16
Gonyaulax tamarensis 16, 17
Green function 34
Groundwater 6, 7
Guides 58
Harbors 8, 43
Herring run 11
High energy electron irradiation 22, 23
HIGH-EFFICIENCY BRAYTON-CYCLE ENGINES FOR MARINE PROPULSION 14
HOLBROOK COVE SURVEY—A 1972 STUDENT SUMMER OCEAN ENGINEERING LABORATORY RESEARCH PROJECT 23
Hook-up block 14
Horseradish peroxidase 23
Hulls 26, 27
HUMAN INTERACTIVE SIMULATION AND DISPLAY OF AN UNDERWATER REMOTELY OPERATED VEHICLE 31
Human-powered vehicles 30
Hyannis Harbor 8
HYBRID ELEMENT METHOD FOR CALCULATING THREE-DIMENSIONAL WATER WAVE SCATTERING 4
Hydrodynamics 5-7, 22, 23, 31, 33, 40, 41
Hydrophones 45
ICARUS—MIT'S HUMAN POWERED SUBMARINE 29
Ice and ice loading 25, 27, 51, 53
Ice, navigation in 25
Imaging systems 50
Impact loads 40
IMPACT OF DIETARY FAT ON HUMAN HEALTH 19
IMPACT OF OIL SPILLAGE FROM WORLD WAR II TANKER SINKINGS 21
IMPACT RESISTANCE OF MODIFIED FERRO-CEMENT PANELS 27
IMPACTS OF OFFSHORE OIL ON NORTHEAST SCOT LAND 9
Impedance control 30
IMPORTANCE OF LIFE CYCLE EVENTS IN THE POPULATION DYNAMICS OF GONYAULAX TAMARENSIS 16
IMPROVED TRAWL DOOR HOOK-UP SYSTEM 13
IMPROVEMENTS IN PART-LOAD EFFICIENCY BY REDUCING PRESSURE RATIO IN REGENERATIVE GAS-TURBINE ENGINES 13
INDUSTRIAL PROSPECTS FOR CHITIN AND PROTEIN FROM SHELLFISH WASTES 17
Information sources 58
INSTABILITY IN THE WAKE OF A STEADILY ADVANCING SHIP 33
Instamatic welding 28
INTERACTION OF WAVES AND OIL SPILLS 22
INTERNATIONAL CONFERENCE ON CHITIN/CHITOSAN—PROCEEDINGS 19
International cooperation 43
INTERNATIONAL TRANSFER OF MARINE TECHNOLOGY—A THREE-VOLUME STUDY 43
INVESTIGATION OF MECHANICAL PROPERTIES OF RAW FLESH AND SKIN OF SPINY DOGFISH (SQUALUS ACANTHIAS) 15
Irish Moss 8, 15
ISOLATION OF BIOACTIVE COMPOUNDS FROM SHARKS 19
Jurisdiction in the arctic 53
Land use 8, 9
LANDSCAPING THE SEASHORE COTTAGE— MARINE AND COASTAL FACTS 58
LARGE VARIABILITY OF WATER QUALITY IN COASTAL WATERS AND SUGGESTIONS FOR HOW WE CAN HANDLE THEM 6
Law and legislation 8, 9, 11, 43, 54, 55
Law of the Sea 43
LIFE HISTORY OF MORPHOLOGY OF FREE-LIVING PILAYELLA LITTORALIS (L.) Kjellm. (Ectocarpaceae, Ectocarpales) IN NAHANT BAY, MASSACHUSETTS 17
Lifeboats 12
LINEAR DYNAMICS OF COMPLIANT RISERS 35
Liquid crystals 28, 48
LIQUID CRYSTALS KIT FOR STRUCTURAL INTEGRITY ASSESSMENT OF FIBERGLASS WATERCRAFT 28
LONGSHORE CURRENT MODEL 5
LONGSHORE SEDIMENT TRANSPORT DATA—A REVIEW 5
Longuet-Higgins model 5
LOW COST SHORELINE PROTECTION IN MASSACHUSETTS 58
LOW FROUDE NUMBER WAKE OF FLOATING BLUFF OBJECTS 33
LOW-COST IMPROVEMENT FOR ALEWIFE (HERRING) PASSAGEWAYS 11
LOW-COST MULTICHANNEL RECORDING PIEZOMETER SYSTEM FOR WETLAND RESEARCH 7
LYNN HARBOR—PLANNING FOR COASTAL DEVELOPMENT 8
Maine 8, 9, 56
Maine Maritime Academy 56
Maine, Gulf of 6
MANAGING GLOUCESTER'S COAST 8

Manganese nodules 9, 46
Marinas 8
Marine and coastal information sources 58
Marine biology 14, 16, 17, 54
MARINE CORROSION AND BIOFOULING—OPPORTUNITY BRIEF #37 47
MARINE DECISIONS UNDER UNCERTAINTY 43
Marine ecosystems 9, 22, 23
MARINE ENVIRONMENT EFFECTS ON FATIGUE CRACK PROPAGATION IN GRP LAMINATES FOR HULL CONSTRUCTION 26
Marine industry advisory service 44-51
Marine researchers at MIT 58
MARINE-RELATED RESEARCH AT MIT 1990-1991 57
MARITIME COMMERCE AND THE FUTURE OF THE PANAMA CANAL 43
MARKETABILITY OF SQUID 14
MARPOL ANNEX V: NO MORE DUMPING PLASTICS IN THE OCEAN 58
MASS TRANSPORT IN DEEP-WATER WAVES 5
Massachusetts 8
Massachusetts Bay 4, 6, 9, 45
Massachusetts Fisheries Program 52
Massachusetts marine organizations 58
Massachusetts Maritime Academy 52
Materials and testing 26-28, 49
MATHEMATICAL MODEL FOR COMPLIANT RISERS 35
MATHEMATICAL MODEL FOR THE PREDICTION OF UNSTEADY SALINITY INTRUSION IN ESTUARIES 6
MATHEMATICAL MODELING OF DISPERSION IN STRATIFIED WATERS 4
MATHEMATICAL MODELING OF NEAR COASTAL CIRCULATION 6
MATHEMATICAL MODELS OF THE MASSACHUSETTS BAY 4
MATHEMATICAL SIMULATION OF POLLUTANT TRANSPORT IN BOSTON HARBOR 23
MATHEMATICAL SIMULATION OF TIDAL TIME AVERAGES OF SALINITY AND VELOCITY PROFILES IN ESTUARIES 6
MEASUREMENT AND PREDICTION OF VIBRATION RESPONSE OF DEEPWATER OFFSHORE STRUCTURES—OPPORTUNITY BRIEF #22 47
MECHANICAL PROPERTIES OF CHITOSAN FILMS—EFFECT OF SOLVENT ACID 18
MECHANICS OF A RESTRAINED LAYER OF FLOATING OIL ABOVE A WATER CURRENT 22
MECHANICS OF DEGRADATION IN MARINE ROPE 25
Mexico 45
Minerals, marine 9, 46, 48, 54, 55
MIT MARINE INDUSTRY ADVISORY SERVICE—A CRITICAL REVIEW 44
MIT research projects 58
MIT Sea Grant College Program 44, 52, 55, 58, 62
MIT SEA GRANT MARINE INDUSTRY COLLEGIUM—A TECHNOLOGY TRANSFER PARTNERSHIP OF INDUSTRY, ACADEMIA AND GOVERNMENT 44
MIT SEA GRANT PROGRAM BROCHURE 58
MIT SEA GRANT QUARTERLY REPORT 58
MIT SEA GRANT THESES LIST 1980-1983 57
MIT SEA GRANT—HELPING TO MANAGE A NATION'S INVESTMENT. A REPORT ON THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY SEA GRANT COLLEGE PROGRAM 1981-1984 59
MIT SEA GRANT—TEN YEARS OF OCEAN DEVELOPMENT. A REPORT ON THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY SEA GRANT COLLEGE PROGRAM 1970-1980 59
MIT SINGLE-SPECIES FISHERY SIMULATOR—APPLICATION TO THE GEORGES BANK YELLOWTAIL 11
MIT UNDERWATER TECHNOLOGY RESEARCH—TELEMANIPULATOR DEVELOPMENTS. OPPORTUNITY BRIEF #40 47
MIT UNDERWATER VEHICLE RESEARCH—RECENT ADVANCES AND FUTURE PROGRAMS—OPPORTUNITY BRIEF #36 47
MODEL BASED APPROACH TO 3-D IMAGING AND MAPPING UNDERWATER 32
MODELING AND GAMING FOR REGIONAL PLANNING—A MAINE STUDY 8
MODELING OF COASTAL PROCESSES—CIRCULATION, DISPERSION, AND WAVES—OPPORTUNITY BRIEF #38 47
MODELLING OF MARINE ROPE FATIGUE BEHAVIOR 27
Models, mathematical 4-6, 8, 11, 22-24, 32, 33, 35, 36, 41, 42, 45, 46, 50
MODIFIED METHOD FOR QUANTIFYING METHYL AND BUTYLTINS IN ESTUARINE SEDIMENTS 21
MOORING DYNAMICS FOR OFFSHORE APPLICATIONS 37
Moorings 35, 37
MULTISENSOR MODELING OF UNDERSEA TERRAIN 32
MULTISENSOR MODELING UNDERWATER WITH UNCERTAIN INFORMATION 32
Nahant Bay, MA 16, 17
Nantucket 8, 22
NANTUCKET SHORELINE SURVEY 8
NASA BUT NOT NOAA? FUNDING FOR OCEAN RESEARCH IN THE 1990s 54
NATIONAL RESPONSE CAPABILITY TO OIL SPILLS—A SYSTEMS APPROACH 22
National Sea Grant College Program 23
Navigation 31, 56
Negotiation 54
NEW DESIGN FOR PARALLEL LINK MANIPULATORS 30
NEW DIMENSIONS OF U.S. MARITIME POLICY 43
New England 9, 11, 16
NEW ENGLAND RED TIDE— MARINE AND COASTAL FACTS 58
NEW GENERATION OF UNDERWATER UNMANNED TETHERED VEHICLES CARRYING HEAVY EQUIPMENT AT LARGE DEPTHS 32
NEW TECHNIQUES FOR OCEAN MEASUREMENT. OPPORTUNITY BRIEF #52 47
NEW TOWING BLOCK FOR SIDE-TRAWLING 14
NEW UNDERWATER COMMUNICATION SYSTEM—OPPORTUNITY BRIEF #19 48
Nitrogen nutrient cycle 4
NONDESTRUCTIVE EVALUATION OF FIBER COMPOSITES—OPPORTUNITY BRIEF #21 48
Nondestructive testing 28, 48
NONLINEAR STATICS OF NONROTATIONALLY UNIFORM RODS WITH TORSION 35
NOTCH GEOMETRY AND LAMINATE CONSTRUCTION EFFECTS ON THE FRACTURE TOUGHNESS OF LAMINATES FOR HULL CONSTRUCTION 26
NOVEL APPLICATIONS OF MARINE BIOPOLYMERS. OPPORTUNITY BRIEF #54 48
NUMERICAL METHODS IN WATER WAVE

DIFFRACTION AND RADIATION 40
NUMERICAL MODEL FOR THE PREDICTION OF TRANSIENT WATER QUALITY IN ESTUARY NETWORKS 4
NUMERICAL MODEL OF SEAWATER INTRUSION IN AQUIFERS 6
NUMERICAL MODELING OF DISPERSION IN STRATIFIED WATERS 4
NUMERICAL MODELING OF SORPTION KINETICS OF ORGANIC COMPOUNDS TO SOIL AND SEDIMENT PARTICLES 24
Nutrition 15
Nylon trawls 13
OBJECTIVE TACTILE SENSING STRATEGY FOR OBJECT RECOGNITION AND LOCALIZATION 31
Ocean acoustic telemetry 45
Ocean circulation 4-6, 45, 47
OCEAN COMMERCE AND THE PANAMA CANAL 43
Ocean currents 5, 6, 22
OCEAN DISPOSAL OF MUNICIPAL WASTEWATER—IMPACTS ON THE COASTAL ENVIRONMENT 23
Ocean dumping 23, 55
Ocean engineering 4, 6, 26-41, 43, 53, 55, 56, 58
Ocean engineering education 23, 55, 56
OCEAN ENGINEERING POWER SYSTEMS 56
OCEAN ENGINEERING SUMMER LABORATORY 56
OCEAN ENGINEERING SYSTEMS 56
Ocean mining 9, 46, 48, 54, 55
OCEAN TRANSPORTATION 43
Ocean transportation 43, 55, 56
Ocean wave energy 10
Oceanographic instrumentation 11, 25, 29, 31, 47-50, 56
OCEANOGRAPHIC INSTRUMENTATION AT WOODS HOLE OCEANOGRAPHIC INSTITUTION—OPPORTUNITY BRIEF #45 48
Oceanography 5-7, 29, 34, 43, 56
OCEANS—PLANETARY ENGINEERING AND INTERNATIONAL MANAGEMENT 53
OCS PETROLEUM PIE 9
OFFSHORE GEOTECHNICAL EVALUATION—OPPORTUNITY BRIEF #27 48
OFFSHORE MINING OF SAND AND GRAVEL—OPPORTUNITY BRIEF #2 48
Offshore petroleum 9, 22, 34, 43, 55
OFFSHORE PETROLEUM ENGINEERING—A BIBLIOGRAPHIC GUIDE TO PUBLICATIONS AND INFORMATION SOURCES 34
Offshore safety 12
Offshore structures 33-41, 45-48, 50, 51, 53, 56
OIL POLLUTION OF THE OCEANS—A TANKER OWNER'S PERSPECTIVE 53
OIL SPILL CLEAN-UP, AN ECONOMIC AND REGULATORY MODEL—OPPORTUNITY BRIEF #25 48
OIL SPILL INCIDENCE SIMULATION MODEL—DESCRIPTION AND USER'S MANUAL 21
Oil spills 9, 21-23, 34, 45, 48, 49, 54
OIL SPILLS—PROBLEMS AND OPPORTUNITIES—OPPORTUNITY BRIEF #9 49
Oil transportation 9
OMEGA-3 FATTY ACIDS IN HEALTH AND DISEASE 54
ON THE RATIONAL SELECTION OF STRENGTHENING CRITERIA FOR NAVIGATION IN ICE 25
Opportunity briefs 45-51
OPTICAL TACTICAL SENSOR FOR MANIPULATORS 31
OPTIMAL RESPONSE TO OIL SPILLS—THE STRATEGIC DECISION CASE 22
Organometals 21
Orinoco clay 37
OVERALL COMPRESSION BUCKLING OF PARTIALLY CONSTRAINED SHIP GRILLAGES 26
Oyster culture 19, 45
Panama canal 43, 55
PARABLE BEACH—A PRIMER IN COASTAL ZONE ECONOMICS 8
Paralytic shellfish poisoning 16
PARAMETRIC WIND-WAVE MODEL FOR ARBITRARY WATER DEPTHS 5
Perched beach construction 60
Peroxidase 23
Pharmaceuticals 19, 53
Phytoplankton 16
PIECEWISE CONTINUOUS ALGEBRAIC SURFACES IN TERMS OF B-SPLINES 41
PIEZOCONE PENETROMETER 38
Pilayella littoralis 16, 17
PIONEER DEEP OCEAN MINING VENTURE 9
Pipelines 45
Plankton 14
Plates, ship 26
Plymouth Nuclear Power Station 4
Pollution 4, 6, 8, 9, 16, 21-24, 48, 50, 54
Polyethylene trawls 13
Polymeric materials 26, 48
Polysaccharides 53
PORE PRESSURE DISSIPATION AFTER CONE PENETRATION 38
PORE PRESSURES DURING CONE PENETRATION IN CLAYS 39
PORT DESIGNS AND ANALYSIS METHODOLOGY 43
Ports 43
POTENTIAL BIOLOGICAL EFFECTS OF HYPOTHETICAL OIL DISCHARGES IN THE ATLANTIC COAST AND GULF OF ALASKA 22
POTENTIAL FOR ADVANCED BRAYTON-CYCLE ENGINES FOR COMMERCIAL VESSELS 14
POTENTIAL IMPORTANCE OF BENTHIC CYSTS OF GONYAULAX TAMARENSIS AND G. EXCAVATA IN INITIATING TOXIC DINOFLAGELLATE BLOOMS 16
POTENTIAL LIPID OXIDATION PROBLEMS IN FATTY FISH PROCESSING 15
POTENTIOMETRIC DETERMINATION OF COPPER COMPLEXATION BY PHYTOPLANKTON EXUDATES 17
Power plants 8, 9, 55
Power sources 55, 56
POWER SYSTEMS FOR SMALL UNDERWATER VEHICLES—OPPORTUNITY BRIEF #51 49
POWER, POLLUTION, AND PUBLIC POLICY 9
PREDICTION OF THE DAMPING-CONTROLLED RESPONSE OF OFFSHORE STRUCTURES TO RANDOM WAVE EXCITATION 40
PREDICTION OF UNSTEADY SALINITY INTRUSION IN ESTUARIES—MATHEMATICAL MODEL AND USER'S MANUAL 6
PRELIMINARY ASSESSMENT OF THE ENVIRONMENTAL VULNERABILITY OF MACHIAS BAY, MAINE, TO OIL SUPERTANKERS 9
PRELIMINARY FEASIBILITY STUDY OF IRISH MOSS HARVESTING SYSTEMS 15
PRIMARY PHYSICAL IMPACTS OF OFFSHORE PETROLEUM DEVELOPMENTS—REPORT TO COUNCIL ON ENVIRONMENTAL QUALITY 9
PROBLEMS AND POTENTIALS OF RECYCLING WASTES FOR AQUACULTURE 19

PROCEEDINGS OF THE FIRST INTERNATIONAL CONFERENCE ON TOXIC DINOFLAGELLATE BLOOMS 55
PROCESSING OF CHITOSAN MEMBRANES 17
PROCESSING SQUID FOR FOOD 15
PROGRESS IN CONTROLLED ENVIRONMENT AQUACULTURE AND ALGAE HUSBANDRY. OPPORTUNITY BRIEF #24 49
PROGRESS IN UNDERWATER TELEMANIPULATOR RESEARCH—OPPORTUNITY BRIEF #23 49
PROPERTIES—COUNTER-ION ACTIVITY IN A CATIONIC POLYELECTROLYTE SOLUTION 18
Propulsion 13, 14, 46
PROSPECTS FOR A NEW REGIME OF THE SEAS—INTERNATIONAL POLITICAL CONSIDERATIONS 43
PROSPECTS FOR HIGH-ENERGY ELECTRON IRRADIATION OF WASTEWATER LIQUID RESIDUALS 23
PROTECTION OF MATERIALS IN THE MARINE ENVIRONMENT—OPPORTUNITY BRIEF #20 49
PUBLIC WASTE MANAGEMENT AND THE OCEAN CHOICE 54
Publications directory 58
QUANTITATIVE GEOMETRIC CHARACTERIZATION OF TWO-DIMENSIONAL FLAWS VIA LIQUID CRYSTALS AND THERMOGRAPHY 28
QUICK-RELEASE HOOK FOR LIFEBOATS AND OFFSHORE RIGGING 12
REALISTIC MODEL OF THE WIND-INDUCED EKMAN BOUNDARY LAYER 5
Recreation 8
Red tide 16, 17, 54
REDUCING POSTHARVEST LOSSES OF FISH IN THE THIRD WORLD 11
Refrigeration systems 13
REGULATION OF GROWTH IN AN ESTUARINE CLONE OF GONYAULAX TAMARENSIS LEBOUR—SALINITY-DEPENDENT TEMPERATURE RESPONSES 17
Remote sensing 29, 31, 49
REMOTE SENSING AND OCEANOGRAPHIC EQUIPMENT TECHNOLOGY—SOME PRESENT SYSTEMS AND FUTURE NEEDS. OPPORTUNITY BRIEF #41 49
REPORT ON FUNDAMENTAL RESEARCH ON UNDERWATER WELDING 28
REPORT ON THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY SEA GRANT COLLEGE PROGRAM—1 JULY 1978 to 30 JUNE 1979 59
RESPONSE OF MASSACHUSETTS BAY TO WIND STRESS 6
RETROFIT SAIL-ASSIST ON NEW ENGLAND FISHING VESSELS 13
REVIEW AND EVALUATION OF BASIC TECHNIQUES FOR PREDICTING THE BEHAVIOR OF OIL SLICKS 22
REVIEW OF EFFECTIVE PLATING TO BE USED IN THE ANALYSIS OF STIFFENED PLATING IN BENDING AND COMPRESSION 26
Risers 34-37
RISKS AND COSTS FOR OCEAN STRUCTURES—OPPORTUNITY BRIEF #17 50
Robot submarine 29, 50
ROBUST DESIGN METHOD FOR IMPEDANCE CONTROL OF CONSTRAINED DYNAMIC SYSTEMS 30
ROLL DAMPING ON A 119 FOOT NEW ENGLAND TRAWLER—AN EXPERIMENTAL INVESTIGATION 34
ROLL DAMPING ON A 76 FOOT NEW ENGLAND TRAWLER—AN EXPERIMENTAL INVESTIGATION 33
Rope 25-27
Run-off 6
RUPTURE ANALYSIS OF SHIP PLATING DUE TO HYDRODYNAMIC WAVE IMPACT 41
RUSSIAN TRANSLATIONS—ON TRAWL HYDRODYNAMICS and HYDRODYNAMIC WATER CHANNEL FOR FISHING GEAR RESEARCH 12
Safety 12
Sail-assist 13
Salinity 4, 6
Salt marshes 6, 7
Salter's Cam wave energy device 10, 51
Sand and Gravel mining 9, 48
SATELLITE IMAGE ANALYSIS FOR MARINE APPLICATIONS—OPPORTUNITY BRIEF #53 50
Saudi Arabia 9
SCIENCE, ENGINEERING, ECONOMICS, AND POLITICS OF OCEAN HARD MINERAL DEVELOPMENT 53
Scotland 9
Sea Grant Lectures 53-55
SEA GRANT PUBLICATIONS FOR THE FISHING INDUSTRY 57
Seafood processing 11, 14, 15, 58
Seakeeping 13, 39
SEAKEEPING CALCULATIONS FOR SWATH SHIPS USING A NEW MODIFIED VERSION OF CAT-5 39
SEARCH FOR DEFENCE AND OTHER OCEAN ENGINEERING PROJECTS 56
SEAS AND THE WATERWAYS—THE NEW FRONTIER 53
Seawater intrusion 6
Seaweed harvesting 15
Sediment transport 5, 6
Sediments 24, 25, 38, 39, 50
SEEDING OF TWO RED TIDE BLOOMS BY THE GERMINATION OF BENTHIC GONYAULAX TAMARENSIS HYPNOCYSTS 16
Sewage 22, 23, 45, 46, 55
SEWAGE DISPOSAL AND THE OCEAN—THE SEA GRANT ROLE 23
SHAFT RESISTANCE OF PILES IN CLAY 37
Shark as food 14, 15
SHARK CARTILAGE CONTAINS INHIBITORS OF TUMOR ANGIOGENESIS 19
Sharks 19
Shellfish wastes 17, 19, 45
Ship design and construction 13, 25, 34, 43, 45, 46
Ship handling 41
Ship hydrodynamics 33, 34, 41
Ship structures 26
Ship wave resistance 33, 34
Shipping 43, 54, 55
Shore protection manual 5
SHORELINE FOR THE PUBLIC—A HANDBOOK OF SOCIAL, ECONOMIC, AND LEGAL CONSIDERATIONS REGARDING PUBLIC RECREATIONAL USE OF THE NATION'S COASTAL SHORELINE 8
Side-trawling 14
Single-species simulator 11
SMALL ROBOT SUBMARINE FOR OCEANOGRAPHIC APPLICATIONS 29
SMALL SCALE TIDAL POWER PLANTS 10
Soil mechanics 25, 37-39, 45
SOLUTION PROPERTIES OF CHITOSAN—CHAIN CONFORMATION 18
SOME FEDERALLY SPONSORED RESEARCH

PROGRAMS FOR UNMANNED UNDERWATER VEHICLES—OPPORTUNITY BRIEF #18 50
Sonar 31
SPECTRAL MODEL FOR WAVE ATTENUATION BY BOTTOM FRICTION—EXPERIMENTS 5
SPECTRAL WAVE ATTENUATION BY BOTTOM FRICTION—THEORY 5
SPECTROFLOUROMETRIC DIFFERENTIATION OF THE RED TIDE ALGA, GONYAULAX TAMARENSIS, FROM OTHER ALGAE COMMON TO NEW ENGLAND WATERS 16
SPINY DOGFISH SHARK, A SEAFOOD SPECIALTY—MARINE AND COASTAL FACTS 58
SPRING RUN-OFF AND NUTRIENT- SEAWATER DENSITY CORRELATIONS IN THE MASSACHUSETTS BAY 6
Squalus acanthias 14, 15
Squid 11, 15, 17, 18
SQUID PROTEIN CONCENTRATES 18
SQUID PROTEIN ISOLATE 18
SQUID TECHNOLOGY APPLIED TO THE STUDY OF ELECTROCHEMICAL CORROSION 25
STABILITY OF A STRING IN AXIAL FLOW 36
STABILIZATION OF BARRIER DUNES BY VEGETATION—MARINE AND COASTAL FACTS 58
STANDARD SERIES TRAWL TESTS 12
STATE INDUSTRY WORKSHOP ON THE COASTAL ZONE MANAGEMENT ACT OF 1972 8
STATIC ANALYSIS TECHNIQUE FOR MULTI-LEG CABLE-BUOY SYSTEMS 35
STATIC AND FATIGUE ANALYSIS OF MULTI-LEG MOORING SYSTEM 37
STATUS OF ENGINEERING IN THE OCEAN ENVIRONMENT TODAY 56
Steel, cathodic protection 47
Steel, offshore structures 40, 50
STOCHASTIC FEM IN SETTLEMENT PREDICTIONS 38
STRENGTH-DEFORMATION PROPERTIES OF ARCTIC SILT 25
STRENGTHENING OCEAN ENGINEERING IN THE SEA GRANT PROGRAM 55
STRESS INTENSITY FACTORS FOR ANISOTROPIC FRACTURE TEST SPECIMENS OF SEVERAL GEOMETRIES 27
STRESS RELAXATION OF A POLYELECTROLYTE NETWORK AS AFFECTED BY IONIC STRENGTH 18
STRUCTURAL ACOUSTICS—AN APPLIED SCIENCE WITH MANY APPLICATIONS—OPPORTUNITY BRIEF #56 50
STRUCTURAL MODELING OF THE TENSILE BEHAVIOR OF EIGHT STRAND ROPES 27
Structural response 34-36, 39-41, 50, 51
STRUCTURE OF CHITIN AND CHITOSAN 17
STRUCTURES WITH PARTIAL FRICTIONAL CONSTRAINTS 25
Stud welding 28
STUDENT PROJECTS ON COASTAL ZONE AND OFFSHORE RESOURCES MANAGEMENT 8
STUDENT PROJECTS ON THE OXIDATION BY MARINE BACTERIA OF AROMATIC COMPOUNDS FOUND IN OIL 22
STUDY OF AUTOMATIC MEANS OF DETERMINING THE AGE OF FISH 14
STUDY OF MEANS OF AUTOMATICALLY CLASSIFYING PLANKTON 14
Submarine topography 32
Submersibles 29-32, 48-50
SUBSURFACE FLOW IN SALT MARSH PEAT 7
SUGGESTIONS FOR THE REVITALIZATION OF THE VILLAGE OF HYANNIS 8
SUPERMAN—A SYSTEM FOR SUPERVISORY MANIPULATION AND THE STUDY OF HUMAN/COMPUTER INTERACTIONS 29
SURFACE-TO-SURFACE INTERSECTIONS FOR GEOMETRIC MODELING 42
SURVEY OF MASSACHUSETTS FISHERIES PROGRAM 52
SURVIVAL IN COLD WATER—MARINE AND COASTAL FACTS 58
Swath ships 39
TACTICAL DECISION ALGORITHM FOR THE OPTIMAL DISPATCHING OF OIL SPILL CLEANUP EQUIPMENT 22
TANKER SPILLS, COLLISIONS, AND GROUNDINGS 21
Tankers 9, 21, 22, 54, 55
TEACHING COASTAL ZONE MANAGEMENT—AN INTRODUCTORY COURSE SYLLABUS 8
Technology transfer 43, 44
TELEMANIPULATORS FOR UNDERWATER TASKS—OPPORTUNITY BRIEF #3 50
Teleoperators 29-31, 46, 47, 49, 50
TELEOPERATORS UNDER THE SEA—OPPORTUNITY BRIEF #14 50
TEST RESULTS FROM THE NEW ENGLAND TRAWL NET TRAINING COURSES 12
THEFT-PROOFING BOATS—MARINE AND COASTAL FACTS 58
THEORETICAL AND EXPERIMENTAL PREDICTION OF THE RESPONSE OF A MARINE RISER MODEL—REPORT SERIES 34, 35
Thermal effluents 4, 19
THERMAL NONDESTRUCTIVE TESTING OF FIBERGLASS USING LIQUID CRYSTALS. A TWO-PART REPORT 28
Thermodynamics 56
Theses 58
THREE-DIMENSIONAL NON-LINEAR DYNAMICS OF COMPLIANT RISERS 36
Tidal power 10
Tides 4, 6
TIME SERIES ANALYSIS OF OCEAN WAVES 4
Topography 32
Tourism 8
TOW TANK RESULTS OF BULBOUS BOW RETROFITS ON NEW ENGLAND TRAWLER HULLS 13
TOWARD DEEP OCEAN MINING IN THE NINETIES 9
TOWARDS IMPROVED TECHNIQUES FOR PREDICTING SOIL STRENGTH—OPPORTUNITY BRIEF #16 50
Towed instrumented glider 31
Towing block 14
Trace metals 16
TRACING AND MODELLING POLLUTION TRANSPORT IN BOSTON HARBOR 23
Trawl door hook-up system 13
Trawl gear 11-14
TRAWL GEAR TOPICS—REPRINTS FROM COMMERCIAL FISHERIES NEWS 12
Trawlers 13, 33, 34
TRIENNIAL REPORT OF THE MIT SEA GRANT COLLEGE PROGRAM 59
Tumor angiogenesis 19
Two-hundred mile limit 11
U.S. Naval Ship R & D Center 13
Undersea operations 28, 29, 31, 49, 50
UNDERSEA TELEOPERATORS AND INTELLIGENT

AUTONOMOUS VEHICLES 29
Underutilized species 14, 15
Underwater archeology 56
Underwater vehicles 29-32, 46-50
Underwater welding 28, 45, 47
UNDRAINED CYCLIC SIMPLE SHEAR BEHAVIOR OF CLAY WITH APPLICATIONS TO PILE FOUNDATIONS SUPPORTING TENSION LEG PLATFORMS 39
UNITED STATES AND THE OCEANS—OPPORTUNITIES FOR INDEPENDENCE 53
UNTETHERED ROBOT SUBMERSIBLE INSTRUMENTATION SYSTEMS—OPPORTUNITY BRIEF #5 50
USER'S MANUAL FOR "CAFE-2"—A TWO LAYER FINITE ELEMENT CIRCULATION MODEL 6
USER'S MANUAL FOR "DISPER-2"—A MULTI-LAYER FINITE ELEMENT DISPERSION MODEL 4
USING COOPERATIVES TO AID THE NEW ENGLAND FISHING INDUSTRY 11
VEHICLE DESIGN—MOTORS AND PROPULSORS. OPPORTUNITY BRIEF #55 50
VIBRATION RESPONSE AND THE STRUCTURAL INTEGRITY OF DEEPWATER STRUCTURES—OPPORTUNITY BRIEF #10 50
VORTEX INDUCED RESPONSE OF A FLEXIBLE CYLINDER IN A CONSTANT CURRENT 36
VORTEX INDUCED RESPONSE OF A FLEXIBLE CYLINDER IN A SHEARED CURRENT 35
Waste disposal and treatment 22, 23, 45, 50, 55
Waste-heat utilization 13
WASTE-HEAT-DRIVEN REFRIGERATION PLANTS FOR FREEZER TRAWLERS 13
Wastes, recycling of 19, 46
Wastewater 19, 22, 23, 50, 55
WASTEWATER MANAGEMENT—TECHNICAL ALTERNATIVES AND REGULATORY OUTLOOK—OPPORTUNITY BRIEF #32 50
Water quality 4, 6, 22, 23, 54
WAVE AND ICE IMPACT LOADING AND RESPONSE OF OCEAN STRUCTURES—OPPORTUNITY BRIEF #39 51
Wave energy 10, 51
Wave forces 6, 33, 34, 37, 39-41, 51
WAVE FORCES ON A SUBMERGED OBJECT 32
WAVE POWER SYSTEMS—OPPORTUNITY BRIEF #15 51
Waves 4-6, 22, 34, 40, 47
WAVES AND WAVE FORCES 6
Welding 27, 28, 45, 47
Wetlands 6, 7
WIDE BANDWIDTH POSITIONING SYSTEMS FOR SPACE AND UNDERWATER VEHICLES 30
Wind 4-6, 22, 23
Wind-generated waves 5
Windmills 56
Woods Hole Oceanographic Institution 48
WORLD ENERGY AND THE OCEANS 53
World War II tankers 21
Yeasts 21
Yellowtail flounder 11
Zooplankton 14

# Sea Grant Number Index 1971-1990


**1971**

71-1 8
71-2 23
71-3 11
71-4 9
71-5 43
71-6 56
71-7 43
71-8 9
71-10 22

**1972**

72-1 25
72-2 14
72-3 56
72-4 32
72-5 43
72-6 27
72-7 6
72-8 11
72-9 9
72-11 6
72-12 37
72-13 8
72-14 15
72-15 4
72-16 9
72-17 43
72-18 43
72-19 23
72-20 56
72-21 6

**1973**

73-1 53
73-2 19
73-4 6
73-5 9
73-6 9
73-8 23
73-9 27
73-10 26
73-11 26
73-12 4
73-13J 43
73-14 27
73-15 26
73-16 26

**1974**

74-1 8
74-3 8
74-4 4
74-6 56
74-7 53
74-8 5
74-9 6
74-10 27
74-11 14
74-12 56
74-13 15
74-14 4
74-15 56
74-16 8
74-18 27
74-19 22
74-20 9
74-21 27
74-22 58
74-24 14
74-25 8
74-26 9
74-27 19
74-28 43
74-29 28
74-30J 18
74-31 43

**1975**

75-1 8
75-2 6
75-3 53
75-4 59
75-6 11
75-7 11
75-8 55
75-10 9
75-11 8
75-12 56
75-13 6
75-14 58
75-15 9
75-16J 18
75-17 17
75-18 27
75-19 23
75-20 11
75-21 8
75-22 22
75-23 8
75-24 14
75-25 27

**1976**

76-1 53
76-2 59
76-3 56
76-4 8
76-5 45
76-6 48
76-7 50
76-8 45
76-9 50
76-10 4
76-11 4
76-12 4
76-13 58
76-14 4
76-15J 29
76-16 4
76-17 4
76-18 23
76-19 6
76-20 30

**1977**

77-1 53
77-2 59
77-3 17
77-4 21
77-5 11
77-6 6
77-7 4
77-8 22
77-9 28
77-10 22
77-11J 5
77-12 58
77-13 58
77-14 46
77-15 45
77-16 46
77-17 49
77-18 16
77-19 22
77-20 43
77-21 11
77-22 56
77-23 8

**1978**

78-1 53
78-2 59
78-3 8
78-4 9
78-5 34
78-6 58
78-7 19
78-8 22
78-9 58
78-10 50
78-11 46
78-12 46
78-13 45
78-14 17
78-15J 16
78-16J 5
78-17J 40
78-18J 5
78-19J 17
78-20J 16
78-22 10

**1979**

79-1 53
79-2 59
79-3 55
79-6 58
79-7 8
79-8 38

79-9J 40
79-10 44
79-11J 11
79-12J 10
79-13 6
79-14 21
79-15 50
79-16 51
79-17 50
79-18 50
79-19J 58
79-20 29
79-21 8
79-22 13
79-23 33
79-24J 16
79-26J 16
79-27 6
79-28J 5
79-30J 15
79-31 21

**1980**

80-2 59
80-4J 22
80-5 50
80-6 48
80-7 49
80-8 48
80-9J 40
80-10 58
80-11 31
80-12 39
80-13 38
80-14 14
80-15 59
80-16J 16
80-17 21
80-18J 22
80-19 31
80-20 38
80-21 38

**1981**

81-1 53
81-2 28
81-3 47
81-4 49
81-5 49
81-6 48
81-7 46
81-8 55
81-9 39
81-10 38
81-11 58
81-13 33
81-14 26
81-15 8
81-16 28

**1982**

82-1 9
82-3 48
82-4 46
82-5 46
82-6J 7
82-7J 7
82-9/10 10
82-11 37
82-12J 18
82-13 35
82-14 58
82-15 16
82-16J 17
82-17J 18
82-18J 17
82-19 30
82-20 57
82-21J 6
82-22J 39
82-23J 12
82-24J 18
82-25 53

**1983**

83-1 54
83-2 34
83-3 34
83-4 34
83-5 34
83-6 34
83-7 40
83-8 57
83-9 50
83-10 45
83-11 13
83-12 13
83-13 38
83-14 9
83-15 34
83-16 6
83-17 23
83-18 34
83-19 34
83-20 34
83-21 34
83-22 35
83-23 35
83-26 52
83-29J 16
83-31 58
83-32 12
83-33 23

**1984**

84-1 54
84-2 45
84-3 47
84-4 47
84-5 47
84-6J 28
84-7J 44
84-8J 19
84-9TN 27
84-10 13
84-11 28
84-13J 18
84-14J 18
84-15 14
84-18 59

**1985**

85-1J 36
85-2J 38
85-3J 20
85-4J 40
85-5J 39
85-6 23
85-7 13
85-8J 14
85-9J 14
85-10 14
85-11J 28
85-12 29
85-13J 41
85-14J 35
85-15 13
85-16J 30
85-17 35
85-18 35
85-19 35
85-20 51
85-21 49
85-22J 25
85-23J 35
85-24J 36
85-25J 35
85-26J 36
85-27 47
85-28 55
85-29TN 31
85-30TN 32
85-31 58
85-32TN 25
85-33 12
85-34 30
85-35TN 30
85-36 54
85-37 12
85-38J 37

**1986**

86-1 37
86-2 37
86-3TN 41
86-5 40
86-6 58
86-7TN 39
86-8J 22
86-9 13
86-10 58
86-11 58
86-12 46
86-13 45
86-14 45
86-15 48
86-16 23
86-18 11
86-19J 31
86-21 37
86-22J 22

**1987**

87-1 29
87-3TN 23
87-5J 31

87-6J 25
87-7J 26
87-8TN 4
87-10J 11
87-11 36
87-12 34
87-13 33
87-14J 25
87-15J 25
87-16J 26
87-17J 26
87-18J 27
87-19 42
87-20 39

**1988**

88-1 46
88-2 58
88-3 19
88-4J 32
88-5 41
88-6J 33
88-7J 5
88-8 42
88-9J 11
88-10J 12
88-11 49
88-12 19
88-13 47
88-14J 24
88-15J 15

**1989**

89-1 54
89-2 54
89-3 50
89-4 29
89-5P 33
89-7 48
89-8 33
89-9 55
89-10J 41
89-11 58
89-12J 27
89-13J 32
89-14J 41
89-15TH 40
89-16 19
89-17J 5
89-18P 17
89-19P 17
89-20P 18
89-21TH 17
89-22P 42
89-23J 5
89-24 50
89-26J 31
89-27J 32
89-28 27
89-29TH 32
89-30J 29
89-31J 12
89-32J 33
89-33 50

**1990**

90-1 59
90-2 54
90-3 57
90-4 32
90-5 30
90-7J 37
90-8 29
90-9J 21
90-10J 21
90-11J 21
90-12 57
90-13 57

# Order Forms

Please send me the following reports:

MITSG#_____ Title:_____ Price:_____

MITSG#_____ Title:_____ Price:_____

MITSG#_____ Title:_____ Price:_____

MITSG#_____ Title:_____ Price:_____

MITSG#_____ Title:_____ Price:_____

TOTAL:_____

Name:_____ Company:_____

Address:_____

City:_____ State:_____ Zip code:_____

Enclosed is a check for the amount of $_____

MIT Sea Grant College Program, Publications Department, Bldg. E38-356, 292 Main Street, Cambridge, MA 02139

Please send me the following reports:

MITSG#_____ Title:_____ Price:_____

MITSG#_____ Title:_____ Price:_____

MITSG#_____ Title:_____ Price:_____

MITSG#_____ Title:_____ Price:_____

MITSG#_____ Title:_____ Price:_____

TOTAL:_____

Name:_____ Company:_____

Address:_____

City:_____ State:_____ Zip code:_____

Enclosed is a check for the amount of $_____

MIT Sea Grant College Program, Publications Department, Bldg. E38-356, 292 Main Street, Cambridge, MA 02139