MIT Sea Grant

# Quarterly Report

## US Naval Facility Made Available for Fishery Research

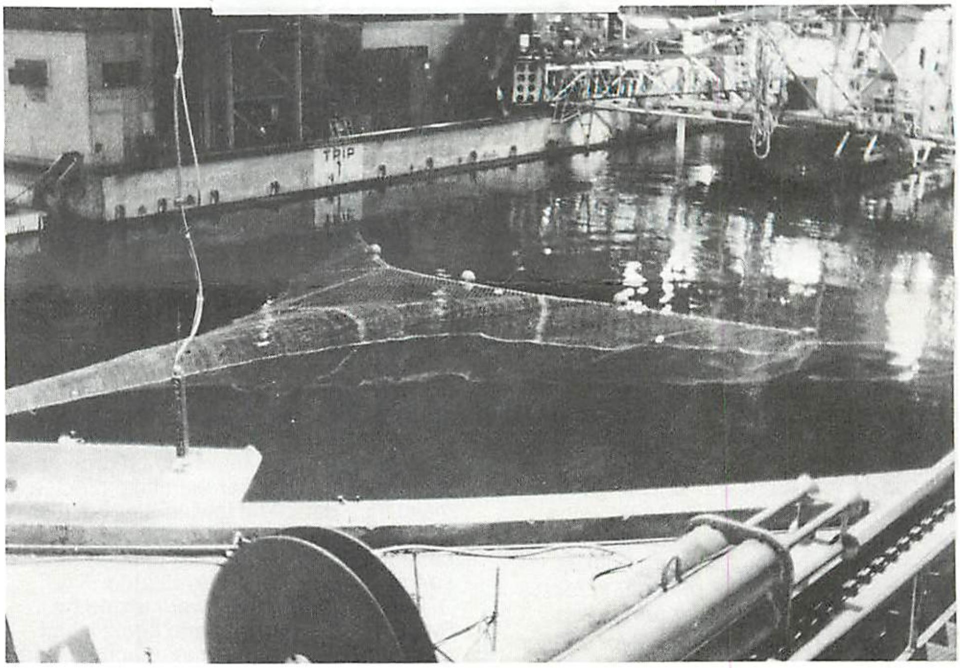


Figure 1 Full scale ground fish trawl being rigged for testing in the towing basin.

For years fishermen have used "trawl" nets as the predominant fishing method to catch fish swimming on the ocean bottom or spread out in the water column. Trawling vessels are equipped with huge nets towed by long cables through the water behind the boat. Large wooden or steel "doors" on either side of the net keep it wide open to capture fish in its path.

It is a time-tested method, one that has not changed much in a long history. Recently, with the high cost of fuel and increased demand for seafood, net manufacturers and gear researchers are taking another look at trawl net design to decrease the amount of fuel needed for towing and increased productivity. Researchers need to experiment with different twines, mesh sizes, net types and handling techniques. Unfortunately it is awkward, expensive, and time-consuming to test trawls at sea. However, many countries with sizable fishing industries have begun constructing land-based facilities for experimenting with scale models of fishing gear. Britain has an excellent testing installation run by the Sea Fish Industry Authority (SFIA) (formerly the White Fish Authority). Denmark has just completed one, and facilities in other countries are in various stages of planning and construction.

The largest and most sophisticated facility suitable for gear testing is located in the United States, in Bethesda, Maryland. The Navy's David W. Taylor Naval Ship Research and Development Center (NSRDC) has been used for many years for studying the hydrodynamics of ships, submerged vessels, and towed equipment. Until recently the Center had not been used for testing fishing nets, but MIT Sea Grant has arranged with the Navy to use NSRDC facilities for this purpose. MIT Sea Grant's plan, aside from its own research goals, is to coordinate use of the facilities by others, including the National Marine Fisheries Service, net manufacturers, designers of trawling gear, and other Sea Grant programs. These researchers will have the advantage of using an outstanding facility built to standards and on a scale that would be difficult economically to duplicate today.

Trawl net testing facilities usually are one of two types. The first is a large closed-loop channel of water with impellers and flow control devices for circulating the water through a test section where scale model nets are positioned. The nets are secured by cables to adjustable vertical struts. In this way, the net is stationary, enabling researchers to take various measurements and observe the net's behavior, while the water passing through gives the effect that it is being towed. The circulating channel is used to test designs in their early stages, when many changes will be made, many different parameters need to be tested, and the unavoidable, minor inaccuracies of reduced scale are not important.

The other type of testing facility is a towing basin. Towing basins are long tanks of water, often large enough to accommodate larger net models. The nets are attached to a towing carriage which travels over the length of the basin at variable speeds, pulling the net. Since the net is moving, observation is more difficult than in the circulating channel, but the advantages of the towing basin are that the velocities are more precise and turbulence present in the circulating tank is eliminated.

NSRDC has both a circulating channel and several towing basins. The overall length of the circulating channel is 150 feet, with a test section 60 feet long. Figure 2 is a vertical longitudinal section of the tank. The test section is 22 feet wide (significantly larger than other facilities), accommodating trawl models of 1/10 to 1/2 scale. In addition to the larger width, the tank is hydrodynamically superior to others. The large motors can circulate water at speeds of up to ten knots and still maintain a uniform flow in the test section. This is important because large net models fill the entire section. Observers can monitor the underwater configuration of the trawls from both sides and from above and below. The channel is fully equipped so that only instrumentation unique to testing fishing gear is required for trawl research.

The towing basin used for net testing at NSRDC is enormous. It is 52 feet wide with a 10-foot-deep section 300 feet long and a 22-foot-deep section 900 feet long. There are 3,000-foot-long basins at NSRDC, but the width of this shorter basin allows testing of larger models, or even full scale nets. It has a fully-instrumented

## In this issue

towing carriage capable of towing a net at any speed required.

Sea Grant has installed the specialized apparatus necessary for midwater trawl research in the circulating channel. Midwater trawls are used to catch schooling fish — herring, mackerel, squid — which are located by sonar and other fish-finding methods. Vertical struts have been installed for attaching the tow cables, and a control system has been developed for positioning the struts and adjusting the cable hookup points to allow easy variation of net configurations. A load measuring system for each of the four hookup points has been built for measuring resistance of the net. In the near future Sea Grant plans to develop a conveyor belt for installation in the bottom of the test section to simulate the ocean bottom during testing of bottom trawls. Bottom trawls are towed along the seabed and catch bottom fish — flounder, cod, haddock — which live close to or directly on the bottom.

Apparatus similar to that installed in the circulating channel has also been developed for the towing basin, except the struts are more robust and rigidly mounted to the carriage. The towing basin can test both midwater and bottom trawls. The circulating channel and towing basin are not redundant since each is better suited to different types of research. The channel is most useful in the initial stages of trawl net design where many adjustments to the towing rig are likely and researchers want to observe rather than take precise resistance data. The towing basin is more suited to final development stages where careful resistance data are needed or full size prototype nets are evaluated.

Two midwater trawls were tested by Sea Grant last January and again in July, one from a West Coast manufacturer and one from Britain. A more recent series of full-scale tests on New England groundfish trawls and a Gulf Coast shrimp trawl inaugurated the towing basin. Sea Grant hopes to schedule future test sessions in both facilities involving other trawl researchers.

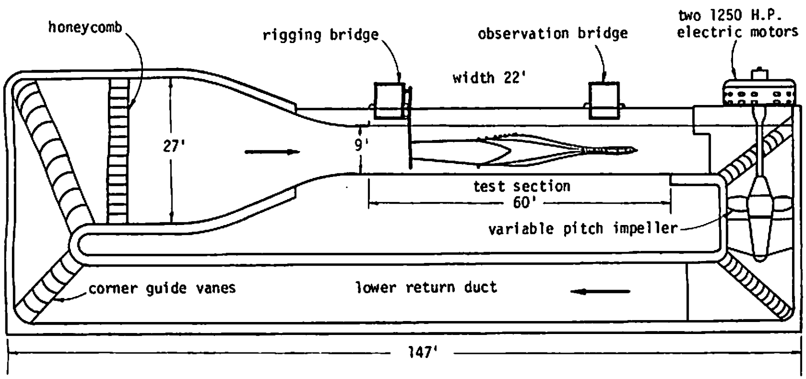


Figure 2 Longitudinal cross-sectional plan of elevation of closed-loop channel.

# Arctic Technology: An Assessment and Review for the Next Decade

Three major events at MIT will be combined this year in a three-day conference on a subject of great interest in the United States and abroad, recovering oil and minerals from Arctic waters. On March 2, the 11th Annual MIT Sea Grant Lecture and the 3rd Annual MIT Department of Ocean Engineering Robert Bruce Wallace Lecture will be held to keynote the conference. On March 3 and 4, the Sea Grant Program will host its second offering in a marine research seminar series. Fourteen speakers will present papers on subjects that include Arctic oceanography, seismic exploration, ice morphology, modeling Arctic ice fields, ice breaking technology, legal and political regimes, economic and environmental considerations.

Program details and registration materials are available from Elizabeth Harding, MIT Sea Grant Communications Information Office, 77 Massachusetts Avenue, E38-368, Cambridge, MA 02139.

# New Leadership for MIT Sea Grant

Chryssostomos Chryssostomidis, an engineer recognized internationally for his research and teaching in the areas of ship design and offshore marine operations, has been appointed director of the MIT Sea Grant Program. He succeeds Dean A. Horn, director of the program since 1976, who resigned from the Sea Grant post on July 1.

"Professor Chryssostomidis, an associate director for research of Sea Grant since 1980, brings to his new position an impressive record of teaching and research in naval architecture and marine systems," said Dr. Kenneth A. Smith, associate provost and vice president for research at MIT, who announced the appointment. "I am confident that he will meet the exciting challenge of furthering the contributions of the MIT Sea Grant Program to the nation."

Dr. Anthony J. Sinskey of the Department of Nutrition and Food Science, professor of applied microbiology, and Dr. Keith D. Stolzenbach, associate professor of civil engineering, will continue to serve as associate directors for research of the Sea Grant Program.

Dr. Chryssostomidis, a faculty member of the Department of Ocean Engineering, has been involved in a variety of Sea Grant-related teaching and research programs since 1975. In 1981 he coordinated a program that studied the economic and engineering considerations involved in a return to coal-powered ships. His 1982 project deals with the design of a ship capable of carrying nuclear wastes to a deep-ocean disposal site. He is currently planning a project for 1983 that will involve research in ships with "unconventional sections," ocean-going vessels designed to minimize wave-induced motion. Such vessels would be used in the offshore recovery of oil.

In another Sea Grant project, the new director also is studying the dynamics of marine risers — the long metal tubes that connect an offshore oil well to the surface platform. The work has attracted considerable attention outside MIT and a consortium of firms working in this area is supporting this research in keeping with the Sea Grant concept of joint industry-academia research activities.

Professor Chryssostomidis plans to continue teaching an undergraduate course in ocean engineering design and a graduate subject in ship design. He also plans to pursue his other major research area of a computer-aided design and

*MIT Sea Grant*
*Quarterly Report*
Summer, 1982

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The MIT Sea Grant *Quarterly Report* reviews the Program's marine-related research, education, and advisory service activities at the Massachusetts Institute of Technology. Funding is provided by the National Oceanic and Atmospheric Administration through the Office of Sea Grant. Free subscriptions of the *Quarterly Report* are available on request from the MIT Sea Grant College Program, Building E38-302, Cambridge, MA 02139. Telephone (617) 253-3461.

# MIT Sea Grant Special Report

## MIT Receives New Grant From NOAA

On July 2, 1981 the MIT Sea Grant College Program received $1.7 million from the National Oceanic and Atmospheric Administration (NOAA) in the Department of Commerce to begin its thirteenth year of exploring safe and farsighted uses of the oceans. Matching funds from MIT, foundations, corporations and other educational institutions ensure that Sea Grant's program is responsive to the people it serves.

MIT Sea Grant is part of the national network of university-based Sea Grant programs. It supports students, engineers, and scientists doing research to remove technical barriers to harvesting the sea's energy, mineral, and biological resources. Research results — *products, technologies*, analyses — reach industry, individuals, and government through services provided by Sea Grant advisors who help users apply the results for their benefit. One of these advisory services, the Massachusetts Marine Liaison Service, keeps in touch with the needs of local marine businesses and coordinates the research expertise at MIT with the experience and knowledge of the marine community to meet those needs. Another service, the Marine Industry Advisory Service (MIDAS), is a partnership with local, national, and international companies, helping them identify and exploit profitable business opportunities in the oceans.

A particularly successful program in support of Massachusetts' billion-dollar-a-year fishing industry is a joint project with the Massachusetts Maritime Academy that offers fishermen the opportunity to learn new fishing techniques, marine electronics, business management, and other valuable skills to help keep the industry up-to-date technologically and in a better position to compete with foreign fleets.

Since an important part of Sea Grant's charge is to train students for work in the marine field, funds are allocated for MIT students to assist faculty in marine research. These students get technical experience as research assistants and through academic courses provided for by Sea Grant.

MIT Sea Grant is nationally recognized for its research in ocean engineering. The program's research falls into five categories: offshore facilities, unmanned underwater work systems, coastal processes, living resource utilization, and technology development for ocean uses. Publications describing all research results in depth are available through the Communications/Information Service. A small reference center in the Sea Grant office also offers access to a range of information on many marine-related subjects.

Brief abstracts of research projects for the coming year follow. Feel free to contact the Communications/Information Office, MIT Sea Grant, 77 Massachusetts Avenue, Cambridge, MA 02139, for more information about these projects.

## Sea Grant Research 1982-1983

### Offshore Facilities

The rapidly expanding oil and gas industries look to Sea Grant's technological innovations for safer and more efficient operation of oil rigs and drilling platforms in deep waters beyond the continental shelf.

**Mechanics of Cable Systems with Offshore Applications.**
C. Chryssostomidis and M. Triantafyllou, MIT Department of Ocean Engineering.
Project Duration: July 1, 1981-June 30, 1984.
Devise simple analytical solutions for the problem of flow excited cable dynamics and apply to preliminary design theory for offshore mooring systems.

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

**Simplified Procedure for Geotechnical Profile Estimation.**
G. Baecher, MIT Department of Civil Engineering.
Project Duration: July 1, 1982-June 30, 1984.
Apply a simplified design approach to geotechnical risk assessment to three well-documented sites in Alabama, northern Quebec, and offshore Venezuela. All sites are on soft marine clays and are under construction.

### Unmanned Underwater Work Systems

MIT Sea Grant early entered the robot age and continues pioneering technology for making remotely operated undersea robots to replace human divers in dangerous waters.

**Remote Control Techniques for Unmanned Underwater Work Vehicles.**
T. Sheridan, MIT Department of Mechanical Engineering.
Project Duration: July 1, 1981-June 30, 1983.
Develop computer-graphic display and control aids for the human operator; demonstrate techniques for simulating and evaluating remote control systems; minimize relative motion problems through computer-aided techniques; and apply research to retrofitted undersea vehicles.

**Performance of the Digital Acoustic Telemetry System (DATS) for Communication from Untethered Vehicles and Sensors.**
A. Baggeroer, MIT Department of Ocean Engineering. D. Koelsch, Woods Hole Oceanographic Institution, Department of Geology and Geophysics.
K. Vonder Heydt, Woods Hole Oceanographic Institution, Department of Geology and Geophysics.
Project Duration: July 1, 1981-June 30, 1983.
Field test the performance capabilities of the MIT-developed Digital Acoustic Telemetry System (DATS), particularly error probability versus data rate and acoustic environment.

**Touch (Proximity and Contact Force) Sensing for Undersea Manipulators.**
T. Sheridan, MIT Department of Mechanical Engineering.
Project Duration: July 1, 1981-June 30, 1984.
Design a touch sensor to make manipulators flexible and dexterous in completing tasks identified by industry and develop alternative schemes to process and display information for human operators.

**Underwater Welding and Cutting by Remote Manipulation Techniques.**
K. Masubuchi, MIT Department of Ocean Engineering.
Project Duration: July 1, 1981-June 30, 1985.
Develop capability of performing single underwater welding and cutting by remote manipulation, based on MIT-developed "instamatic" welding system and research in remote control techniques.

### Coastal Processes

Coastal zone managers can better anticipate the consequences of human activities in the near-shore environment as a result of Sea Grant research into the complex interrelationships between physical, chemical, and geological processes of the coastal ecosystem.

**Enhancement of Hydrodynamic Circulation in Semi-enclosed Water Bodies.**
J. Connor, K, Stolzenbach, MIT Department of Civil Engineering.
Project Duration: July 1, 1981-June 30, 1984.

Implement a new computational scheme using frequency domain techniques for calculating tidal circulation in small embayments with irregular shape and topography. The scheme will be applied to the study of generic solutions to improve circulation in semi-enclosed water bodies.

**Computation of Water Movement and Mass Transport in Coastal Salt Marshes.**
H. Hemond, K. Stolzenbach, MIT Department of Civil Engineering.
*Project Duration:* July 1, 1982-June 30, 1984.
Create computer codes for determining surface and subsurface water movement and associated dissolved mass transport in coastal salt marshes. Existing vertical flow algorithms will be extended to consider horizontal movement.

**Finite Water Depth Wind Wave and Current Model.**
O. Madsen, MIT Department of Civil Engineering.
Project Duration: July 1, 1982-June 30, 1985.
Extend existing deep water model to account for finite depth in forecasting wind-generated waves. A complete and general model will be developed for predicting wind, waves, currents, and set-up in water of finite depth.

**Predicting New England Red Tides: The Role of Zooplankton Grazing.**
S. Chisholm, MIT Department of Civil Engineering.
Project Duration: July 1, 1982-June 30, 1983.
Measure mortality of *G. tamarensis* from zooplankton grazing and compare to loss from encystment and tidal advection. The measurement is a missing link in understanding key factors regulating population of *G. tamarensis.*

## Living Resource Utilization

Taking full advantage of the living resources of the sea requires developing new technologies that are practical and economical.

**High-efficiency Brayton-cycle Engines for Marine Propulsion.**
D. Wilson, MIT Department of Mechanical Engineering.
Project Duration: July 1, 1981-June 30, 1984.
Develop a regenerative Brayton-cycle system to meet the needs of fishing vessels for propulsion, auxiliary power, heating, and cooling requirements. The high efficiency system will be based on off-the-shelf components.

**Design and Fabrication of Microcapsules for Fish Larvae Feed.**
C. Rah, MIT Department of Nutrition and Food Science.
Project Duration: July 1, 1981-June 30, 1984.
Engineer a complete, encapsulated feed for fish larvae grown in a mariculture system. A fabrication process will be designed to control solubility, texture, density, and the size and shape of feed for specific fish species.

**Isolation of Bioactive Compounds from Shark.**
R. Langer, MIT Department of Biochemical Engineering.
J. Glowacki, Boston Children's Hospital.
Project Duration: July 1, 1980-June 30, 1983.
Purify and biochemically characterize an inhibitor of tumor growth in shark cartilage for application in medical tests on animals. Other important enzyme-inhibitors, particularly a collagenase inhibitor, in shark cartilage are being tested.

**Chitosan Matrix for Biotechnology Processes.**
C. Rha, MIT Department of Nutrition and Food Science.
Project Duration: July 1, 1982-June 30, 1985.
Determine principles for using chitosan in biotechnology processes. A chitosan matrix will be built for recovery, isolation, and concentration of product during fermentation.

## Technology Development for Ocean Uses

Projects that solve marine-related problems or create new opportunities, but do not fit neatly into specific categories, are listed below.

**Enzymatic Removal of Hazardous Pollutants from Industrial Aqueous Effluents.**
A. Klibanov, MIT Department of Nutrition and Food Science.
Project Duration: July 1, 1981-June 30, 1983.
Investigate use of the enzyme peroxidase, present in horseradish and in some bacteria, in removing phenol and aromatic amines from industrial wastewater. These compounds can be toxic to fish and carcinogenic for humans.

**On the Rational Selection of Strengthening Criteria for Navigation in Ice.**
P. Xirouchakis, MIT Department of Ocean Engineering.
Project Duration: July 1, 1981-June 30, 1984.
Develop a structural design methodology for the rational selection of criteria for strengthening ships against ice. Particular attention is given to failure modes of an ice sheet under compression in order to determine maximum ice loading.

**Putting the MIT Oil Spill Model to Work.**
J. Nyhart, MIT Sloan Schol of Management and Department of Ocean Engineering.
H. Psaraftis, MIT Department of Ocean Engineering.
Project Duration: July 1, 1982-June 30, 1983.
Test and generalize an economic and regulatory model, developed during the past two years, that will analyze existing cleanup policy and decision-making processes so that regulatory, legislative, and operational changes can be made in oil spill cleanup management.

executive system that can be applied to virtually any discipline.

Norman Doelling has been named executive officer to assist Dr. Chryssostomidis in the management of Sea Grant.

Mr. Doelling joined the program in 1975 as manager of the Marine Industry Advisory Service Collegium, an organization that brings Sea Grant services to ocean-related industries and government including Industrial Liaison Program members. The Collegium has grown from 15 members to about 100 since Mr. Doelling helped establish it, and has served as a prototype for other industry collegia at the Institute. In addition to his new program management duties he will continue to oversee Collegium activities.

## Collision Protection for Offshore Structures

Although major shipping lanes traverse the North Sea oil fields, so far there have been no serious collisions between ships and offshore platforms. However, many accidental impacts result when small (2000 ton displacement) support and supply ships dock directly against the platforms, often in heavy seas. These continuous low-level contacts could eventually weaken a structure.

Joao Gomes de Oliveira, associate professor of ocean engineering at MIT, proposes creating effective fender systems and developing strengthened structures which can withstand large accidental impacts. Since July 1980, with support from Sea Grant and the American Bureau of Shipping, he has been working on a theory to predict the energy absorbing capabilities of typical steel tubular members in offshore structures.

"We want to absorb this energy in a controlled fashion, so the structure won't be damaged in case of a major accident," says de Oliveira. "The steel itself has good energy-absorbing capabilities." Accidental loads caused by collision, dropping a heavy object or an explosion have largely been ignored during the design process, de Oliveira says. "They can be a real threat to the structure and should be taken into consideration."

Conventional fender systems such as rubber tires or hydraulic bumpers fail to provide sufficient protection during a collision. Rubber cannot dissipate enough of the energy transmitted to it, while hydraulic and pneumatic systems are prone to mechanical failures. De Oliveira proposes orienting steel tube bumpers in alternating horizontal and vertical rows against each other, so that an impact would flatten the tubes but would transmit little force to the structure. The eventual configuration and thickness of the tubes should provide maximum energy absorption for the lowest possible weight and expense, since these bumpers will have to be frequently replaced.

Fender systems are not designed to withstand a full speed collision, and in any case, a far more frequent source of impact results from heavy machinery dropped accidentally on the platform decks. De Oliveira's research considers local strengthening and optimum dimensions for those platform parts directly subject to a possible impact, and for their adjoining tubular joints. The results should suggest the best structural layouts for the installation.

Given the basic definition of a structure, de Oliveira says, "We are trying to compare alternative configurations, and come up with the one that would be better in absorbing the energy of an impact." Statistical studies show what type of accident could possibly occur, and the probable overall dimensions, displacement and velocity of the ship most likely to hit the platform.

Whenever possible, de Oliveira correlates the theories in this mathematical approach with the available experimental results, which come mostly from English and Norwegian studies. He plans to develop a computer code which the designer can use in preliminary stages to analyze which types of loads should be taken into consideration.

At this stage of the research, de Oliveira and graduate student Yanni Mavrikios are studying local deformation of tubular members. The next stage is to examine the behavior of the structure as a whole when subject to impact. The third phase will apply the results of the first two phases to produce design guidelines and make some conclusions regarding the design of protective fender systems.

"We found the problem of lateral flattening of tubes much more difficult than we had anticipated," says de Oliveira, "because the distortion is nonsymmetric and involves mechanisms of plastic deformation which are not present in other problems." They are also considering very large deformations. "On conventional structural mechanics, deformations are a very small percentage of the overall dimension of a structure. In this case we are really talking about crushing structural elements, essentially flattening them out so that the initial geometry is completely changed. That makes the problem much more difficult."

No other work on collision protection is currently underway in the US, says de Oliveira, adding that there are ongoing protection projects in Norway, Denmark and the United Kingdom. Problems of offshore structure protection are perpetually changing, as future plans call for nuclear power generating stations, ocean mining sites, and deepwater ports in addition to today's oil rigs.

## Biotechnology in the Marine Sciences

"Modern science is taking a technological 'leap' forward, an advance so profound that it may alter the very structure of our society," Dr. Rita Colwell, Director of the University of Maryland Sea Grant Program, told an audience of 250 students, scientists, and industry people at MIT Sea Grant's tenth annual lecture on March 18, 1982. The subject of this year's lecture was "Biotechnology in the Marine Sciences." "As occurred with the invention of the steam engine, the discovery of the atom, and the advent of the computer — each of which resulted in a revolutionizing of science and society — the explosive development of biotechnology and its handmaiden, 'genetic engineering,' will pervade all our lives," predicted Dr. Colwell.

In particular, Dr. Colwell forecasts substantial benefits from applying biotechnology and genetic engineering to the marine sciences, where research has barely scratched the surface. The lecture focused on four marine-related areas in which biotechnology is currently being applied (each of these areas was discussed in detail in seminars held during the two days following the lecture): aquaculture, marine pharmaceuticals and bioproducts, marine biofouling, and marine pollution control.

Genetic engineering could help revolutionize aquaculture just as it revolutionized agriculture by producing more, hardier, better quality crops, Colwell said. "Since successful aquaculture of many species of invertebrate animals has been achieved, since large populations of shellfish at the larval and intermediate stages can be manipulated and their genes cloned, the stage is set for the realization of genetic engineering's staggering potential." A large part of that stage has been set by the National Sea Grant College Program. Dr. Colwell described how Sea Grant programs across the country are using available technology and developing new to realize the "staggering potential."

For example, a program to enhance stocks of salmon has been underway at the University of Washington Sea Grant Program since 1977. Researchers there are attempting to produce salmon that grow faster, healthier, and bigger on a minimal amount of food. Current projects focus on population dynamics, effects of incubation on salmon fry, and improved salmon nutrition.

A major problem of mariculture, Dr. Colwell said, is disease, predominantly microbially mediated infections and epidemics. University of Maine Sea Grant is studying a common disease in hatcheries, infectious pancreatic necrosis (IPN), in order to develop antisera and vaccines against the virus. Research at other institutions is directed at creating disease resistant fish populations.

In the area of marine plants, the genes responsible for salt tolerance in salt-tolerant plants (Halophytes) may be isolated and transferred to agricultural plants for cultivation in areas where the soil has become too salty for conventional agriculture. At Delaware Sea Grant researchers are identifying wild halophytes with hardy genetic traits and sound nutritional value and selectively breeding them for desirable taste, texture, and color.

Exploring another promising and exciting field, Dr. Colwell continued, "Perhaps one of the most dramatic examples of biotechnological application is that of marine pharmaceuticals." Currently several marine organisms yield useful drugs: insulin comes from whales and tuna, vitamins A and D from liver oil, and red alga has long been used as an anthelminthic. However, Dr. Colwell explained that it has often been uneconomical to extract and purify drugs from organisms that have to be captured in large quantities from remote corners of the world. As a result, only a limited number of drugs come from the sea. "Genetic engineering can change this situation dramatically, by opening up a vast and diverse range of marine life to probing for valuable pharmacological compounds." Potential anticancer, -virus, and -tumor agents have been identified in such organisms as the sea anemone, sponges, and Caribbean gorgonians, corals, and tunicates (sea squirts). Also, some substances from certain sponges act on the cardiovascular and central nervous systems.

Toxins produced by marine organisms are particularly interesting. In certain cases they can be used as drugs, but even if use as a drug is impossible because of harmful side effects, the toxin may be a model for synthesis or improvement of other drugs. Toxins also have value other than pharmaceutical. A toxin from a marine annelid, *Lumbrinereis brevicirra,* was first isolated in 1934, and when its structure was determined, a new insecticide was developed from the toxin. The insecticide works against the rice stem borer and other insect pests, and does not appear to be toxic to warm-blooded animals; also, insects do not readily develop a resistance to the poison.

Dr. Colwell said that although marine toxins are fascinating from a scientific point of view, in the near future the more marketable bioproducts will be industrial chemicals derived from marine organisms. Already, carrageenin, a product from red seaweed, is widely used as an extender in food and other products, from evaporated milk to toothpaste. "The message is, clearly, that directed search for non-antibiotically active natural products in the marine environment, especially those . . . unique to marine organisms, can open an entirely new source of industrial chemicals," Colwell claimed.

Fouling of surfaces, such as boats and docks, by marine organisms that set there is a costly problem. But getting shellfish larvae to set in a shellfish hatchery is critical to success of the hatchery. Thus, an understanding of the process by which organisms attach themselves and adhere to surfaces could contribute greatly both to preventing unwanted biofouling and inducing useful effects. Colwell said that the tools of genetic engineering are well suited to an analysis of the process of biofouling. She described research underway in that direction.

"It is obvious that, with increased use of the world oceans for man's waste, attention must be paid to the problems of marine pollution," Colwell continued. In contrast to natural products, man-made compounds are relatively resistant to biodegradation, often because organisms naturally present in the environment cannot produce the enzymes necessary to break down the man-made compounds. This is especially a problem in waste treatment. "What has not yet been considered, however," said Colwell, "is the engineering of microorganisms to be added to wastes that are to be discharged into the marine environment." Colwell listed the modifications of genetic information in microorganisms that are useful in pollution control, including amplification of enzyme concentrations in an organism, introduction of new enzymatic functions into organisms not possessing them, and changing the characteristics of specific enzymes. Engineering microorganisms to biodegrade wastes from the seafood industry, such as shellfish wastes, also have not been considered.

Clearly, the surface has only been scratched in the application of biotechnology to marine problems and opportunities. Enthusiasm for the promise of biotechnology was a distinct message from Dr. Colwell and reflects enthusiasm in the business community. "The financial possibilities of genetic engineering have not been lost on the stock market," Dr. Colwell said, adding that investors have "nearly smothered" new companies with risk capital, with the result that these companies have sprung up "like mushrooms."

Business was well represented at the seminars following the lecture. Economic and technical overviews and research papers were presented by specialists who came mostly from industry and were leaders in theif field. A proceedings of the lecture is available from MIT Sea Grant. Papers from the seminars will be available in book form in early 1983.

## MIT Sea Grant Quarterly Report Re-up

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