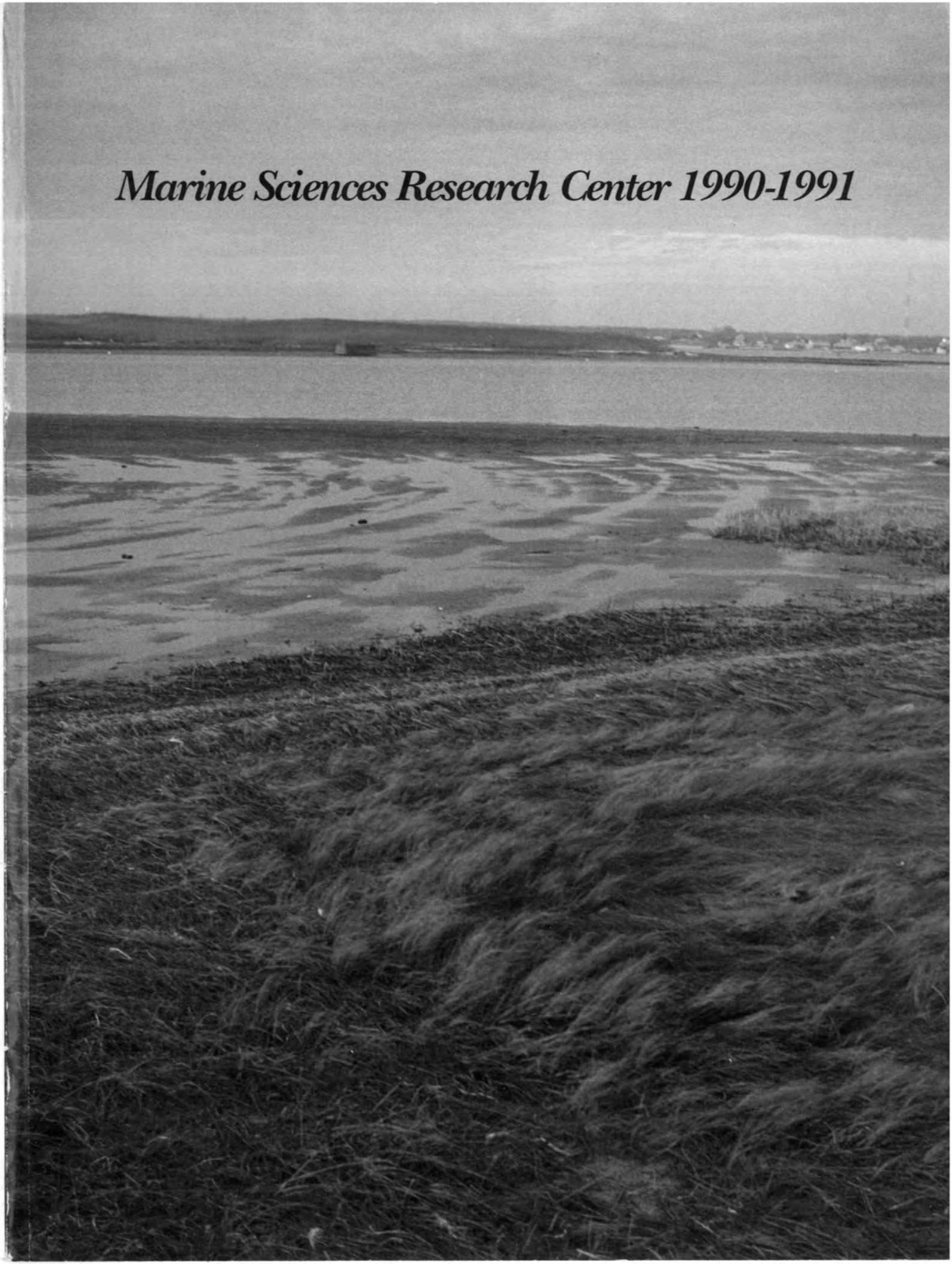
Marine Sciences Research Center 1990-1991



Acknowledgements

cover photograph
R. George Rowland

editor
Trudy M. Bell

designer
Lori J. Palmer

editorial contributors
J. Kirk Cochran
Jeri Schoof
Anne West-Valle

photographic contributors
Byron Boekhoudt
Vincent Breslin
David Colflesh
Susan Dooley
Maxine Hicks
Wendy Metcalf
B. Millsaps
Richard Murtagh
Lori J. Palmer
R. George Rowland
W.G. Rowntree
Eric Schultz
Ian Stupakoff
R.L. Swanson

table of contents

introduction

" Excellence in coastal oceanography and commitment to the use of science to serve society continue to be the standards against which all MSRC decisions are measured."

"The use of science to serve society becomes increasingly important as growing populations in coastal regions increase stresses on coastal environments."

It is a pleasure to present this report which summarizes highlights of MSRC's progress in research, education, and public service for the past two years, 1990-1991. In 1993 MSRC will celebrate its 25th anniversary. Over its brief history, MSRC has achieved a remarkable degree of distinction by focusing its efforts and its energies on achieving excellence in carefully selected areas — areas important to the region and to the nation. The same two themes that have guided the development of MSRC for nearly two decades, excellence in coastal oceanography and commitment to the use of science to serve society, continue to be the standards against which all decisions are measured. Over the years MSRC has developed excellence in blue water oceanography where there were particular needs or opportunities. It will continue to do so.

The ultimate strength of MSRC lies in the excellence of its faculty and their commitment to fundamental research. Over the past 15 years MSRC has gone from having no support from the National Science Foundation to ranking first in 1990 among all coastal institutions in support from the National Science Foundation.

Excellence in fundamental research is a prerequisite to MSRC's second goal, the use of science to serve society. But it does not guarantee success in achieving that goal. That success is more difficult to measure, but it becomes increasingly important as growing populations in coastal regions increase the stresses on coastal environments and their living resources.

This is an international problem. Approximately half of the U.S. and half of the world populations live within coastal areas. The global population of 5.3 billion is projected to grow to more than 10 billion before the end of the

next century, with 70% of the growth coming in developing countries — much of it in coastal areas.

None of these countries has waste water infrastructure to collect and treat the enormous volume of human wastes that will be produced. Unless steps are taken soon, valuable coastal environments and their living resources will be lost. The U.S. and other countries in the developed world need to address these "loomings" now and develop strategies to avert them. MSRC is already at work in this area.

During this past year the University expanded MSRC's roles to include the atmosphere. The President and Provost transferrred the Institute of Terrestrial and Planetary Atmospheres and the atmospheric scientists on the faculty of the College of Engineering and Applied Sciences to MSRC. They also charged MSRC with responsibility for leadership in expanding and enhancing the University's programs in environmental sciences. We look forward to these challenges and expect to have many important and exciting things to report in the next Biennial Report.

Rowland Photo

J. R. Schubel
Dean and Director

message from the provost

Dear Readers:

I came to Stony Brook in July, 1989 as the University's fifth Provost. After examining our needs and opportunities, one of my priorities is to expand and enhance the University's array of environmental programs in research, education, and public service. Long Island so clearly is the place for a spectrum of rich and varied environmental programs which combine the best of education, research, and policy analysis. Because of MSRC's established and growing leadership not only in oceanography, but in waste management, in groundwater, in fisheries and aquaculture and in marine policy, as well as its commitment to excellence in environmental education and public service, I asked the MSRC for a strategy for reconfiguring Stony Brook's environmental programs.

As part of this expanded role for MSRC, it was a constructive initiative to extend the Center's capabilities by reassigning the University's atmospheric scientists and its Institute of Terrestrial and Planetary Atmospheres to the MSRC. The combination of Stony Brook's atmospheric scientists with its marine scientists will allow the University to make even greater contributions to understanding the coupling of the ocean and the atmosphere in controlling global climate change and all the environmental and societal implications of such change. I am encouraged by the enthusiasm for this effort by the participating scientists and the University community.

One of the characteristics of MSRC that has impressed me most is its constant restructuring, repositioning, and rebuilding to take full advantage of changing needs and opportunities. This commitment to change is a quality that is rare within academic institutions, where too often change is resisted until it is unavoidable. Like the title of a recent book, "If It Ain't Broke, Break It," it seems that MSRC has a tradition of constantly breaking itself, only to emerge stronger in its reconfiguration. I expect to see MSRC continue to rebuild and review itself in its quest for excellence in coastal oceanography, under the dynamic leadership of Dean Jerry Schubel. I will do everything I can to assist MSRC because of its central importance to the University and Long Island.

Sincerely,

Tilden G. Edelstein
Provost and Academic Vice President

Rowland Photo

Rowland Photo

This Harbor

This harbor melts at sunset,
cools with afterglow
under cobalt meadows,
a twilight upside down.
This island, long and intricate,
crabbed with fingers in and out
of waterways, lifts
a dark smudge here, some
clumps of ceder there.
It's a Dutch painting,
a Hobbema, where nightfall
makes the lambent pond waters
oily with frail refracted lights,
first red, then startling yellow.
The old oaks brush in sky
as sailboats, barges, motor launches
through streaming estuaries
propel a churn
against this island's welcoming hand.

— *R. Elman*

"While maintaining its research activities, the center is increasingly helping to set public policy on complex issues involving Long Island Sound, South Shore and East End bays, wetlands, barrier beaches and the ocean's continental shelf to about 100 miles off shore."

— Newsday, "Marine Center Charts Course; Facility Growing at Stony Brook" Tom Morris, 12/4/89, p23

"I think we'll see this Center emerge more and more in public service as faculty come to realize they can be a vital resource and agent for change."

— Senator Kenneth P. Lavalle Chairman, Senate Higher Education Commission, NY State Senate

"We will work more closely with decision makers to tailor informational products to their specific needs: to help tackle some of the most pressing problems that result from society's conflicting uses and demands of the coastal ocean."

— J. R. Schubel, MSRC Dean and Director

Metcalf Photo

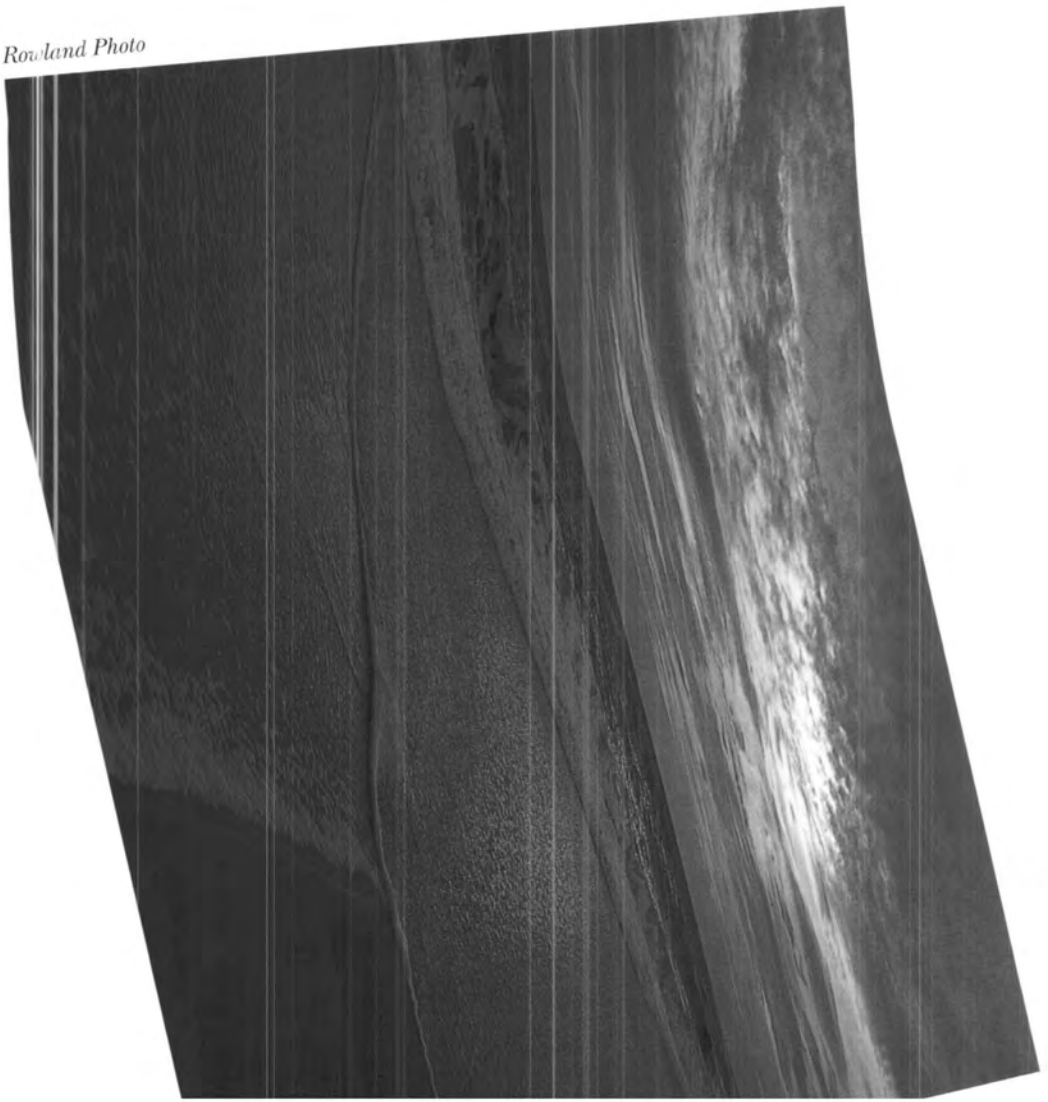
▲ *Professor Henry Bokuniewicz and graduate student Chris Schubert look for changes in the beach by measuring water table elevations.*

These comments were all made in 1989, the last year of the two-year period covered in our first Biennial Report. What major advances has MSRC made since then?

In the past two years, MSRC has increased research activities and funding for reasearch. We have broadened the scope of our interactions with policy makers and environmental conservators, formed new partnerships in research programs, and continued working on extended programs with previous partners.

The Center has added several new faculty in important areas of the marine sciences, strengthened our graduate and undergraduate curriculum, and increased the number of graduate students and undergraduate students enrolled in the minor program. We have extended our education to the public, offering more continuing education courses, publishing a new Bulletin series, and producing a series of educational videos about the marine environment.

Rowland Photo



research objectives

emphasis on coastal oceans

In 1990, MSRC ranked number 1 in National Science Foundation funding among the nation's coastal oceanographic institutions and in the top 10 in NSF support of the nation's more than 100 oceanographic programs.

Some of the research projects discussed in our last report have ended, others have new phases in progress, and many new projects have been started, some the fruition of previous initiatives. Many of these new partnerships between MSRC scientists from different disciplines or between MSRC and other institutions and agencies were based on our strengths in coastal marine sciences.

MSRC's emphasis on coastal ocean research has led to a large effort to solve local and regional coastal marine problems. And connected closely to this commitment is another commitment—to translate research data into useful and timely information for resource managers.

MSRC research focuses primarily on local and regional coastal environments with all their challenging problems and promises. But some of MSRC's research programs relate to other parts of the ocean and other parts of the world. The study of certain processes may be done better or may be done only in other coastal areas of the world or in the open ocean. For example, several decades of established thought about which phytoplankton contribute most to primary production in the tropical and subtropical oceans has been challenged by an MSRC biological oceanographer's study of a nitrogen-fixing cyanobacterium living in these nutrient-poor open ocean waters. (See pages 28-29).

multidisciplinary focus

Every MSRC researcher is a specialist in one of the core scientific areas: physical, chemical, gological, and biological oceanography. But many of the most important and exciting processes and problems in the marine environment are fundamentally multidisciplinary in nature.

In some of the most exciting new programs, MSRC scientists from different disciplines have developed integrated research approaches by pooling their common interests in a particular problem relating to the marine environment. Physical and biological oceanographers, for example, have formed partnerships in several different studies to determine the effects of currents on dispersal of zooplankton, finfish larvae, and shellfish larvae in a number of diverse marine environments. Such integrated studies will offer a mosaic of information on the multiple factors affecting marine processes.

beyond research — data to information

MSRC has long realized the vast gulf between *data* collected in the field and *information* that others can use to act on a problem. In all MSRC research programs, a common theme prevails: translating data—the raw products of research—into information usable by resource managers, legislators, and regulators to make informed decisions.

MSRC researchers do this in many different ways. For example, the intent of MSRC's Northeastern Environmental Data Systems project is to create a database from which data can be retreived easily and in a variety of ways to produce information needed by scientists and managers. Many of the data collected from the Long Island Sound Study have already been entered into this database.

As federal and regional agencies tend to focus more on coastal oceans and the effects of population growth at the coast, MSRC has taken a leading role in developing programs that address these problems. One of these programs is the Long Island Sound Study.

update on research programs

About half of the nutrients in th Sound are from sewage treatment plants and combined sewer overflow and the other half from street, lawn, and agricultural runoff.

hypoxia in Long Island Sound

In 1991 the initial research phase of the five-year Long Island Sound Study ended. Over the previous four years, a team of MSRC scientists, along with scientists from other institutions, studied the causes of hypoxia and anoxia (low and no dissolved oxygen) in the western Sound during summer months. The results of the research, funded by the U.S. Environmental Protection Agency, showed that excessive nutrient loading causes hypoxia in the western Sound; that about half of these nutrients are from point sources (sewage treatment plants and combined sewer overflow); and the other half from non-point sources (surface runoff from streets, lawns, and agricultural areas). These findings provided the scientific basis for recommending immediate and long-term remediation strategies.

While long-term plans are being considered, immediate plans to set a cap on nitrogen at 1991 levels and to initiate a monitoring program to track the changing conditions of the Sound are being enacted during the next phase of this study.

Stupakoff Photo

capping nutrients insufficient

MSRC scientists demonstrated that because of population growth alone, society will have to remove 25% more nutrients in the year 2020 than in 1991, just to maintain the 1991 concentrations—a condition few are satisfied with. Capping of nutrients at 1991 levels is not enough to improve the Sound, but even holding the line will require substantial investments over the next several decades.

seeking innovative solutions

The high cost of upgrading existing sewage treatment plants stimulated the search for other potential solutions for reducing nutrient levels in the Sound. Scientists have proposed several innovative technologies as possible components in a comprehensive nutrient management strategy to reduce the need for expensive sewage treatment plant upgrading. Exploring these novel approaches to reduce hypoxia was the reason for gathering regulators, scientists, and managers for two MSRC workshops during the past year.

Some of these ideas include construction of tide gates across the East River and creation of artificial wetlands and seaweed farms. The tide gates would be open only when the the tide is flowing from the Sound to New York Harbor. Closing the gates when the flow reverses and moves into the Sound would prevent nutrient-laden wastewater effluent discharged into the East River from entering the Sound. Artificial wetlands would be used to remove nutrients from wastewater before it is allowed to enter the Sound. The wetlands may also provide important new habitat for finfish and shellfish.

The final nutrient management plans, still being worked out, will include a combination of strategies, each tailored to a specific segment of the Sound. ***See detailed description of faculty research, beginning page 27.***

Palmer Photo

▲ *Professor Vincent Breslin using atomic absorption spectrophotometer.*

Stupakoff Photo

new research partnerships

Rowland Photo

MSRC and Nature Conservancy Bioreserve

MSRC has recently joined in a new partnership with the Nature Conservancy in their Peconic Bays Bioreserve initiative. The Peconic Bays are a network of shallow bays between Long Island's East End north and south forks—a rural area with farms and vineyards, pristine beaches and solitude for vacationers. In this partnership, the Center will coordinate developing and conducting a research program to provide scientific information needed to manage the bays.

"Last Great Places"

The Peconic/Block Island Bioreserve has been selected as one of 12 places included in the Nature Conservancy's "Last Great Places: An Alliance for People and the Environment." Protection of these critical and sensitive areas is accomplished through the Conservancy with such public and private efforts as making outright critical land purchases and transferring development rights.

The Alliance also depends on organizations such as MSRC to join the Conservancy in studying and managing these critical areas. Their goal is to conserve and even enhance them while recognizing the economic and recreational needs of people.

Complimenting the Nature Conservancy program is the bays' nomination for inclusion in the U.S. Environmental Protection Agency's (EPA) National Estuary Program (NEP). Presently, two other local water bodies are included in the NEP—Long Island Sound and New York-New Jersey Harbor Estuary. The ultimate goal of this program is to develop effective management plans to protect valuable coastal resources.

LI Sound Study branch office at MSRC

To continue the research on hypoxia and other important processes and problems of Long Island Sound and to begin managing and monitoring the Sound, the EPA is establishing two offices, the main office in Stamford, Connecticut and a branch office at MSRC. The office at Stony Brook is designed to take advantage of the concentration of scientific expertise at MSRC and to serve as a public outreach office for Long Island. MSRC scientists continue to work with Sound Study personnel to use all available scientific knowledge to manage and rehabilitate the Sound.

new public outreach activities

"People are causing changes as large as the natural variability of the Earth's system."

educational videos

During the past two years, MSRC has been a partner and sponsor, and our faculty and staff have served as advisors, on the production of two educational videos, one on the health of Long Island Sound, the other on the New York-New Jersey Harbor Estuary. The Center's scientists and staff are now working with film makers John J. Stevens and Elizabeth Irwin to produce a series of educational videos on the physical, biological, chemical, and geological oceanography of Long Island Sound.

"Celebrations and Concerns for the Earth"

In 1991 MSRC sponsored a number of outstanding visitors to give talks for the general public. Among these were visits by Nobel Laureate, astronomer, and author Arno Penzias of Bell Labs and Rick Anthes, President of the University Corporation for Atmospheric Research (UCAR). UCAR is a consortium of 59 academic institutions including most of the nation's top atmospheric sciences programs.

Penzias, who wrote *Ideas and Infor-mation: Managing in the Information Age,* spoke about handling large amounts of data to produce useful information. Anthes summarized the latest findings and thoughts on the greenhouse effect and global warming: "People are causing changes as large as the natural variability of the Earth's system."

Two renowned environmental writers, Roger Stone and Peter Matthiessen, conducted writing workshops and presented selected readings. Roger Stone, senior fellow of the World Wildlife Fund and Whitney H. Shepardson Fellow at the Council on Foreign Relations, writes about environmental changes and the people who work to conserve pristine ecosystems (*Voyage of the Sanderling, Dreams of Amazonia*). He has written an essay for this publication (p. 23).

Stefakoff Photo

Peter Matthiessen, author of *Snow Leopard, Far Tortuga, Men's Lives,* and *At Home in the Fields of the Lord,* among many others, has been a supporter of MSRC's efforts to make environmental writing accessible to the public, and to foster better communication between scientists and writers. Both Matthiessen and Stone will be workshop leaders for environmental journalism workshops beginning in 1992.

educational Bulletin series

MSRC launched an educational Bulletin series in late 1990, with four to six issues each year discussing timely environmental topics in easily understandable format. The Bulletins are intended to aid high school educators more effectively teach current environmental issues, particularly regional marine issues, in their classrooms. They are also intended to inform the general public about important regional and national environmental issues.

Bulletins this past year addressed "brown tide" algal blooms, floatable wastes in New York coastal waters, population growth and the coastal ocean, and hypoxia in Long Island Sound.

speakers bureau

1991 marked the second year MSRC has had a speakers bureau, a formal program with 17 faculty and staff speakers covering 42 different topics. The speakers are available on request at no charge to schools and organizations. The following is an example of a few of the broadly ranging issues brought to diverse public groups: Long Island's problems with trash, research in Antarctica, plate tectonics, global climate and the oceans, plastics recycling, and water quality around Long Island.

education

the graduate studies program

Our graduate population is larger than it has ever been, with 111 students enrolled in the program full time and ten others attending on a part-time basis. During 1990-1991, thirty-four Masters degrees in Marine Environmental Sciences and 12 Ph.D. degrees in Coastal Oceanography were awarded.

Graduate Studies Program Director Henry Bokuniewicz, has helped to shape an evolving, stronger program for graduates with wide ranging interests. These scholars from many different backgrounds bring together a range of perspectives and experiences that is as important to MSRC's success as any element of the graduate program. The presence of these young scientists, who come from throughout the United States and 17 foreign countries, brings vitality and breadth to the Center's research.

Research support, University financial aid for educational programs, fellowships, and internships provides all MSRC students with financial assistance. This includes four scholars from underrepresented groups receiving fellowships for graduate study in marine sciences.

core courses and multidisciplinary problem solving

The core curriculum in biological oceanography, chemical oceanography, physical oceanography, and geological oceanography ensures that all students, whatever their background, receive broad instruction necessary to assume leadership roles in the multidisciplinary field of marine sciences.

At the same time, advanced course offerings continue to expand and evolve. MSRC's course in Oceanographic Problem Solving (OPS) is designed to train students to work together as a group, using their diverse knowledge to solve specific problems in marine sciences. The course draws on their skills in geological, biological, chemical, and physical oceanography. This approach to learning strengthens and builds competence in multidisciplinary problem solving, an emphasis in MSRC's graduate program and a stong point of the Center's faculty.

This year the OPS course focused on the impacts of pollutants from sources such as storm drain runoff from residential development along a local beach. This practical, on-site study served as a mechanism for students to transcend disciplinary boundaries and bring the complex interrelationships of marine phenomena into focus.

The course culminated in a meeting to summarize their results. The meeting attracted nearly 80 people, including agency heads from Suffolk County Department of Health Services and New York Department of Environmental Conservation, citizens from the community that was involved in the investigation, and scientists from other institutes and University departments.

Stupakoff Photo

▲ *Professor Valrie Gerard conducting field trip at Flax Pond.*

Map and photo by graduate student David Fields.

▲ *Computer generated figure of a copepod (small marine crustacean) within the flow field it generates by vibrating its second pair of antennae. The result of this action is to funnel a large volume of water toward its mouth so that it can catch prey. The various colored isolines represent different velocities ranging from 0 (blue) to greater than 25 milimeters per second (red).*

creative advanced courses

Every year new courses are fashioned by MSRC faculty eager to explore creative ways to bring the most advanced thinking into the classrooms. Thirty such advanced courses introduce students to unanswered questions in various fields and the knowledge that exists to try to answer them. Notable recent additions to our graduate curriculum include a course in global change, a laboratory course in zooplankton ecology, and a course in radioisotopic techniques in biology.

independent initiatives

MSRC graduate students participate fully in all aspects of the professional and intellectual life of the Center, and are encouraged to independently initiate their own projects in areas that interest them. Over the past year, for example, students organized and conducted their first Student Symposium in which 14 students gave research talks and six others presented posters. Their purpose was to receive critical analysis by a faculty panel and to discuss their research results with the MSRC community.

Among the many research initiatives undertaken the past two years, students investigated local fisheries issues for legislators, studied copepod distributions in the waters of

Antarctica, modeled environmental conditions in Long Island Sound, documented sedimentary processes off the mouth of the Amazon River, explored the geochemistry of groundwater in coastal aquifers on Long Island, and investigated the influence of circulation on larval dispersal around Barbados.

the undergraduate program

MSRC has sought to expand every opportunity to reach out to Stony Brook's undergraduates—to capture their interest in the marine environment and foster their involvement in marine science activities. One way MSRC achieves this is through our undergraduate minor program and the personal dediction of faculty members who teach courses in the minor program and sponsor activities in the Marine Sciences Club.

Chemical oceanographer James Mackin is coordinator of the undergraduate program and has a keen interest in teaching introductory oceanography. Through his strong commitment, the number of courses—and the number of students taking those courses—has increased. In 1991 over 100 students were enrolled in MAR 101, Long Island Sound: Science and Use, filling that class to capacity. Over 500 students enrolled for MAR 104, Oceanography, and MAR 340, Environmental Problems and Solutions.

Directed research for undergraduates has been broadened with MSRC's involvement in the Minority Research Apprenticeship Program and our summer student fellowships. Nine summer fellows completed their own research projects this past year on topics ranging from nutrient distributions in Long Island Sound to acoustic properties of sediments.

Palmer Photo

Stupakoff Photo

special programs

MSRC continued to be a magnet for high school and undergraduate students seeking opportunities for hands-on research in the laboratoray and at sea. These students come from an array of science advocacy programs such as the University's Undergraduate Research and Creative Activities program; Minority Research Apprenticeship Program; Suffolk County Board of Cooperative Educational Services; the New York Academy of Sciences Young Scholars Program; and the New York State's Science and Technology Education Program.

In these programs, each student collaborates with an MSRC scientist to learn first-hand how to formulate a research hypothesis, to design an experiment for testing, and to write a report of the results. These reports, coauthored by the students and faculty advisors, are often published in the refereed scientific literature.

Our special Dillard University-Stony Brook articulation agreement allows undergraduates from Dillard, an historically Black institution, to spend two semesters at MSRC, return to Dillard until graduation, and then enter graduate school at MSRC with a head start. This partnership has brought us our first African-American Ph.D. student, and we are hopeful it will bring us many more Dillard students in the years to come.

◀ *Professor Jim Mackin teaching undergraduate oceanography.*

update on our institutes

Living Marine Resources Institute

origins and mandate

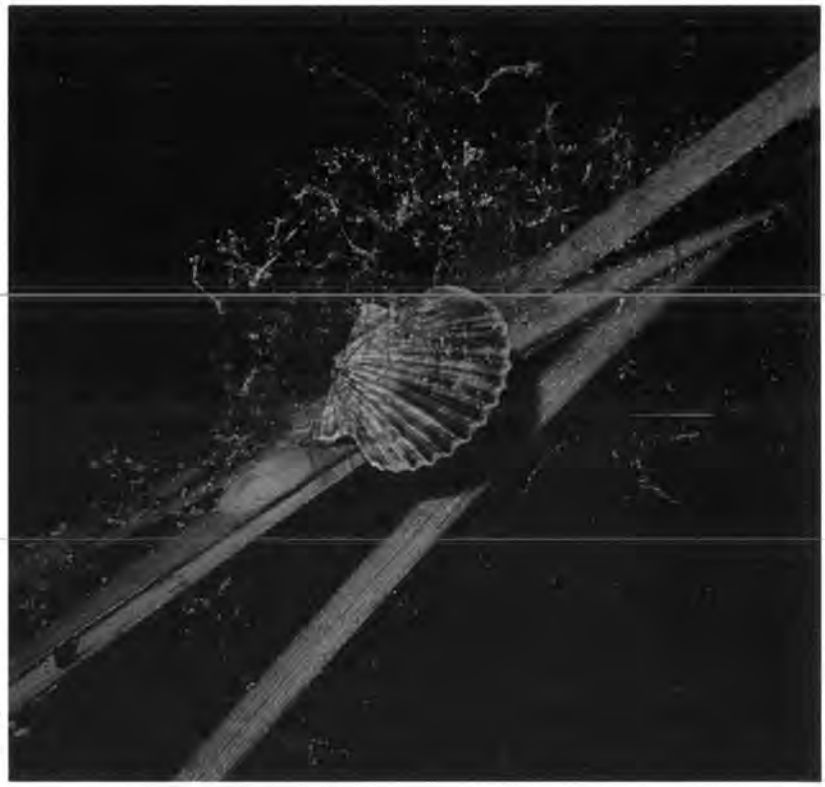
New York's and the surrounding mid-Atlantic regional finfisheries and shellfisheries have always been important economically. But many of the key stocks have dwindled in abundance over the years, causing recreational and commercial fishermen great concern. The impetus for legislative action to create the Living Marine Resources Institute (LIMRI) at MSRC in 1985 was to restore the health and vitality of these resources through management based on the findings of research.

new threats to an age-old industry

The problems affecting coastal fisheries are complex. Almost as soon as one set of problems is remediated, new ones emerge in these dynamic coastal systems. Increasing coastal development, decreasing stocks, and increasing emphasis on fishing and fish products as healthy food require that top priority be placed on obtaining scientific results that managers can use.

To obtain these results, the Institute taps the top fisheries researchers at MSRC and other institutions in the region. LIMRI relies on the work of its core faculty, but also promotes a number of collaborative projects with other MSRC

Murtagh Photo



Murtagh Photo

fisheries faculty. And to aid these scientists, LIMRI has enhanced MSRC's fishery-related research facilities.

Research is only part of LIMRI's activities, however. Public policy, resource management, and educational activities to improve public awareness are equally important in conserving the region's living marine resources and its economy.

research to aid resource managers

LIMRI's research program concentrates on gaining fundamental scientific and technical information that can significantly improve resource management. For example, shellfish — clams, oysters, scallops, lobsters, and crabs — sustain important commercial fisheries in New York's marine waters, but many have declined in recent years. Improved understanding of the natural and human forces that govern their productivity and abundance is essential for effective management of public shellfish resources and for culturing shellfish for commercial sale or wild stock augmentation.

survival and habitat

Among the Institute's current activities is research on the role of eelgrass as habitat for juvenile bay scallops in reducing predation by various crabs. Another current program involves assessing the biological and physical factors that determine why some areas within inshore bays produce more hard clams than others.

Lying adjacent to one of the nation's most densely populated coastal areas, marine fishery habitats in the New York metropolitan region are exposed to a variety of threats—from physical modification of nearshore areas to degradation of environmental quality by the introduction of various waste materials into coastal waters. Besides affecting habitat, these wastes may also have a direct impact on the organisms, resulting in a population reduction of the principal species or the forage species on which they feed.

Traditionally, fishery managers have been primarily occupied with understanding and controlling harvesting by

Forage species—species that are food for predator species, and typically not of commercial interest for human consumption.

Recruitment—The number of juvenile organism arriving at a habitat where they will grow and live for an extended time.

commercial or recreational fishers. But as the impacts from human activity on estuarine and marine systems have become more prevalent, these managers have begun considering the habitat requirements of important species as another essential ingredient in fishery management.

Habitat requirements for survival of the resident organisms and habitat modifiction and destruction have drawn greater attention from LIMRI over the past two years. In one such project, in collaboration with the Waste Management Institute, researchers are investigating waterfront development along the northern shore of Great South Bay, assessing the effects of different degrees and patterns of development on water quality and fishery habitat. In another study, LIMRI scientists assessed the abundance and dynamics of key ***forage species*** in Long Island Sound and examined how this fishery forage base might respond to declining levels of dissolved oxygen in the bottom waters of the Sound.

recruitment and abundance

Mortality among the young of most marine finfish and shellfish is extremely high—about 99.99%. LIMRI scientists are interested in learning how natural environmental factors affect survival of key species, particularly in the

Stutpakoff Photo

larval stages. This knowledge will provide a basis for assessment and prediction of trends in population abundance. It will also help resource managers determine what natural factors they might manipulate to improve survival of these species during early life history stages and thus contribute to larger stocks of adults.

A better understanding of the conditions that govern ***recruitment*** of important marine fish and shellfish species is a growing focus of LIMRI's research program. One such project is an examination of the biological and physical factors influencing the recruitment of bluefish to New York's coastal embayments. Learning what factors influence the movement of juvenile bluefish and what threats await them as they move into the bays will help resource managers decide what is needed to maintain and even increase their survival rates.

These studies in coastal waters of the New York Bight are complimented by an investigation of how the movement of water in the Hudson estuary influences recruitment of a variety of species, including blue crabs and lobster. Complex circulation patterns in this estuary can move particles such as plankton and larvae either out to sea or into the estuary. Learning how the larvae behave under the influence of these hydrodynamic processes will tell us more about timing and success of recruitment.

new "brown tide" study tracks food web dynamics

The devastating algal bloom known as the "brown tide" has nearly eradicated the scallop fishery in several Long Island embayments, particularly in the Peconic-Gardiners Bay system. Continued transplanting of hatchery-reared juvenile scallops into the Peconic Bays may be required to reestablish and sustain this population. But LIMRI researchers remain dedicated to unraveling the mystery of what triggers the brown tide organism to bloom and what causes it to crash by studying its biology and interactions with its environment.

Since the first bloom in 1985, LIMRI has been involved in basic studies of the organism, such as its nutrient requirements for growth and the mechanisms by which it impacts shellfish. Recently, researchers completed a new study examining part of the food web in the bays where the brown tide blooms. Specifically, they examined the role of the grazers—zooplankton—on the brown tide organism, hoping to add another piece to this complex puzzle.

policy development and education

Research alone is rarely sufficient to address the many pressing problems facing the region's fisheries. LIMRI has therefore become an active participant in the complex, interactive management process that governs the region's fisheries. Its staff and associated scientists sit on a variety of advisory councils, assisting government resource managers to make the best use of the scientific and technical information available.

LIMRI staff and scientists are also frequently invited to discuss their work and its implications to various public groups. During the past two years, the Institute convened, or co-convened with other organizations, a number of workshops and meetings on issues important to the region's living marine resources, such as the 1990 workshop on the Long Island Sound Study.

the future

Most of LIMRI research is conducted in collaboration with other academic, governmental, and private organizations. The Institute's major research themes will continue for at least several years. During that time, however, LIMRI plans to develop a more focused program of policy analysis related to fisheries and more structured educational programs at the graduate, undergraduate, and adult education levels, dealing with topical, emerging fishery issues in the region.

See pages 78-81 for a more detailed description of the Living Marine Resources Institute activities.

Society must more intelligently and aggressively confront waste issues through better management – waste reduction, recycling, and reuse.

Waste Management Institute

Balancing the requirement for a clean environment with sustained development is a challenge that confronts Long Island today. It is a growing concern in New York State, the nation, and the world. Wastes from society are at the center of the dilemma, as population, consumer demand, and technological innovation are increasing the size and complexity of the waste stream. MSRC's Waste Management Institute (WMI) has been helping to lessen the impacts of waste disposal through research, environmental assessment, public outreach, and policy analysis since its inception in 1985.

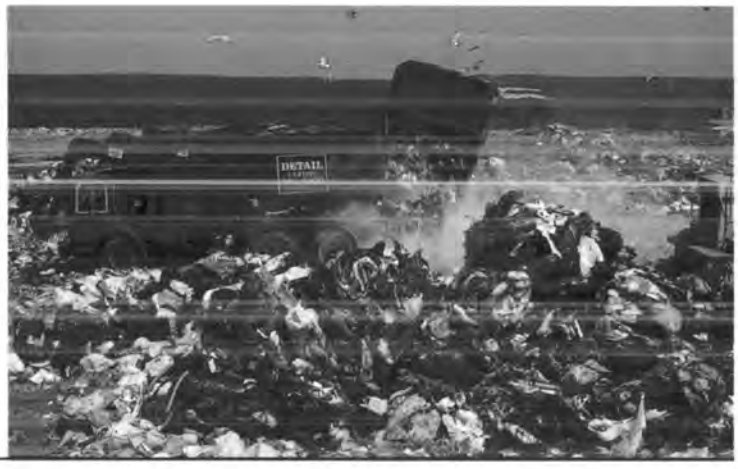
regional research with worldwide applications

The part of the waste stream that has been the subject of most prominant and immediate concern in many communities is municipal solid waste (MSW). It is also a concern of WMI, and a chief motivation for much of WMI's research, particularly in regard to how MSW impacts the region. But while WMI researchers focus primarily on waste management problems generated by New York's actions—problems which mainly affect the citizens and environment of New York— the Institute is helping to develop strategies for handling waste problems that can be applied across the nation and the world.

when landfills close

Disposal in landfills has been the traditional approach to handling MSW over the years, but it is becoming less and less desirable. With the closing of landfills and increasing hauling costs and decreasing willingness of communities to accept out-of-state garbage, society must more intelligently and aggressively confront waste issues through better management—*waste reduction, recycling, and reuse.* And the residual must be disposed of safely and economically.

Long Island's sole source of drinking water is its aquifer, which is recharged with surface water. In "sensitive



Breslin Photo

Swanson Photo

areas" recharge is fast and direct without much filtration through layers of sediments. Pollutants at the surface, such as leachate from landfills, may thus enter the aquifer.

Besides flowing down to the level of the aquifer, leachates may extend to surface waters of our coastal marine environment. In the eastern part of the island, our coasts are pristine, supporting several threatened and endangered species and a number of sport and game species. These resources, in turn, support a thriving tourism and recreation economy. The health and welfare of Long Island requires protecting the aquifer and marine environment from landfill pollution.

Despite the imminent closing of landfills, the island's demographics and geography require alternatives to landfilling beyond hauling municipal solid waste off the island. The configuration of the island and location near metropolitan New York makes hauling off the island very expensive. Yet, the population density ensures a substantial residual MSW stream for disposal, even after citizens attain major recycling success.

With limited time available, WMI is working to aid local and regional governments with the products of its research to make informed decisions about MSW handling after landfills are closed. A large portion of the Institute's research is devoted to developing and testing secondary materials and products—those made from waste products for reuse as a different product from the original.

finding uses for secondary materials

lumber from recycled plastics

WMI is testing the environmental safety and strength of lumber made from recycled plastics, a project that may lead to dual benefits—for the environment and the economy.

building materials and erosion control structures made from incineration ash

Since the mid-1980s WMI has had an active research program on the production of construction and erosion control materials made from a composite of incineration ash and cement.

As incineration of solid waste replaces landfilling in some communities, disposal of the ash residue will become more and more of a problem. Using the ash as construction aggregate will decrease the amount of ash to be landfilled, as well as providing a substitute for natural aggregate, which is in short supply on Long Island.

Blending the ash with cement has produced a number of potentially useful composites that have been formed into various construction materials such as blocks and molded forms. These materials are used in artificial reefs, storage buildings, pavement, and erosion control structures. WMI researchers carefully test the ash-composite materials used in these structures for durability and environmental safety. Following completion in 1990 of the first full-size building using ash-composite building blocks, the WMI team embarked on a long-term research project to assess the building for air quality and the surrounding soil for potential leachates from the blocks.

compost from sorted municipal waste

In a collaboration with Cornell University's Waste Management Institute, WMI has recently initiated a program to assess public health effects and environmental impacts of composting garbage and trash from which recyclables have been removed. The results of this research will provide information on how the quality of the end product—compost—and its potential uses are related to the initial composition of the mixed solid waste. With this informa-

Palmer Photo

▲ *MSRC boat storage building made from incineration ash-composite blocks.*

tion, composting can become another option for addressing the mounting waste crisis, particularly for smaller communities where landfilling or incineration are not acceptable.

public education

Public education is equally important to WMI as its research—to discuss waste management issues with the community through brochures, speaking engagements, classroom talks, and symposia. More formal education is provided through a certificate program on waste management issues, created by WMI several years ago. WMI graduated its first students in 1991.

environmental assessment

Understanding the scientific aspects of pollution is only beneficial if the information is used to maintain and perhaps enhance environmental conditions and public health. WMI has taken a leading role in monitoring and assessing conditions that may lead to such events as hypoxia and anoxia, particularly in the New York Bight, and washups of floatables on New York and New Jersey beaches.

For example, WMI researchers have assessed the role of winds on the transport of floatables once introduced into the region's waters. By identifying weather patterns that may

cause washups, they are able to provide warnings to appropriate agencies when necessary.

WMI has demonstrated that some secondary materials can be used as safe alternatives to disposal. Using these positive results, WMI has worked with the New York Department of Environmental Conservation and legislators to encourage public demonstration projects, such as road construction, for these materials. Through such programs, WMI measures long-term effects of secondary materials, assesses their durability, and determines public acceptability.

policy analysis

WMI played an active role in establishing the national agenda for marine pollution research, development, and monitoring. In January 1991, the Institute assembled experts from around the country in a workshop to identify the important scientific issues and problems in marine pollution that need to be addressed between 1992 and 1997.

The workshop, funded by the National Ocean Pollution Planning Office of the National Oceanic and Atmospheric Administration, provided input to the National Ocean Pollution Program Plan. This plan guides federal agencies in ocean pollution research, development, and monitoring.

See pages 82-95 for a more detailed description of the Waste Management Institute activities.

COAST Institute

linking science with management

James Gleick, author of the book entitled, *Chaos: Making a New Science* said, "At the boundary, life blossoms." It is also at the boundaries – the interfaces – among the sciences where the most exciting breakthroughs in science, particularly in the environmental sciences, will come. And it is at the interfaces between the sciences and management where new paradigms will blossom.

The Coastal Ocean Action Strategies (COAST) Institute is designed to operate at the edges – at the interfaces – of research with management and policy and at the boundaries of research with education at all levels. The goals of the COAST Institute are to develop mechanisms to effectively bridge these interfaces and to use those linkages to make singularly important contributions. The COAST Institute was created because of our belief that more of the same or even more rigorous kinds of research, more of the same kinds of environmental management, and more of the same kinds of environmental education will not even allow society to keep pace with increasing stresses on coastal environments, let alone reverse the deterioration that has occurred.

In the last Biennial Report we stated that the COAST Institute had no counterpart anywhere in the world. It still does not. The Institute was designed to have a major annual session which focuses on a single issue, problem, or opportunity to be addressed by experts and scholars gathered from around the world into a "think tank" environment. The focus is on developing new, different, novel approaches to persistent problems that have been resistant to traditional approaches. Each session includes decision makers as

Rowland Photo

participants: members of government, regulatory agencies, environmental groups, regional planning boards, and industry.

Rowland Photo

The Institute's annual sessions provide a forum for exploring all types of critical issues related to the coastal ocean. The topics may be controversial; most will be largely scientific and technical, but they need not be. All problems, issues or opportunities that are tackled, however, must have major policy or management implications.

The Institute activity does not stop when the report is printed. Part of COAST's name is Action and its success will be measured by its effectiveness as a change agent. Recommendations from each session specify what actions are needed, who should take them, and on what schedule. Since the sessions involve some of the key decision makers associated with the particular issue, they serve as catalysts for change.

The intensive annual session is still the major mode of operation of the COAST Institute, but requests for assistance from COAST have led to involvement in a large number of relatively short-term projects throughout the country. These have included assistance in formulating a vision for the Delaware Bay estuary in the year 2020, in developing a salinity standard for the San Francisco Bay estuary to manage freshwater inflow, preparation of an overview of the world's waste problem and the impacts of these wastes on the coastal ocean, and preparation of an overview of how diversion and damming of rivers worldwide have impacted coastal environments and their living resources. The COAST Institute is now being sought out as a problem solver.

public education

national beach cleanup

The COAST Institute has sponsored several projects over the past two years for public education about the threats to our coasts. One such event is the annual beach cleanup, a national event targeting local beaches for cleanup by citizens' groups, environmental agencies, and marine institutions.

In 1991, the occasion coincided with a State of New York initiative, "Coastweeks." During this time, institutes such as MSRC are asked to hold special events related to our coasts. MSRC's geological oceanographer Henry Bokuniewicz took the opportunity to lead a field trip for beach cleanup participants at Smith Point County Park, on Long Island's south shore, to discuss beach geology and erosion dynamics. Several members of the MSRC staff, faculty, and students also joined in Coastweeks activities at an information booth set up in a local shopping center.

marina recycling

During the summer of 1990, COAST initiated a marina recycling effort at Port Jefferson, a busy pleasure boating port on Long Island's north shore. The purpose of this project, conducted in cooperation with the Town of Brookhaven, New York State Department of Environmental Conservation and MSRC's Waste Management Institute, was to provide recycling receptacles for easy access to boaters, and to generate awareness about garbage and trash dumped overboard by distributing pamphlets about recycling and the effects of garbage in the sea.

See pages 97-101 for a more detailed description of the COAST Institute activities.

Rowland Photo

▲ *MSRC 60-foot R/V* ONRUST

Institute for Urban Ports and Harbors

Creation of the Institute for Urban Ports and Harbors in 1988 signaled MSRC's commitment to continuing leadership in environmental issues in New York Harbor. Its creation marked more than two decades of activities in this harbor and in other urban ports and harbors around the world.

Over the years, MSRC scientists have been involved in many research and advisory projects concerning New York Harbor. Geological oceanographers developed a dredging and dredged materials management plan and assessed the environmental effects of different strategies of sand mining in the lower bay of the harbor. They have served as advisors on the environmental effects of creation of artificial islands in different areas of the harbor, of deepened principal navigation channels, and of waterfront development projects.

MSRC researchers carried out the most comprehensive studies ever done of harbor fish populations and examined the nutrient distribution in the lower Hudson Bay and the nutrient flux through the mouth of the harbor.

MSRC's geological oceanographers have studied the potential effects of sea level rise on the infrastructure of New York City; our physical oceanographers investigated the two-layer flow in the East River, helping to explain the shoaling of navigation channels and trapping of contaminants in the harbor. Together, physical and geological oceanographers conducted field studies of the fate of suspended particles and their associated contaminants in the Hudson River estuary.

Others helped develop special monitoring plans for water quality in the Harbor and contributed to understanding the causes and effects of the low dissolved oxygen problem in western Long Island Sound and alerting environmental managers about the problem.

One MSRC researcher served as an expert, giving physical oceanographic testimony, for a legal case to determine whether Long Island is truly an island or an extension of the mainland based on whether the East River is a river or a tidal strait. The case came to court to determine the extent of New York's three-mile territorial fishing boundary. In the final verdict, Long Island was determined to be an extension of the mainland.

Rosaland Photo

harbor video premiere

The most recent project of the Institute was the creation of an educational video on the Harbor for the U.S. Environmental Protection Agency's (EPA) New York-New Jersey Harbor Estuary Program. The video, "Alive in an Urban Harbor," will have its premiere on public television early in 1992.

message from William Simon

As the time draws near for me to leave the MSRC Visiting Committee, I have naturally been reflecting on my tenure as chairman. It has certainly been an exciting and challenging three years. Under Jerry Schubel's able leadership, the MSRC has significantly increased the number of its faculty and full-time graduate students and raised its sponsored research budget by a remarkable 33 percent. We have also added four new institutes: the Living Marine Resources Institute, Waste Management Institute, Coastal Ocean Action Strategies Institute, and the Institute for Urban Ports and Harbors.

Among the community of oceanographic institutions, MSRC is not only the best, but also unique, in its focus on coastal oceanography and in its willingness to tackle tough environmental problems, to challenge conventional wisdom, and to search for alternative approaches to seemingly intractable problems. Although MSRC's achievements of the past three years have been remarkable, in many ways I think the best is yet to come. I expect MSRC to be a leader in development of the most innovative strategies to combine economic growth with concern for our natural environment.

We have asked some of our friends to reflect on our progress over the past two years since our last Biennial Report was published. Here is what they had to say:

In the last two years, the Center has made great strides in advancing marine education, in providing richer opportunities for those who aspire to become marine scientists; in enhancing service to the Long Island community and to the region; and in responding to managers by utilizing research to solve problems.

— NY Senator Kenneth Lavalle

A decade ago my hope for the Marine Sciences Research Center at Stony Brook was that it would become a world leader in coastal zone marine studies. Its ideal location, its strong interest in policy formulation and implementation, as well as basic science, and its vigorous leadership made it easy to predict success.

Today we can honestly say those hopes have been fulfilled. But what is even more gratifying is the sense within the Center that the real work is just beginning. The new century is bringing new challenges that cannot be addressed adequately with the old ways of thinking. The issues of global change, the recognition of the mutual interaction of oceans and the atmosphere, and the impact of industrialization on the environment, especially in third world nations, are among those that the Marine Science Research Center is well poised to attack. I am confident that at the end of the nineties we will be able to look back upon the growth and success of the Center with as much pride as we now celebrate the progress of the past few years.

—John H. Marburger, President The University at Stony Brook

As I depart the Visiting Committee, I am confident that the next Biennial Report will reflect MSRC's continued success and accomplishments in the critical field of coastal oceanography.

The Matter Over
by Heather McHugh

It is better to say "I am suffering" than
to say "This landscape is ugly."
SIMONE WEIL

From the piling's kelp I drew
the starfish with its five blunt fingers.

First I thought the creature
less than handsome, less of a hand

than I expected, rigid, with a stumpy gray
asymmetry of grasp. It wasn't soft. It hardly moved. So maybe

it was dead? I couldn't see
beyond myself, until I turned

the matter over, and beheld
billions of unfamiliar

facts—minute transparent
footlets, feelers, stems

all waving to the quick, and then
the five large radials beginning

gradually to flail, in my slow sight,
and then, in my thin air,

to drown. I'd meant
to send it, as a gift, to you

who were my missing part,
so far inland. Instead

to a world the sighted have no rights to
to the dark that's out of mind,

I made myself resign it,
flinging the hand from my hand.

Editors Note: The author's father is Professor Emeritus J.L. McHugh

an essay from author Roger Stone

In my book, *The Voyage of the Sanderling*, an ecological account of a sailboat voyage from Maine to Rio de Janeiro, I devote several pages to my passage through Long Island Sound late in the summer of 1986.

After spending a peaceful night at anchor in Port Jefferson Harbor, I state,

> At dawn we set off again toward Hell Gate, the East River, and New York City. Early on we passed Crane Neck and Stony Brook Harbor, a little hole where grassy mud flats occasionally give way to narrow channels, and where as a child I had learned something of sailing in open sixteen-foot Comets. Our well-organized fleet, which consisted of a dozen or so boats, had two races a week during the summer season, a committee to which to protest rule violations, and many trophies to award at the annual Labor Day finale. Despite fluky winds and currents, and the often realized threat of capsizing or running aground, we took it all very seriously and felt special delight in beating the adult skippers, who usually turned out only for the Sunday races... All week, at least when we did not have summer jobs, we would bash around among ourselves, racing and cruising: the Comets were our hot rods, and we would ask the girls to go out with us, and our beer and cigarettes, on moonlight sails. We also went clam digging on the mud flats, listened to the quawks of the black-crowned night herons along the shore, endured stubborn gnats when it was calm, absorbed the full presence of nature in what then was still a rural place.

By the time Rachel Carson's *Silent Spring* was published in 1962 I had left the region, to return only infrequently over the next three decades. So I missed local repercussions of her powerful lament about the use of DDT and its consequences for many familiar species. I was absent during the great wave of development along the Jericho Turnpike; the clamorous construction of a major university campus that has brought radical change to the region's landscape; the relentless reduction of potato fields into little residential parcels. I knew only by hearsay of such new realities as red and brown tides and other forms of marine pollution out in the Sound and along the shore, the threat of groundwater contamination from saltwater intrusion and leakage from septic tanks into the aquifer, the waste management crisis, the frequent incursions of bulldozers into pollution filtering saltmarshes and pine barrens. A combination of nostalgia and distance insulated me from these harsh new truths.

In 1991, I returned once more to the Three Villages as the guest of the Marine Sciences Research Center, and with some time to rummage around ashore. This visit enabled me to comprehend more clearly the magnitude of the change that has beset the region since the carefree days of my midcentury adolescence. And in my mind it triggered a wave of broad thoughts. The planet seems somehow able to adjust to the presence of artificial environments in the form of large asphalted cities. But, I now asked myself, what happens when you asphalt the surrounding greenbelts as well, systematically substitute an ersatz "second nature" for their natural ecosystems? In places such as the Three Villages, as well as in Mexico City, or in the grimy industrial belts of Eastern Europe, or in the devastated former tropical forests of the Amazon

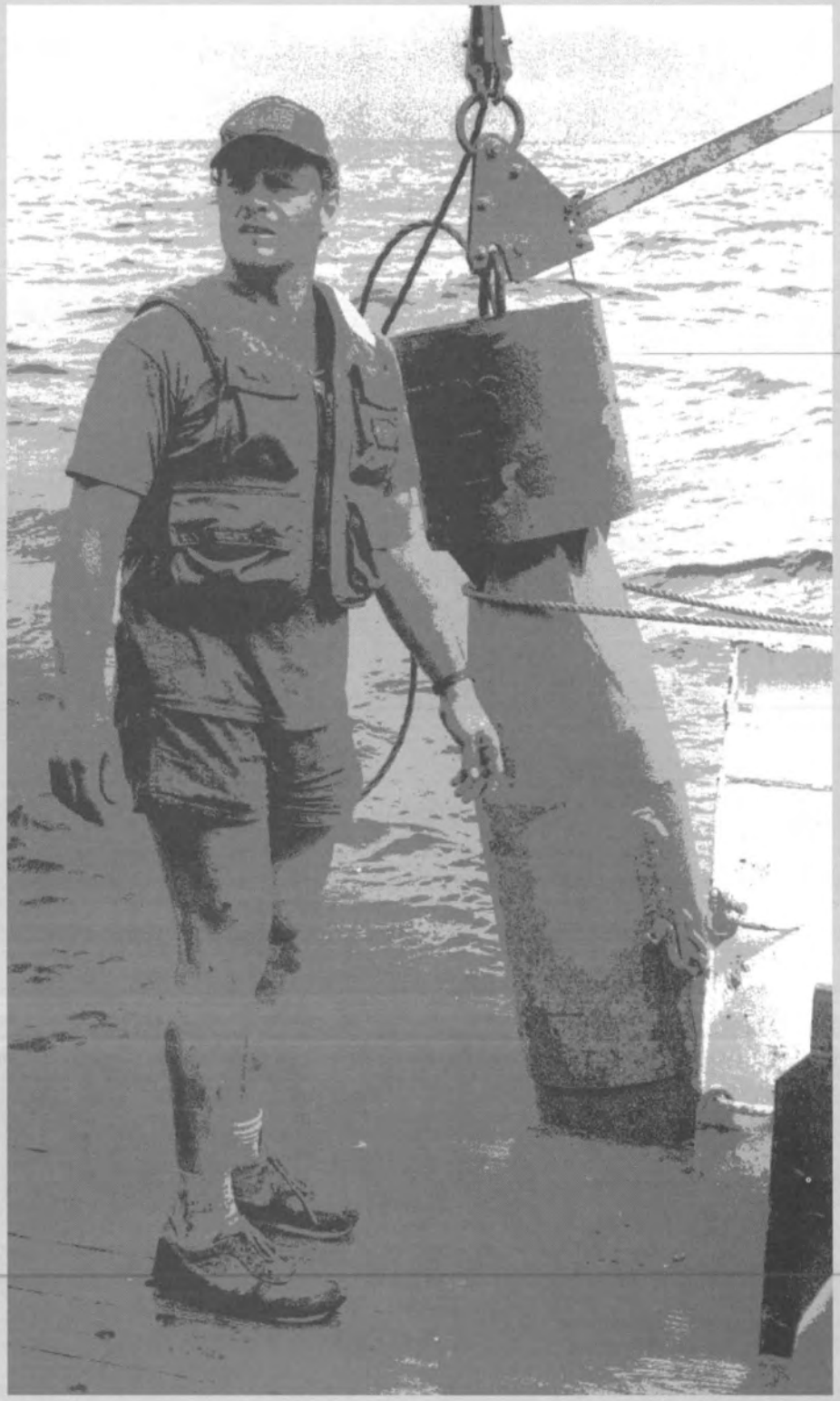
and Philippines, are we proceeding headlong toward some form of severe ecological trauma? Are we talking here not only about the quality-of-life considerations that still make many people think of environmentalism as a rich man's game—but also about forms of pollution that may affect human health as well as human well-being? For how long can these villages *survive* the environmental pressure now being placed on them?

No doomster, I welcome the hope that such commentators as Julian Simon put forth: that new technologies will carry the day, moving the world during the coming century away from the environmental brink faster even than people are hurtling in its direction. But in the absence of firm evidence that these miracles await us, it strikes me that it is sound planning—a new kind of insurance policy—for people to try to trim their lifestyles to fit within the boundaries of "sustainable development." And what my visit made me question most about the Three Villages has to do with how willing their citizens are to make the adjustments in consumption, in resource usage, in design of homes and gardens and lifestyles, that would bring stability to the local ecology *without* the techno-fixes that Simon foresees.

I wonder about individual behavior. What is there to learn about levels of local enthusiasm for recycling programs, string bags, biking to work and conserving energy in other ways? And what forms of collective pressure for sustainable development are being applied? Are citizen groups working hard to save the barrens, the saltmarshes, the Sound? Stop, ar at least slow, the erosion of Crane Neck and Old Field Point? Assuming some organization around these and other similar issues, what evidence is there of its political effectiveness? Can politicians in these communities express "green" thoughts and also get elected? Who if anyone feels alarmed, senses danger? On the positive side, is there local evidence of synergy between economics and the environment as a substitute for the old adversarial relationship?

It is not customary, I know, for people to ask such questions about neighborhoods that appear as tidy, as well-managed, indeed as affluent as does much of the Three Villages region. But being there again forced me to them. It made me resolve to return for a longer stretch, to look carefully at how these communities have responded to the environmental warning signals that I saw and heard. And to try to formulate some thoughts about what the nature of these reactions (or the absence of them) might teach us about the future of the planet.

faculty research programs



Stubakoff photo

See shaded columns for glossary terms shown in bold italics in text.

Benthic—Associated with the sea bottom.

Bioturbation—Reworking of sediment by the activities of animals living within or on the sediments.

Diagenetic Processes—Processes involved in the modification of sediments between the times of deposition and metamorphism.

Benthos—Organisms which are associated with the sea bottom collectively form the benthos.

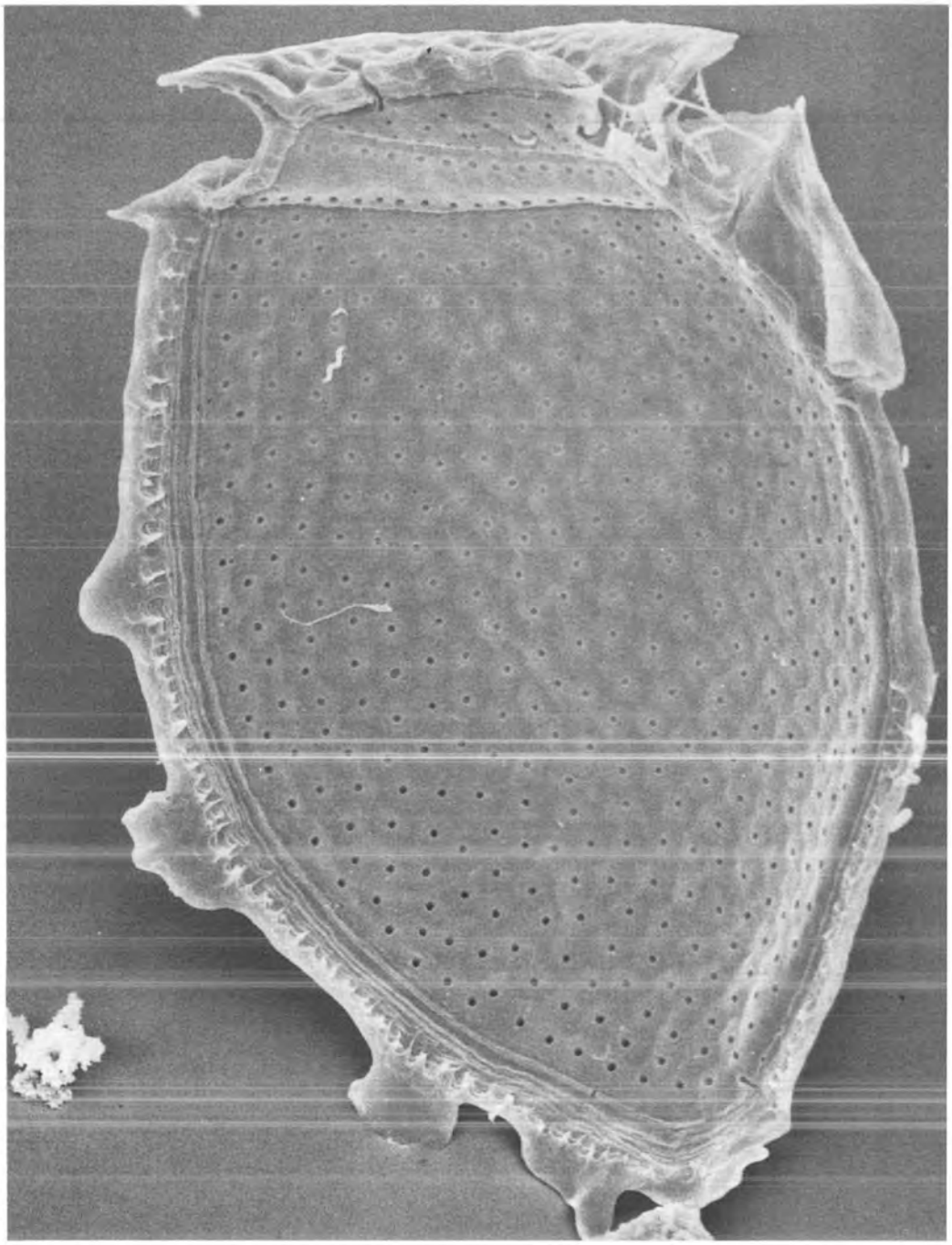


Photo courtesy of University of Stokholm

▲ *Scanning electron micrograph of the dinoflagellate,* Dinophysis norvegica, *from the Baltic Sea. Marine biologist Edward Carpenter studies growth rates and photosynthetic characteristics of this toxic blooming species to learn what causes it to bloom.*

biological oceanography

Biological oceanographic research at MSRC is widely diverse, much of it focused on the production, ecology, biochemistry, and physiology of bacteria, plants, and animals living in marine environments. Several research groups, in particular, those involved with marine plankton, are applying molecular biological techniques to better understand the role of gene structure and expression in the biology of microorganisms.

The biological oceanography faculty conducts research in Long Island Sound, the Hudson River estuary, and other nearby waters, as well as locales around the world—from tropical to polar, and from intertidal to deep sea. The aim is to understand marine life on earth, from the local to the global scale.

MSRC's biological oceanographers are a large and varied group, many of whom are involved in interdisciplinary research. One group is primarily engaged in studying plankton biology, while others focus on fish and benthic organisms. In shallow coastal waters, water column and ***benthic*** processes are interconnected, so collaborative research is common. Access to colleagues in other departments on campus and at Brookhaven National Laboratory also facilitates this collaborative approach.

research programs

Josephine Aller

dynamics of benthic organisms

The reaction of marine species to oxygen deficiency helps to predict their capacities to survive in habitats which periodically experience low dissolved oxygen, a condition called hypoxia. While more motile fin and shellfish can leave such an area, *infauna*—animals that live in the sediments—rarely can. The impact of a change or even a temporary elimination of benthic infauna on fin and shellfish, for which they are a food source, is not known. Moreover, ***bioturbation*** by an active bottom community is critical to decomposition processes and nutrient regeneration in estuarine ecosystems.

Aller is assessing the impact of low oxygen on benthic infauna common to Long Island sediments. In collaboration with Robert Cerrato, Aller and her graduate student Patrick Dooley are determining the effects of variations in temperature and oxygen levels, comparing metabolism in the presence of oxygen (aerobic) or absence of oxygen (anaerobic), and evaluating the responses in terms of successional stages represented — which organisms colonize the sediment first, next, and so on.

biogeochemical process in Amazon shelf sediments

As part of the AmasSeds (a multidisciplinary shelf sediment study) group, Aller has been examining the structure and dynamics (recruitment, growth, survival, and activities) of the benthic community on one of the most physically active continental shelf environments in the world—the Amazon. Seabed geochemistry and associated benthic biological studies in this project are designed to document large-scale ***diagenetic processes*** on the Amazon Shelf, to exploit unique biogeochemical and physical features for study of modern elemental cycles, and to provide insights into ancient sedimentary environments.

In collaboration with MSRC biogeochemist Robert Aller, Neal Blair of North Carolina State University, and several Brazilian chemists and biologists, Aller is trying to elucidate the major physical, chemical, and biological factors controlling benthic community patterns in Amazon shelf sediments and is evaluating the effect of biological activities on sediment characteristics. Preliminary results of samples collected during descending, ascending, and peak river discharge conditions indicate distinct spatial and seasonal patterns in the ***benthos*** which mirror the physical regime.

Pelagic—Living on or near the surface of the open sea at some distance from land.

Dinoflagellate—A unicellular algae with two flagella. Usually one flagellum has the form of a helical ribbon encircling the cell body, and the other is a simple flagellum trailing behind.

The ability to fix nitrogen can be as important as a fertilizer in adding new nitrogen to a low nutrient environment, such as the tropical oceans.

meiofauna and nutrient fluxes in sediments

Macrofauna rework the sediments in activities including irrigation, feeding, burrowing, and tube construction. The impact of these activities on sediment-water exchange rates has been well documented. What role the smaller, meiofaunal sized organisms might play has not been examined. In a collaborative effort with Robert Aller, she has been conducting laboratory experiments using whole community and individual meiofaunal groups to study this question.

The results of this work show that meiofauna do stimulate sediment-water-nutrient exchange and rates of aerobic decomposition, particularly nitrification in the oxic zone of marine sediment. This contrasts with the activities of macrofauna, which have a greater relative effect on anaerobic processes and subsequent reoxidation of reduced metabolites.

disturbances and benthic fauna in the deep sea

Aller has also been funded to complete the analysis of samples collected several years ago in 4800 m of water on the Nova Scotian Rise as part of the HEBBLE project. She is trying to understand how the presence, frequency, and strength of near-bottom currents in this deep-sea region affect seabed topography, sedimentary structures, and benthic fauna.

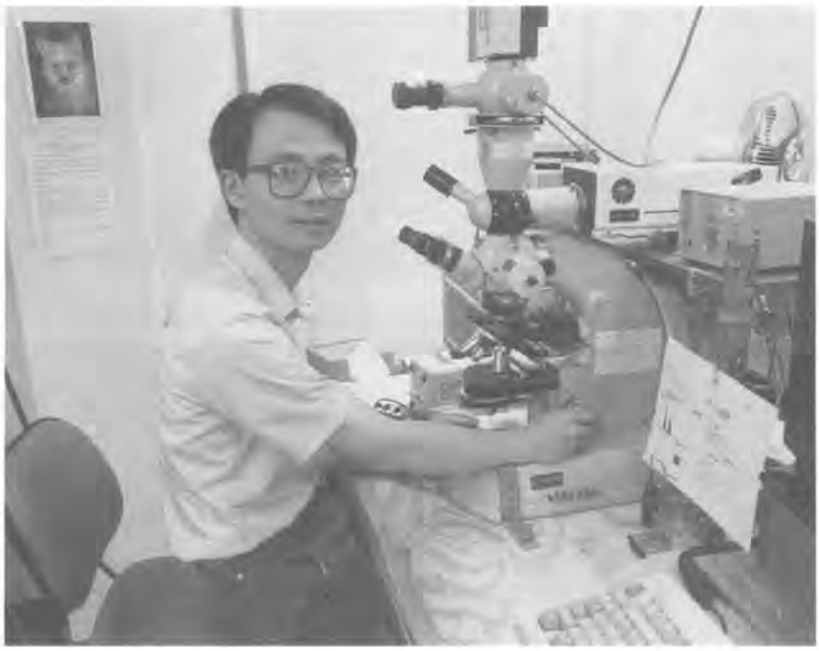
Edward Carpenter

phytoplankton growth and nitrogen fixation

Edward Carpenter's research team has developed a new method of calculating species-specific growth rates of phytoplankton in the field. These measurements are important to determine how significant individual species are in the food chain or how environmental conditions affect the growth of a species. But up to now it had been very

Palmer photo

◀ *Josephine Aller*



Palmer photo

▲ *Jeng Chang*

difficult to measure growth rates of individual species in nature.

Carpenter and Research Assistant Professor Jeng Chang measure DNA content of individual nuclei in phased populations of phytoplankton—those dividing all at the same time—over a 24-hour period. They have now completed a field program to measure growth rates and quantum efficiency of open ocean and coastal populations of phytoplankton. The data from this research are valuable in assessing the contributions of individual species to primary production and determining factors that limit photosynthesis.

Carpenter and student Pirzada Siddiqui are also interested in the particular capability of a ***pelagic*** marine cyanobacterium, a blue-green alga, to serve as a nitrogen fertilizer in the ocean. This cyanobacterium, *Trichodesmium,* frequently blooms, creating dense populations in tropical and subtropical seas. It is also the major nitrogen fixing microbe in open ocean waters, taking atmospheric nitrogen and converting it to ammonium, a form of nitrogen that phytoplankton use for enzyme production and nutrition.

Over the past year Carpenter has initiated a program to study the major biochemical and physiological factors involved in the fixation of nitrogen by this species. The study, involving two research cruises in the central Caribbean Sea, centers on nitrogenase, an enzyme that converts atmospheric nitrogen to ammonium. Carpenter is trying to learn how the enzyme, which is deactivated by oxygen, is protected from deactivation while in the presence of oxygen created during photosynthesis.

Since *Trichodesmium* is important in the nutrient budget of the sea, Carpenter and student Ajit Subramaniam have initiated a program to develop the algorithms for the optical detection and measurement of this organism from aircraft or space-based sensing equipment. Carpenter and Subramaniam study images from the Coastal Zone Color Scanner satellite to map bloom frequency and size of blooms in tropical seas in an effort to understand causes of blooms.

Jeng Chang
phytoplankton growth rates

Analytical measurements of single cells is Jeng Cheng's approach to obtain species-specific information from a phytoplankton community. This research provides valuable information about important processes such as growth, seasonal succession, competition, and red tide formation which shape the communities.

Chang, who collaborates closely with Edward Carpenter, has been involved in a long-term project to develop a method to estimate growth rates of individual species by measuring cellular DNA content. During the past year, he used a computer simulated cell population to determine the best computational procedure for accurate estimates, and has applied this method to measure growth rates of an oceanic ***dinoflagellate***

Microtubule—One of the basic types of filaments in a cell that maintains a cell's shape and internal organization.

Immunostain—The technique that labels and identifies specific proteins with antibodies.

Trophic—Having to do with nutrition.

Coupling—A connection between two systems, causing one to oscillate when the other does.

Mettaloids—Elements having properties of both a metal and a nonmetal.

Marine snow—Aggregates of detritus, mostly of biological origin, which sink in the water column.

Trophic transfer— Flow of nutrition from producer (organism eaten) to consumer.

Depuration—Release of contaminants from marine organisms in sea water.

Colloids— Substances composed of particles that are extremely small but larger than most molecules. These particles do not actually dissolve, but remain suspended in a suitable gas, liquid, or solid.

Courtesy of Stazione Zoological, Naples

▲ *Scanning electron micrograph (SEM) of* Oxytoxum sp., *which belongs to a group of large dinoflagellates living in the open ocean. Little is known about how fast they grow and how effective they are in fixing carbon dioxide. New techniques developed at MSRC will help answer these questions and to understand their importance in marine ecosystems.*

Ceratium teres in both the Caribbean Sea and Sargasso Sea. He is currently refining this technique by investigating the use of ***microtubule*** morphology made visible by an ***immunostain*** technique, instead of DNA content, to determine growth rates. This approach should greatly improve the performance of the growth rate method for two reasons: several species can be measured simultaneously and a fluorescence-detecting microscope is all that is needed to do the measurement.

In a related project, he measures the light absorption capability of a phytoplankton species to estimate its photosynthetic efficiency. This capability is analyzed from the absorption spectrum of a single cell. Using a microscope equipped with a monochromator and a photocell, he can pass a light beam through a single cell, and determine the absorption of light at various wavelengths. Chang has used a culture of the dinoflagellate *Heterocapsa triquetra* to test the microscope system and has started to apply this technique to natural populations of *C. teres*. Using these techniques, he will be able to examine the relationships between growth, light absorption capability, and environmental light intensity.

Elizabeth Cosper
diatom ecology

Cosper is interested in the physiological ecology of marine phytoplankton. Research in her laboratory has involved evaluating the mechanisms that allow marine diatoms to

develop resistance to toxic chemical pollutants such as PCBs, and the ecological consequences of this resistance.

She has also become involved in both field and laboratory research into the causes of the "brown tide" blooms which have plagued Long Island embayments since 1985. She is conducting studies of this previously undescribed phytoplankton species' growth physiology to better explain its explosive growth in local bay waters.

In collaborative efforts with Darcy Lonsdale, she is investigating the nature and degree of ***trophic coupling*** between phytoplankton productivity and zooplankton grazing in the Hudson River estuary and Long Island bays.

Nicholas Fisher
association of metals with marine plankton

Nicholas Fisher's research focuses principally on the interactions of metals and ***metalloids*** with living marine plankton and planktonic debris, such as dying phytoplankton and zooplankton, zooplankton fecal pellets, and ***marine snow***. Specifically, he studies adsorption and desorption kinetics of metals, biochemical association of the metals in cells, ***trophic transfer*** and assimilation of ingested elements in animals, and retention of metals in planktonic debris as they undergo bacterial decomposition. This research generally employs radiotracer methodology, using gamma-emitting radioisotopes, which enables experimentation with environmentally realistic metal concentrations, often in the picomolar range. This work is applicable in part to better understanding the chemical and biological interactions in marine systems of long-lived radioactive wastes emanating from the nuclear fuel cycle.

Other ongoing projects in Fisher's laboratory include studies on the physiological ecology of marine phytoplankton, quantifying the rates and routes of metal bioaccumulation and ***depuration*** in marine phytoplankton, zooplankton, bivalves, and fish, and an investigation of factors affecting the release of carbon from biogenic debris.

Recently, Fisher and his students have also been examining the association of metals in marine systems with ***colloids*** and investigating the nature of the binding of different elements to cell surfaces. This work is aimed at providing a mechanistic, fine-scale depiction of the processes governing the binding of metals to particle surfaces and relating it to the bioavailability and trophic dynamics of metals in marine food webs.

The results of these investigations are used to better understand biogeochemical cycles of a variety of metals and metalloids in the oceanic water column and to enable predictions on the fate and effects of contaminants entering marine waters.

***See additional research conducted as part of the Waste Management Institute*, pp. 82-95**

Dooley photo

◀*Nicholas Fisher and graduate student Wenxiong Wang.*

Palmer photo

▲ *Valrie Gerard*

Valrie Gerard
ecology and physiology of seaweeds

Valrie Gerard's research interests focus on the ecology and physiology of seaweeds, particularly species which are important as primary producers in marine ecosystems or as commercial aquaculture crops.

Much of her recent research examines genetic variation among populations of the common kelp, *Laminaria saccharina*, which occurs throughout the northern hemisphere. The wide geographic range of this species is partly due to its ability to adapt genetically to different environmental conditions.

She has identified several genetic varieties, or ecotypes, of *L. saccharina* from Long Island Sound and the New England coast. These ecotypes show different responses to light and temperature conditions, and genetic differences are expressed in both the large spore-producing phase and the microscopic sexual phase of the life-cycle. Her next step will be to explore how genetic adaptation in one of these phases influences the complementary phase, i.e., how natural selection works in an organism with a complex life-history.

Gerard has conducted several other research projects in her laboratory recently. In one, she developed a computer model to predict the population dynamics of giant kelp in California. In another, she examined the relationship between nitrogen-fixing cyanobacteria and the green seaweed *Codium fragile*.

In a third project, she determined effects of high-frequency light fluctuations on the carbon metabolism of the

red seaweed *Chondrus crispus*. And her newest research project will determine whether environmental stress that occurs during the early developmental stages of a seaweed influences the physiology and growth of that plant later on in its life.

Millsaps photo

◀Acartia tonsa, *a coastal marine copepod.*

R. Patrick Hassett
copepod feeding activity

Observations of the feeding activity of marine copepods (Class Crustacea) have revealed a wide range of responses both between and within species. Feeding may be continuous, with no change in gut fullness over a diel period, or feeding may occur on a cyclical, diel pattern.

A cyclical pattern may be seen even when copepods are continuously exposed to food, as with *Acartia tonsa*, *Calanus finmarchicus*, a vertical migrator that rises to food-rich zones at night and returns to deeper, food-poor regions in the day, was found to have a cyclical pattern in gut cell development in which certain cell types are depleted during feeding and regenerated during a non-feeding period.

As a vertical migrator, *C. finmarchicus* has a natural period during the daylight hours in which to allow this regeneration. The question then arises, does a non-migrating copepod, exposed to continuous food, also require a period of time for gut cells to regenerate? Put another way, is this cell regeneration an adaptation to vertical migration or an inherent part of copepod feeding biology?

Zooplankton live in a food environment that is constantly changing, whether viewed over time scales of minutes, hours, days, or months. This fact lies at the heart of Postdoctoral Fellow R. Patrick Hassett's research interests. In past research, he has looked at feeding rates, digestive enzyme activities, and assimilation efficiency to investigate how a marine planktonic copepod responds to changes in its food environment. His recent research has been directed towards coastal zooplankton, and has ranged from polar seas to the sub-tropics.

Hassett's current research, with MSRC's Darcy Lonsdale and in collaboration with P. Blades-Eckelbarger of the Darling Marine Center in Walpole, Maine, involves a study of gut cell cycles and feeding rhythms in the nearshore copepods, *Acartia tonsa* and *A. hudsonica* over a 24-hour period in the laboratory. This research arose from his earlier thesis work on the role of feeding history in subsequent feeding behavior on the copepod *Calanus pacificus* over time scales ranging from hours to weeks. In his thesis work, he investigated the ability of copepods to produce one type of gut cell, a large vacuolated cell called the B-cell, which limits the ability of Calanus-type copepods to feed continuously at high rates.

Etiology—The part of any science that deals with the causes of its phenomena.

Demographic—Concerning the study of the statistics of births, deaths, disease, etc. as illustrating the conditions of life in communities.

Autotroph—Self-nourishing, e.g., photosynthetic plants.

Heterotroph—Nourished by intake of other organisms; e.g., herbivorous or carnivorous animals.

Productivity—The rate of energy fixed, or made into biomass.

Several types of cells in the copepod gut continually are produced, differentiate, perform their function, and die. Hassett is now investigating whether the patterns observed in *Calanus* can be more generally applied by studying the responses of *Acartia tonsa*, which has a very different life-history strategy. He is combining a micrographic study of gut cells during feeding with measurements of physiological rates and gut fullness. His goals are to understand the physiological limitations of feeding processes in copepods under different environmental conditions.

Darcy Lonsdale
zooplankton and phytoplankton interactions

Over the past year, Darcy Lonsdale has initiated several new research projects. One project, in collaboration with Fred Dobbs, a former MSRC postdoctoral fellow and Coastal Marine Scholar, is to study the ***etiology*** and ***demographic*** effects of an "affliction" in an estuarine copepod, which renders females unable to reproduce.

Based upon histological examinations of healthy and afflicted copepods with light and electron microscopy, Lonsdale and Dobbs have ruled out pathogens as the cause. They have concluded that the phenomenon represents a reproductive resting state and hypothesize that this trait is an overwintering response. The offspring of these overwintering females may be the source of early spring recruitment of the copepods.

▼ *Darcy Lonsdale with graduate student Asha Divadeenam*

Dooley photo

Colflesh photo

◀ *Electron micrograph of browntide cells, magnified 30,000 times.*

Lonsdale discovered that whether developing juvenile female copepods eventually become overwintering or actively reproducing females is linked to water temperature and light cycle. The results from laboratory studies suggest that in nature, photoperiod in particular serves as the critical cue for copepods in differentiating between the onset of harsh (winter) and favorable (spring) environmental conditions for growth. At these times, water temperatures are similar, but spring has a longer period of daylight and winter has a shorter photoperiod.

Moreover, laboratory experiments showed a shorter photoperiod induces overwintering in copepods taken from a southern population (Maryland), compared to those derived from a northern population (Maine). The southern population, which has a longer, milder growing season, is cued into the overwintering phase later in the season, at about 12 hours of daylight (in nature, between October and November). On the other hand, the northern population switches to overwintering at about 14 hours of daylight, equivalent to September—about the time when their natural environment turns too harsh for growth and reproduction.

This study has revealed an elegant mechanism in which temperature and photoperiod cues induce the copepod to adopt a life-history strategy (i.e., to reproduce or overwinter) appropriate for a particular environment. Lonsdale hypothesizes that the genetically based population differences in response to photoperiod have evolved to reflect latitudinal differences in optimal growth and reproductive periods.

Another project, begun in 1990 in collaboration with Elizabeth Cosper, is an investigation of plankton dynamics in the lower Hudson River estuary. Their overall objective is to develop a better understanding of the key trophic interactions controlling the flow of materials, derived both from ***autotrophs*** and ***heterotrophs***. In this project, field and experimental studies of phytoplankton ***productivity*** and composition, and their relationship to zooplankton grazing, growth, and reproductive success are being explored.

A similar suite of questions about phytoplankton-zooplankton interactions are also being explored by Lonsdale and Cosper in two shallow embayments on Long Island—Great South Bay and the Peconics Bay system. The emphasis in this study, however, is to understand the factors that contribute to the growth and decline of noxious algal blooms, which frequent these bays, particularly the brown tide.

Ontogeny—The development of an organism, or the history of its development.

Ichthyoplankton—eggs and early life stages of fish, prior to their ability to swim.

Forage fishes—species of fish that are food for predator species and typically not of commercial interest for human consumption.

Biofouling—A series of processes leading to the colonization of an inert or living surface by attached organisms.

Conditioning film—A film formed by adsorption and binding of dissolved organic molecules that initiate biofouling.

Biofilm—A layer of pioneer microorganisms that attach and grow on surfaces conditioned by a conditioning film.

Glenn Lopez

ecology of deposit-feeding organisms

Benthic ecologist Glenn Lopez has focused for the past several years on the adaptations and constraints of deposit-feeding animals in mud. Deposit feeders are the major functional group associated with the ocean bottom: they provide most of the food for demersal fish and control the rates of geochemical-microbiological processes in sediments. Deposit feeders subsist on a remarkably poor food source—organic matter in mud—necessitating very rapid feeding rates. Some species eat hundreds of times their body weights of sediment daily.

Recently, Lopez has focused on two aspects of deposit feeding biology. One is an investigation, in collaboration with former student Valery Forbes and a scientist from Odense University in Denmark, of the role of gut residence time. Having high feeding rates results in rapid gut transit of food in many deposit feeders, especially smaller species. Lopez and his colleagues developed a mathematical model of time-dependent absorption of different types of food and tested the model in experiments on deposit-feeding snails.

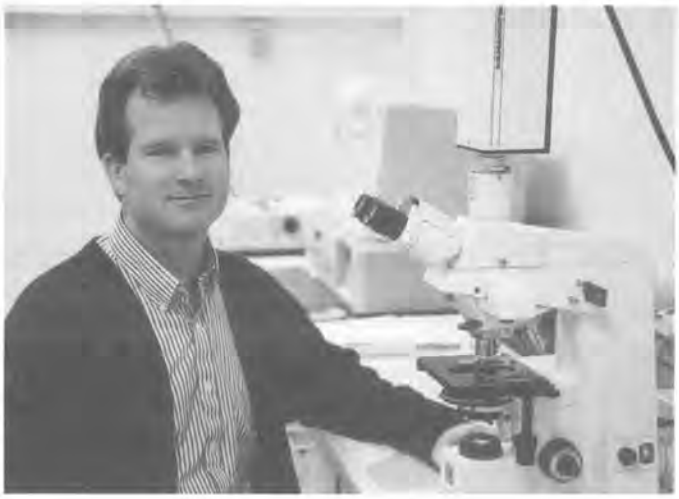
All benthic animals are very small when they recruit to the benthos; thus, the second aspect of deposit feeding biology of interest to Lopez is the ***ontogeny*** of deposit feeders. Because juveniles have a higher metabolism than adults and require more food per unit body weight, juvenile deposit feeders must feed faster than adults, resulting in exceedingly short gut residence times. For example, juveniles of the polychaete worm *Streblospio benedicti* pass sediment through their guts in as little as two minutes. Lopez is studying whether this places a constraint on absorption rate and what foods can be absorbed during this short period.

Dooley photo

▲ *Glenn Lopez*

cadmium contamination in blue crabs

Lopez has joined Nicholas Fisher and the University at Stony Brook's Ecology and Evolution Professor Jeffrey Levinton to study the transfer of toxic metals, especially cadmium, from



Palmer photo

◀ *Gordon Taylor*

contaminated sediment to the blue crab *Callinectes sapidus*. In an integrated field and laboratory project, they are studying dissolved, particulate, and trophic transfer processes in the cadmium-contaminated Foundry Cove, an EPA Superfund site on the Hudson River.

Doreen Monteleone
ecology of fish early life stages

Since fall 1989, Doreen Monteleone has been the John M. Olin Postdoctoral Fellow for the COAST (Coastal Ocean Action Strategies) Institute (see pp. 17 - 19). As an Olin Fellow she works with Dean and Director J. R. Schubel to make effective linkages among environmental groups, the scientific community, and decision makers. In addition to working with the COAST Institute, her research interests are the factors that affect trophic interactions of ***ichthyoplankton*** with their predators and prey.

Monteleone's recent collaboration with MSRC biological oceanographers Darcy Lonsdale and Robert Cerrato and Dr. William T. Peterson (NOAA Center for Ocean Analyses and Prediction) has produced a summary report of the abundance and distribution of lower trophic level organisms in Long Island Sound. This report covers recent research as well as surveys done almost 40 years ago and includes data on phytoplankton, zooplankton, ichthyoplankton, benthic organisms, and ***forage fishes***. Information from this USEPA funded investigation may be used to determine the effects of hypoxia on lower trophic levels.

Her collaboration with Dr. Edward D. Houde of the University of Maryland has led to verification of otolith marking techniques which were then used to mark and recapture striped bass *(Morone saxatilis)* larvae in the Patuxent River. By being able to determine mortalities after release, they were able to demonstrate the potential to stock a river with 10-day-old fish larvae. Other joint efforts with Houde include maternal influences on growth, survival, and vulnerability to predation of early life stages of striped bass.

Gordon Taylor
biochemical and microbiological processes

Gordon Taylor's main research activity during the past two years has been completion of lab and field studies on molecular and microbiological processes occurring on inert surfaces immersed in sea water, which constitute the earliest events of marine ***biofouling***. The interactions of the substrata, ***conditioning film***, and microbial ***biofilm*** may control subsequent biofouling at the macroscopic level.

This was the third of a three-year program, during which he and his co-workers developed sophisticated techniques to quantitatively and qualitatively examine the dynamics of thin layers of organic molecules (e.g., proteins and polysaccharides) on a variety of substrata.

Taylor examined how the nature of the surface and the presence of organic (conditioning) films influence microbial colonization in the marine environment. He also completed experiments

Sorption—Adsorption or absorption.

Functional morphology—The form and structure of organisms, taking into account the function.

Mechanoreception—Reception by specialized sensory receptors that respond to mechanical stimuli, such as pressure.

comparing the bioavailability and decomposition of adsorbed proteins with suspended proteins to determine how ***sorption*** to a surface affects rates of degradation. A better understanding of these processes is beneficial for developing effective countermeasures in marine engineering applications, for example, development of coatings that bind organic molecules and microbes inefficiently.

Understanding these processes will also be useful in studies of microbial colonization on other organisms, and studies of sediment and groundwater processes. Many elements, compounds, and pollutants bind strongly to surfaces in natural waters. Therefore, many transformation, degradation, and remobilization processes may be mediated by microorganisms also bound to the surface.

On another program, Taylor and coworkers have been evaluating the feasibility of applying new laser spectroscopic techniques to measurement of low level inorganic nutrients in seawater. Their focus has been on nitrite and nitrate measurement, which is now feasible down to subnanomolar levels, a hundredfold improvement over current techniques. Such high sensitivity may be useful in studying nitrogen dynamics in areas where nitrite-nitrate concentrations are below current detection limits, such as surface waters of the open ocean.

As a spin-off from this project, they found it relatively easy to obtain detailed structural spectra of natural abundances of dissolved organic matter, which yield information on composition and quantity of matter in this carbon reservoir. Unlike previous qualitative techniques, no concentration or isolation procedures are required.

Taylor and a co-worker have also completed and published a study on the relationships of microorganisms to sinking debris and productivity in the open ocean. Vertical transport downward of microorganisms is strongly dependent on surface productivity and decreases more rapidly with depth than sinking debris. The authors concluded that attached microorganisms probably have a secondary role in particle decomposition. This study is important to understanding the cycling of carbon in the upper ocean and the fate of atmospheric carbon dioxide.

Charles Wurster

PCB persistence and public policy

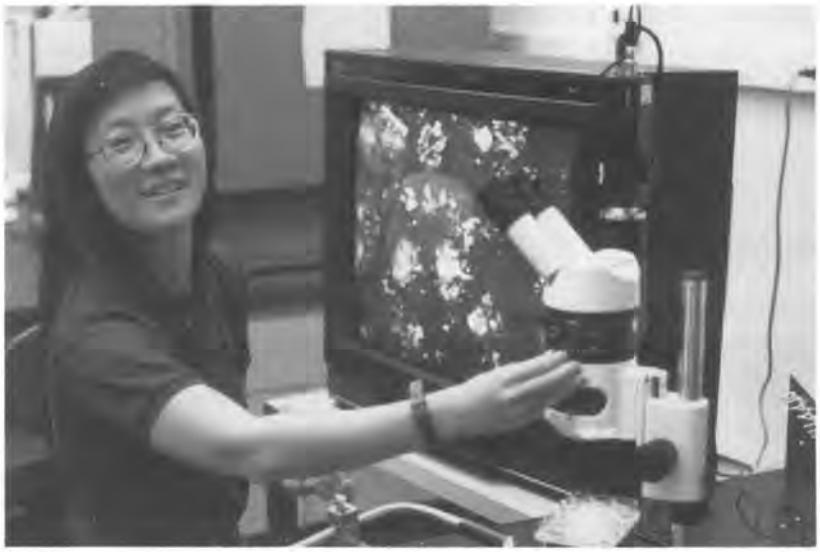
Charles Wurster has long been interested in the effects of stable chlorinated hydrocarbon pollutants on marine plankton communities. Focusing on those chemicals found regularly in the environment (polychlorinated biphenyls, or PCBs; DDT; DDE; and dieldrin), he and his

coworkers have studied the effects on individual species, mixed cultures, and natural phytoplankton and zooplankton communities in an attempt to understand the impact of these chemicals on aquatic ecosystems.

They have found that the growth of some species of algae is inhibited by chlorinated hydrocarbon concentrations as low as the parts per trillion range. This sensitivity varies greatly with the species, the supply of nutrients, the temperature, light intensity, and the site of origin of the clone. Furthermore, selective toxicity may alter the species composition within the community.

Currently, Wurster is studying the development of resistance to toxic chemical pollutants by phytoplankton. He has found that phytoplankton from chronically polluted areas are more resistant to toxic pollutants than are those from unpolluted areas. In fact, cross-resistance to other toxicants sometimes develops when resistant strains are produced in the laboratory. He is currently investigating the mechanisms by which phytoplankton become resistant to toxic pollutants.

Concurrent with traditional laboratory research, he has had a long-term concern with the involvement of science in the development of public policy on issues of environmental importance. For 25 years, Wurster has been substantially involved with the Environmental Defense Fund, a non-profit, public benefit organization that seeks to combine science, economics, and law to influence public policy for environmental protection.



Stefakoff photo

▲ *Jeannette Yen*

Jeannette Yen
copepod sensory perception

Jeannette Yen is hoping to advance our understanding of how zooplankton remotely detect and respond to hydrodynamic disturbances. Her area of research interest is the ***functional morphology*** of sensory receptors, mainly of a pelagic predatory copepod in the genus *Euchaeta*. *Euchaeta* catches its prey with is enlarged maxillipeds, predominantly using ***mechanoreception***, and Yen is asking how mechanoreception aids it in capturing prey of a preferred size.

Members of this genus of crustaceans feed on other crustacean prey and fish larvae. Four different species of *Euchaeta* exhibit size-selective predation. An acute sensory system must contribute to their survival, not only to capture food, but also to distinguish between the signals of escaping prey, lunging predators, and attractive mates. To study this problem, Yen is using fixed-frame, laser-illuminated videophotography to examine the size, shape, and temporal stability of the flow field and capture area of the predatory copepod and the fluid deformations produced by the prey that elicit the predatory response.

Yen also extends her research far to the south, in Antarctica. She is studying the reproductive ecology of

Congener—Two or more different species from the same genus.

Recruitment—The number of juvenile organisms arriving at a habitat where they will grow and live for an extended period of time.

Phenotype—Discernable characteristics of an organism resulting from genetic and environmental interactions.

Recruitment, the establishment of planktonic larval organisms in habitats such as estuaries where they will grow to a larger size and possibly to adults, is the subject of several important studies by the Fisheries Group.

Euchaeta antarctica, a large, carnivorous marine copepod, twice the dry weight of its subarctic ***congener***, four times that of its temperate congener and 20 times that of its tropical congener. Yet, in each of their respective communities, this genus is considered abundant and one of the largest of the copepods in its community.

Others have observed the increase in size of plankton towards higher latitudes and deeper depths, although the reason for the increase in body size has not been adequately explained. The extreme seasonality in food availability, according to Yen's hypothesis, exerts a selective pressure for those animals able to take maximum advantage of available food by either storing the excess in their bodies or by allocating it to making young. Within this framework, Yen hopes to understand *Euchaeta's* nutritional and physiological status and to characterize the life history traits that led to its evolution and success in the rigors of the polar environment.

Jonathan Zehr
molecular biological basis of nitrogen fixation

The focus of Jonathan Zehr's research is the factors regulating the fixation of atmospheric nitrogen by marine microorganisms. This process is particularly important, since the availability of fixed inorganic nitrogen often limits primary productivity of the oceans.

Trichodesmium is one of the major nitrogen-fixing microorganisms in open ocean water. Moreover, it is capable of fixing nitrogen in the same cell where oxygen, which deactivates nitrogenase, is produced.

It is not clear why this microorganism is so successful ecologically, and why other nitrogen-fixing microorganisms are not more abundant. The answers to the questions of the ecological success and peculiar biological capability of *Trichodesmium* lie in the molecular characteristics, the protein composition, and even in the DNA that encodes the genes for nitrogenase and other proteins.

Zehr has begun to characterize the nitrogen-fixation apparatus of *Trichodesmium*, including studies of regulation of the nitrogenase protein, and analysis of the physical arrangement and DNA sequence of the genes encoding nitrogenase. An exciting outgrowth of his research is the use of a very sensitive molecular technique, the polymerase chain reaction, to amplify a segment of the nitrogenase genes. This technique can now be used for other nitrogen-fixing microorganisms, and provides a powerful new tool for detecting and characterizing the nitrogen-fixing microorganisms from many marine environments.

fisheries biology

MSRC's Fishery Biology group continues to focus attention on a variety of problems affecting New York's marine finfisheries and shellfisheries. We are the only institution in the U.S., and probably the world, with a major research program focusing on the ***recruitment*** and retention of the larvae of bluefish (*Pomatomus saltatrix*), the number one species landed in the recreational fishery of the U.S. East Coast. We have continued our strengths in bivalve research, while expanding our roles in new areas—crustacean biology and striped bass genetics.

Our researchers continue working on recruitment to learn how young bluefish, as well as the young of other species, are transported from their offshore spawning grounds to inshore nurseries. Recruitment studies of other fish species now underway involve coral reefs off Barbados and retention of larvae in the Hudson River estuary.

They are also looking at how predation on fish larvae by juvenile bluefish enhances the growth of bluefish while diminishing the abundance of other fishes. And a new area of research on genetic variation in growth rate of striped bass is now underway in our group.

Shellfish research at MSRC has also been extremely active. Our researchers have concentrated on interpreting patterns of growth based on morphological features of the shell and to statistically analyze growth data. Results from new studies of paralytic shellfish poisoning (PSP) in bivalves and continued research on predators of newly settled bay scallops will aid in the management of these species.

The addition of Steven Morgan to our faculty has added to our expertise in crustacean biology, in particular, and in recruitment dynamics, in general. Our continued research strengths and growth into new areas have clearly enhanced MSRC's reputation as one of the premier institutions in marine fishery biology in the United States.

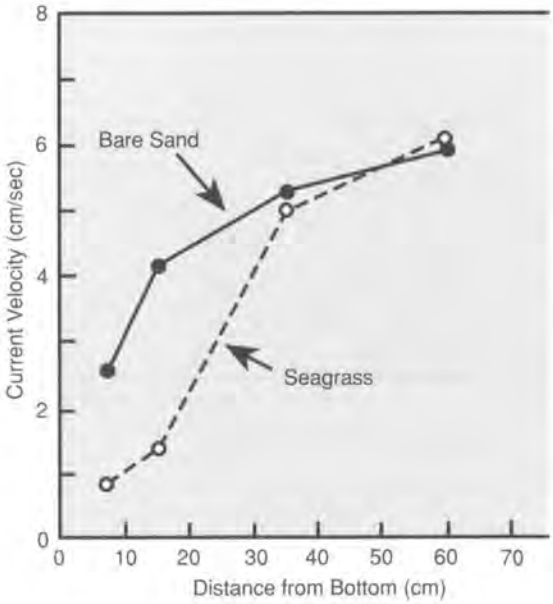
research programs

Francisco Borrero
seagrass beds and scallop growth

Francisco Borrero joined the Marine Sciences Research Center in 1991 as a postdoctoral fellow working with Monica Bricelj. Borrero's previous work centered on the physiological mechanisms of adaptation to contrasting environmental conditions and the role of plasticity of ***phenotype*** on capacity for adaptation. His dissertation research involved studies of the bioenergetics of natural populations of mussels differing in level of occurrence across the intertidal zone.

Borrero is now collaborating with Monica Bricelj in a project aimed at elucidating the various ways in which the seagrass habitat influences the survival, performance, and growth of bay scallops (*Argopecten irradians*).

Previous observations demonstrated that juvenile scallops obtain a partial refuge from predation by climbing the seagrass blades, thus maintaining an elevated position above the substratum. Because the presence of seagrasses exerts an influence on the hydrodynamic



▲ *Flow velocity profiles at two adjacent locations, with and without seagrasses (Zostera marina). Effective grass height in the area averages 30 cm. Seagrasses reduce the velocity of water flow near the bottom. Bricelj and Borrero are studying the effects of varying patterns of water flow on juvenile scallop growth.*

Seston—A mixture of living and non-living, organic and inorganic particles dissolved in natural fresh and marine waters. Seston constitutes the main food source of suspension-feeding animals.

Trophic levels—Position in the food web relative to size and food value of the organism being eaten; e.g. higher trophic level large fish eat smaller fish, zooplankton, and phytoplankton.

Bivalves—Any mollusk whose shell consists of two parts hinged together, such as oysters and clams.

Anadromous—Moving from seawater to freshwater to spawn.

characteristics of these shallow environments, they are also likely to affect scallop growth.

Borrero and Bricelj are studying the patterns of water flow and the composition of the ***seston*** in areas differing in type of substratum, abundance, and height of seagrasses. These data are used to determine the rates of seston flow and the characteristics of food in various habitats and at various depths on the water column, and is, in turn, related to variation in growth of shell and soft tissue of juvenile scallops maintained at the same flow regimes.

The results of these investigations, along with ongoing studies on the rates of predation by various species of crabs and fishes on juvenile scallops, will contribute to a better understanding of the natural scallop population dynamics and to optimized efforts to restock bay scallops in New York waters.

Monica Bricelj

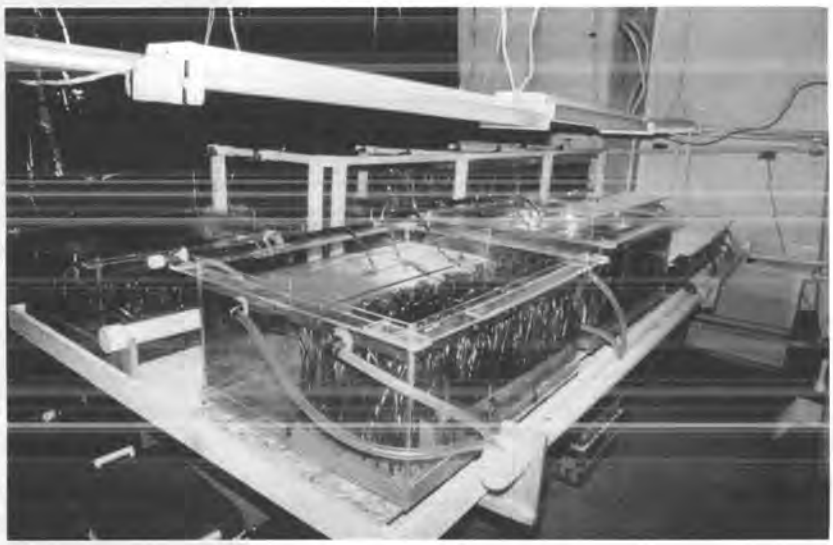
paralytic shellfish poisoning

Monica Bricelj and her students have just completed a two-year study on the transfer of paralytic shellfish poisoning (PSP) toxins through the various ***trophic levels*** in the food web. Their recent work has focused on how the variable toxicities of different strains of red-tide dinoflagellates (species of phytoplankton in the genus *Alexandrium*) affected toxin accumulation in filter-feeding ***bivalves***, such as hard clams and mussels.

Bricelj's research showed that bivalves, following ingestion of dinoflagellate cells, are capable of efficiently converting low-potency, but highly labile, toxins to highly toxic compounds. Thus, the toxin composition of dinoflagellate cells can be altered during transfer up the food web. The low-toxicity dinoflagellates become highly toxic once ingested by clams.

predation on juvenile bivalves

Bricelj is also studying predation by crabs on juvenile bay scallops. She is continuing her research on the role of eelgrass in providing a nursery habitat for bay scallops, and has found that above-bottom



Rowland Photo

◀ *Recirculating seawater system used to conduct short-term experiments on scallop and crab behavior under controlled light and temperature conditions.*

attachment to eelgrass blades offers post-settlement scallops effective, though only partial, protection from several common crab species.

Mud crabs (*Dyspanopeus sayi*) were identified as the dominant predator of juvenile scallops in several Long Island embayments. Bricelj and her students thus continue to study this species' foraging behavior and ecology in eelgrass meadows. These studies will help them learn what the optimal requirements are for the success of scallop reseeding programs, both in Long Island bays and in several other East Coast states.

Rowland photo

▲ *Juvenile bluefish*

David Conover

bluefish recruitment

Conover and his students continue to concentrate on a bluefish (*Pomatomus saltatrix*) recruitment program which he established in 1985. Focusing on recruitment into Great South Bay, Long Island, they have found that young bluefish migrate from offshore to inshore estuarine waters, and at the same time, their diet shifts from zooplankton to fish. After recruitment, the young bluefish grow extremely rapidly and continue feeding on the young of other fishes. Their abundance thus directly affects the abundance and recruitment of other estuarine species. His research group is now focusing attention on the impact of bluefish predation on young ***anadromous*** fishes in the Hudson River.

evolution of sex ratio and somatic growth rate

Conover has been the first to provide answers to the question that has concerned scientists for many years: Why do so many species have balanced (one female to every male) sex ratios? He reared five populations of Atlantic silverside at different temperature extremes over many generations. Since the silverside's sex is determined by the temperature experienced by the larvae, the experiment should have yielded a skewed sex ratio, with mostly females at one temperature and mostly males at another. To the contrary, whichever sex was in the minority invariably increased until a balanced sex ratio was once again established. These unique experimental results appeared in *Science* and *Scientific American*.

Conover's work on silversides has also provided the first insight into how growth rate evolves. He has shown that the shorter the length of the growing season at different latitudes, the larger the capacity for growth in the fish living in those latitudes. For example, fish living at high latitudes with a short growing season have the genetic capacity to grow much faster than do populations of the same species living at lower latitudes.

He is now testing for genetic variation in the growth rate of striped bass from different latitudes. These results will have important implications for choosing natural stock with high growth rates to be used in aquaculture.

J. L. McHugh

resource management policies

Professor Emeritus J.L. McHugh continues to contribute important ideas to marine fisheries and shellfisheries. In the past he has served on a variety of resource management commissions, including the International Whaling Commission, of which he was chairman until he resigned. He also served on the Inter-American Tropical Tuna Commission, the Mid-Atlantic Fishery Management Council, and many others.

In his writings on various fisheries topics, he has taken a balanced approach, being critical of scientists as well as managers. He published a lead article in *BioScience*, which took scientists to task for extremely poor handling of literature citations in published papers. He also has published reviews of several books on oceanography and fisheries: "The Oceans: A Book of Questions and Answers;" "Poisoners of the Seas;" and "The Provident Sea."

McHugh published a paper in *Ocean Development and International Law*, criticizing the Magnuson Act for failing to adequately manage fisheries all around the United States. The Magnuson Act was established in 1976 to restrict fishing rights off our nation's coast to U.S. citizens, to the exclusion of foreign countries, in a zone up to 200 miles from U.S. shores. Despite this, most of the U.S. fisheries have declined, probably as a result of poor regional or local management. He cited Alaska as probably the only state in the country which has shown some success in managing its fisheries.

Eric Schultz

reproductive timing and recruitment

In the last six years, Eric Schultz has concentrated on the ultimate determinants of reproductive timing in marine fishes. Surprisingly little is known about the ecological and evolutionary influences on seasonal timing of breeding. Do adult energy reserves play a role in determining when an individual can breed? Are the prospects for offspring born early in the season better or worse than the prospects for those born late?

Schultz has sought to answer such questions in a study of the dwarf surfperch, a small live-bearing fish of the California coast. In this study so far, he has determined that female energy stores play an important role in the timing of breeding, and that a good birth date for female offspring may be a bad date for male offspring. For example, females have the best chance of surviving if they are born in the middle of the season, but males (which are born already mature) have the best overall chance of reproducing if they are born early.

In his current appointment as a Coastal Marine Scholar at the Marine Science Research Center, he is collaborating with fisheries biologist Robert Cowen on studies of larval fish ecology and recruit-

ment processes. Schultz and Cowen are currently studying the recruitment of coral reef fish species to the Atlantic island of Bermuda. Despite its remote location, this island's coral reefs have many species in common with the Caribbean and the tropical Atlantic coast of the U.S. It is not known whether the planktonic coral reef fish larvae that settle to Bermuda's reefs were spawned elsewhere or whether they originated locally.

Schultz and Cowen are attacking this problem by utilizing the daily age record in the otoliths (earstones) of juvenile fish captured on the reef. Using this age record, they will determine the length of the dispersive larval phase (to see if current-borne transport from mainland populations is likely) and the timing of arrival to Bermuda (to see if episodes of recruitment correlate with large- or mid-scale hydrographic events that could suggest modes of transport).

Peter Woodhead

fishes of the Hudson estuary

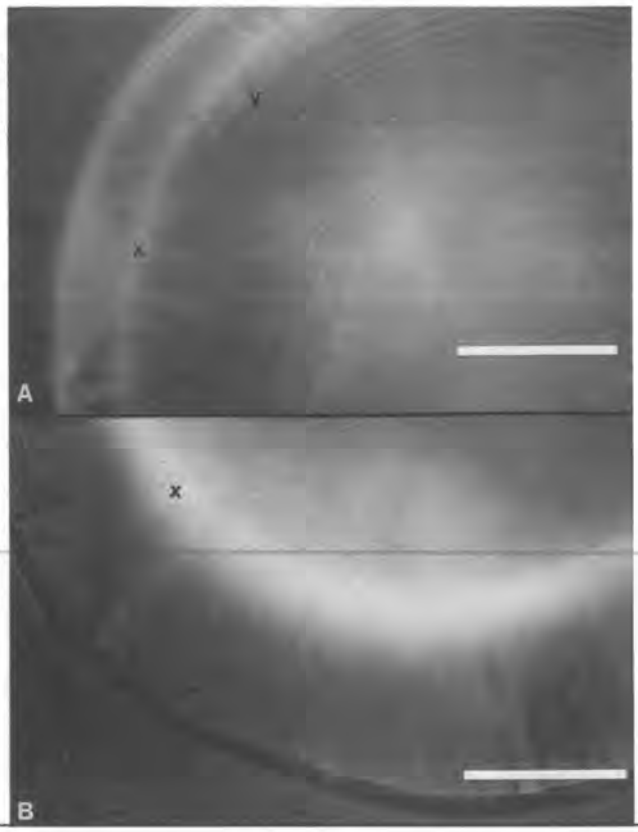
The lower Hudson-Raritan estuary system, including New York Harbor, contains a large and dynamic fish community, the subject of Peter Woodhead's research. He collected 35 fishery data sets between 1979 and 1989, each comprising samples taken through all, or most, of the annual cycle. He used these data sets to characterize the spatial subdivision of the fish community in 15 reaches of the Hudson estuary, standardizing species abundances for sampling effort and performing pattern analysis to expose groupings in the reach samples.

Woodhead found three groups: one in Manhattan and Palisades reaches, one in the Hackensack River, and a large group in the lower reaches, including Lower and Upper Bays, Jamaica Bay, Raritan Bay and Raritan River, Arthur Kill, Newark Bay, and the East River. The latter group may be subdivided into fish communities living in higher and lower salinity reaches.

Woodhead found that the group of samples from Hackensack River was most different from the two other groups. This differentiation increased with distance up the Hackensack River, and may be related to environmental stress from pollution.

Light photomicrograph (using both ultraviolet and visible light) of fish otoliths (earbones) magnified 400 X (scale bars = 0.05mm). Bright bands (marked x) are fluorescent under u.v. light, acheived by immersing the fish in oxytetracycline. The number of narrow lines after the bands correspond to the number of days the fish survived after oxytetracycline treatment, representing a daily age record. Photo A: fish captured in the field (at y) and kept in an aquarium, inhibiting its growth. Photo B: fish tagged with oxytetracycline in the field, released back into the wild, and later recaptured. ▼

Schultz photo



the biological oceanography faculty

Josephine Aller
Francisco Borrero
Edward Carpenter
Jeng Chang
Elizabeth Cosper
Nicholas Fisher *
Valrie Gerard
Patrick Hassett
Darcy Lonsdale
Glenn Lopez
Doreen Monteleone
Gordon Taylor
Charles Wurster
Jeannette Yen
Jonathan Zehr

**also part of the WMI faculty (see WMI research programs, pages 82-95, for description of his research)*

the fisheries faculty

Francisco Borrero
Monica Bricelj
Robert Cerrato*
David Conover
Robert Cowen*
Eric Schultz
J.L. McHugh
Steven Morgan*
Peter Woodhead

** also part of the LIMRI faculty (see LIMRI research program, pages 78 - 81 for description of their research)*

funding sources

Animal Behavior Society; International Atomic Energy Agency; Hudson River Foundation; National Aeronautics and Space Administration; National Science Foundation; New York State Department of Environmental Conservation; New York Sea Grant Institute; Northeast Regional Aquaculture Center; Office of Naval Research; U.S. Environmental Protection Agency;

publications

Aller, R.C.; **Aller, J.Y.** Meiofauna and solute transport in marine muds. Limnology & Oceanography (in press).

Green, M.A.; **Aller, R.C.**; **Aller, J.Y.** Carbonate dissolution and temporal abundances of foraminifera in Long Island Sound sediments. Limnology and Oceanography (in press).

Green, M.A.; **Aller, R.C.**; **Aller, J.Y.** An experimental evaluation of the influences of biogenic reworking on carbonate preservation in nearshore sediments. Marine Geology (in press).

Kristensen, E.; **Aller, R.C.**; **Aller, J.Y.** Oxic and anoxic decomposition of tubes from the burrowing sea anemone *Ceriantheopsis americanus:* implications for bulk sediment carbon and nitrogen balance. Journal of Marine Research; 49:1-28; 1991.

Aller, J.Y. Quantifying sediment disturbance by bottom currents and its effect on benthic communities in a deep-sea western boundary zone. Deep-Sea Research; 36(6):901-934; 1989.

Bricelj, V.M.; Lee, J.H.; Cembella, A.D. Influence of dinoflagellate cell toxicity on uptake and loss of paralytic shellfish toxins in the northern quahog, *Mercenaria mercenaria* (L.). Marine Ecology Progress Series; 74:33-46; 1991.

Bricelj, V.M.; Shumway, S. Physiology: energy acquisition and utilization. In: Shumway, S., ed. Scallops: biology, ecology and aquaculture. New York: Elsevier; pp. 305-337; 1991.

Pohle, D.G.; **Bricelj, V.M.**; Garcia-Esquivel, Z. The eelgrass canopy: an above-bottom refuge from benthic predators for juvenile bay scallops, *Argopecten irradians*. Marine Ecology Progress Series; 74:47-59; 1991.

Bricelj, V.M.; Lee, J.H.; Cembella, A.D.; Anderson, D.M. Uptake kinetics of paralytic shellfish toxins from the dinoflagellate *Alexandrium fundyense* in the mussel *Mytilus edulis*. Marine Ecology Progress Series; 63:177-188; 1990.

Bricelj, V.M.; Fisher, N.S.; Guckert, J.B.; Chu, F.-L.E. Lipid composition and nutritional value of the brown tide alga, *Aureococcus anophagefferens*. In: Cosper, E.M.; Carpenter, E.J.; Bricelj, V.M., eds. Novel phytoplankton blooms: causes and impacts of recurrent brown tides and other unusual blooms. Coastal and Estuarine Studies, Vol. 35. Berlin: Springer-Verlag; pp.:85-100; 1989.

Borstad, G.A.; Gower, J.F.R.; **Carpenter, E.J.** Development of algorithms for remote sensing of marine *Trichodesmium*. In: Carpenter, E.J.; Capone, D.G.; Reuter, J., eds. Marine Pelagic Cyanobacteria: *Trichodesmium* and other Diazotrophs. Dordrecht: Kluwer Academic Publishers (in press).

Carpenter, E.J.; Capone, D.G. Significance of *Trichodesmium* blooms in the marine nitrogen cycle. In: Carpenter, E.J.; Capone, D.G.; Reueter, J., eds. Marine Pelagic Cyanobacteria: *Trichodesmium* and other Diazotrophs. Dordrecht: Kluwer Academic Publishers (in press).

Chang, J.; **Carpenter, E.J.** Species-specific phytoplankton growth rates via diel DNA syntheses cycles. V. Application to natural populations in Long Island Sound. Marine Ecology Progress Series; 78:115-122; 1992.

Siddiqui, P.J.A.; **Carpenter, E.J.**; Bergman, B. *Trichodesmium*: ultrastructure and protein localization. In: Carpenter, E.J.; Capone, D.G.; Rueter, J., eds. Marine Pelagic Cyanobacteria: *Trichodesmium* and other Diazotrophs. Dordrecht: Kluwer Academic Publishers (in press).

Bergman, B.; **Carpenter, E.J.** Nitrogenase confined to randomly distributed trichomes in the marine cyanobacterium *Trichodesmium thiebautii*. Journal of Phycology; 27:158-165; 1991.

Carpenter, E.J.; Chang, J.; Shapiro, L. Blue and green fluorescing dinoflagellates in Bahamian waters. Marine Biology; 108:145-149; 1991.

Carpenter, E.J.; Romans, K. Major role of the cyanobacterium *Trichodesmium* in nutrient cycling in the North Atlantic Ocean. Science; 254:1356-1358; 1991.

Hawser, S.P.; Codd, G.A.; Capone, D.G.; **Carpenter, E.J.** A neurotoxin from the marine cyanobacterium *Trichodesmium thiebautii*. Toxicon; 29:277-278; 1991.

Antia, A. N.; **Carpenter, E. J.**; **Chang, J.** Species-specific phytoplankton growth rates via diel DNA synthesis cycles. III. Accuracy of growth rate measurement in the dinoflagellate *Prorocentrum minimum*. Marine Ecology Progress Series; 63:273-279; 1990.

Capone, D.G.; O'Neil, J.M.; **Zehr, J.**; **Carpenter, E.J.** Basis for diel variation in nitrogenase activity in the marine planktonic cyanobacterium *Trichodesmium thiebautii*. Applied Environmental Microbiology; 56:3532-3536; 1990.

Carpenter, E.J.; **Chang, J**; Cottrell, M.; Capone, D.; Paerl, H.; Bebout, B. Reevaluation of nitrogenase oxygen protective mechanisms in the planktonic marine cyanobacterium *Trichodesmium*. Marine Ecology Progress Series; 65:151-158; 1990.

Chang, J.; **Carpenter, E.J.** Species-specific phytoplankton growth rates via diel DNA synthesis cycles. IV. Evaluation of the magnitude of error with computer simulated cell populations. Marine Ecology Progress Series; 65:293-304; 1990.

Villareal, T.A.; **Carpenter, E.J.** Diel buoyancy regulation in the planktonic marine cyanobacterium Trichodesmium thiebautii. Limnology and Oceanography; 35:1832-1837.

Cohn, M.K.; West, A.S.; **Cosper, E.M.**; **Wurster, C.F.** Mechanisms of resistance to polychlorinated biphenyls (PCB) in two species of marine diatoms. Journal of Marine Biological Association, U.K.; 71; 1991.

Cosper, E.M.; **Lee, C.**; **Carpenter, E. J.** Novel "brown tide" blooms in Long Island embayments: a search for the causes. In: Graneli, E.; Sundström; Edler, L.; Anderson, D.M., eds. Toxic Marine Phytoplankton. New York: Elsevier; 1990: pp. 17-28.

Cosper, E.M.; **Carpenter, E.J.**; Cottrell, M. Primary productivity and growth dynamics of the brown tide in Long Island embayments. In: Cosper, E.M.; Carpenter, E.J.; Bricelj, V.M., eds. Novel phytoplankton blooms: causes and impacts of recurrent brown tides and other unusual blooms. Coastal and Estuarine Studies, Vol. 35. Berlin: Springer-Verlag; 1989: pp.139-158.

Fisher, N.S.; Guillard, R.R.L.; Bankston, D.C. The accumulation of barium by marine phytoplankton grown in culture. Journal of Marine Research; 49:339-354; 1991.

Fisher, N.S.; Reinfelder, J.R. Assimilation of selenium in the marine copepod *Acartia tonsa* studied with a radiotracer ratio method. Marine Ecology Progress Series; 70:157-164; 1991.

Reinfelder, J.R.; **Fisher, N.S.** The assimilation of elements ingested by marine copepods. Science; 251:794-796; 1991.

Fisher, N.S.; Reinfelder, J.R.; Selenium assimilation in a marine copepod. Rapp. Comm. Int. Mer. Medit. 32:232; 1990.

Bricelj, V.M.; **Fisher, N.S.**; Guckert, J.B.; Chu, F.-L.E. Lipid composition and nutritional value of the brown tide alga, *Aureococcus anophagefferens.* In: Cosper, E.M.; Carpenter, E.J.; Bricelj, V.M., eds. Novel phytoplankton blooms: causes and impacts of recurrent brown tides and other unusual blooms. Coastal and Estuarine Studies, Vol. 35. Berlin: Springer-Verlag; 1989: pp.85-100.

Fisher, N.S.; Honjo, S. Intraspecific differences in temperature and salinity responses in the coccolithophore *Emilienia huxleyi.* Biological Oceanography; 6:355-361; 1989.

Burgman, M.A.; **Gerard, V.A.** A stage-structured, stochastic population model of the giant kelp *Macrocystis pyrifera*. Marine Biology; 105:15-23; 1990.

Gerard, V.A. Ecotypic differentiation in the common kelp *Laminaria saccharina:* Phase-specific adaptation in a complex life-cycle. Marine Biology; 107:519-528; 1990.

Gerard, V.A.; Dunham, S.; Rosenberg, G. Nitrogen-fixation by cyanobacteria associated with *Codium fragile* (Chlorophyta): Environmental effects and transfer of fixed nitrogen. Marine Biology; 105:1-8; 1990.

Greene, R.M.; **Gerard, V.A.** Effects of high-frequency light fluctuations on growth and photoacclimation of the red alga, *Chondrus crispus*. Marine Biology; 105:337-344; 1990.

Hassett, R.P.; Landry, M.R. Effects of diet and starvation on feeding rate and digestive enzyme activity of the copepod *Calanus pacificus*. Journal of Plankton Research; 12:991-1010; 1990.

Hassett, R.P. Landry, M.R. Seasonal changes in feeding rate, digestive enzyme activity, and assimilation efficiency of the copepod *Calanus pacificus*. Marine Ecology Progress Series; 62:203-210; 1990.

Hassett, R.P.; Landry, M.R. Short-term changes in feeding and digestion by the copepod *Calanus pacificus*. Marine Biology; 99:63-74; 1988.

Lonsdale, D.J.; Jonasdottir, S.H. Geographic variation in naupliar growth and survival in a harpacticoid copepod. Biological Bulletin; 179:113-120; 1990.

Lonsdale, D.J.; Levinton, J.S. Energy budgets of latitudinally separated *Scottolana canadensis* (Copepoda: Harpacticoida). Limnology and Oceanography; 34(2):324-331; 1989.

Forbes, T. L.; **Lopez, G.R.** The effect of food concentration, body size, and environmental oxygen tension on the growth of the deposit-feeding polychaete, *Capitella* species I. Limnology and Oceanography. 35:1535-1544; 1990.

Forbes, V.E.; **Lopez, G.R.** The role of sediment type in growth and fecundity of mud snails (Hydrobiidae). Oecologia (Berl.) 83:53-61; 1990

Lopez, G.R.; Elmgren, R. Feeding depths and organic absorption for the deposit-feeding benthic amphipods *Pontoporeia affinis* and *Pontoporeia femorata*. Limnology and Oceanography. 34:982-991; 1989.

Lopez, G.R.; Taghon, G.; Levinton, J., eds. Ecology of marine deposit feeders. New York: Springer-Verlag; 1989.

McHugh, J.L. Fisheries management under the Magnuson Act: is it working? Ocean Development and International Law; 21: 255-261; 1991.

McHugh, J.L.; Hasbrouck, E. Fishery management in New York Bight: experience under the Magnuson Act. Fisheries Research; 8:205-221; Amsterdam: Elsevier Science Publishers, B.V.; 1990.

McHugh, J.L.; Wise, W.M.; Young, R.R. Historical trends in the abundance and distribution of living marine resources. In: Cleaning up our coastal waters: an unfinished agenda. Regional conference co-sponsored by Manhattan College and the Management Conference for the Long Island Sound Study, the New York-New Jersey Harbor Estuary Program, and the New York Bight Restoration Plan, March 12-24, 1990 Riverdale, NY; pp. 71-85; 1991.

Monteleone, D.M.; Houde, E.D. Vulnerability of striped bass (*Morone saxatilis* Waldbaum) eggs and larvae to predation by juvenile white perch *(Morone americana* Gmelin). Journal of Experimental Marine Biology and Ecology (in press).

Monteleone, D.M. Seasonality and abundance of ichthyoplankton in Great South Bay, New York. Estuaries 15(3) (in press).

Monteleone, D. M., Cerrato, R. M.; Lonsdale, D. J.; Peterson, W. T. Characterization and assessment of potential impacts of hypoxia of forage species in Long Island Sound, Task 1: abundance and seasonality of key resource species and their forage species. USEPA Report; 1991.

Houde, E. D.; Rutherford, E. S.; Nyman, R. M.; Chesney, Jr., E. J.; Newberger, T. A.; **Monteleone, D. M.**; Morin, L. G. Egg production and larval dynamics of striped bass and white perch in the Potomac River and Upper Chesapeake Bay. Report to Maryland Department of Natural Resources, Tidewater Administration. Ref. No. [UMCEES] CBL 90-114, 673 pp.; 1990.

Monteleone, D.M. and E. D. Houde. Influence of maternal size on survival and growth of striped bass *Morone saxatilis* Waldbaum eggs and larvae. Journal of Experimental Marine Biology and Ecology; 140: 1-11; 1990.

Houde, E. D.; **Monteleone, D. M.**; Morin, L. G.; Linley, L. S. Development of otolith-marking methods to estimate survival and growth of early life stages of natural and hatchery-produced striped bass in the Patuxent River. Ref. No. [UMCEES] CBL 90-153, 52 pp.;1990.

Schultz, E.T. The effect of energy reserves on breeding schedule: is there a saturation point? Functional Ecology; 5; 1991.

Schultz, E.T.; Warner, R.R. Phenotypic plasticity in life-history traits of female *Thalassoma bifasciatum* (Pisces: Labridae). 2. Correlation of fecundity and growth rate in comparative studies. Environmental Biology of Fishes; 30:333-344; 1991.

Schultz, E.T.; Clifton, L.M.; Warner, R.R. Energetic constraints and size-based tactics: the adaptive significance of breeding schedule variation in a marine fish (Embiotocidae: *Micrometrus minimus)*. American Naturalist; 138; 1991.

Schultz, E.T. Daily otolith increments and the early life history of a viviparous fish, *Micrometrus minimus*. Copeia; 59-67; 1990.

Taylor, G.T.; Karl, D.M. Vertical fluxes of biogenic particles and associated biota in the eastern North Pacific: implications for biogeochemical cycling and productivity. Global Biogeochemical Cycles; 5: 289-303; 1991.

Taylor, G.T.; Sharma, S.K.; Mohanan, K. Optimization of a flow-through sampling system for quantitative analysis of dilute aqueous solutions using combined resonance and surface-enhanced Raman spectroscopy (SERRS). Applied Spectroscopy; 44:635-640; 1990.

Taylor, G.T. Variability in the vertical flux of microorganisms and biogenic material in the epipelagic zone of a North Pacific central gyre station. Deep-Sea Research; 36:1287-1308; 1989.

van der Sloot H. A.; **Woodhead, P.M.J.**; Hockley, D.; **Roethel, F.J.** The long-term behavior of stabilized coal ash in the sea. Proceedings of American Coal Ash Association's 9th International Coal Ash Symposium, January 22-25. Orlando, FL.; 1991.

Woodhead, P.M.J. The fish community of New York Harbor, spatial and temporal distributions of major species. Conference Report, Impacts of New York Harbor Development on Aquatic Resources; 1987. New York: Hudson River Foundation; pp. 123-143; 1991.

Woodhead, P.M.J. Inventory and characterizations of habitat and fish resources, and assessment of information on toxic effects in the New York-New Jersey Harbor Estuary. Report in 6 sections to U.S. EPA, concerning Tasks 3.2, 5.1 and 5.3 of the Harbor Estuary Program; 199 pp.; 1991.

Woodhead, P.M.J. The Hudson River artificial reef study program. Report in 6 sections to New York City Public Development Corporation; 391 pp; 1989.

Cohen, M.K.; West, A.S.; **Cosper, E.M.**; **Wurster, C.F.** Mechanisms of resistance to polychlorinated biphenyls (PCB) in two species of marine diatoms. Journal of Marine Biological Association (U.K); 71:247-263; 1991.

Ruben, H.J.; **Cosper, E.M.**; **Wurster, C.F.** Influence of light intensity and photo-adaptation on the toxicity of PCB to a marine diatom. Environmental Toxicology and Chemistry; 9:777-784; 1990.

R. J. Whyte; **Wurster, C.F.** Impact of endosulfan on waterbirds in cotton growing areas. Report to New South Wales State Pollution Control Commission (Australia); 52 pp. 1989.

Wurster, C.F. Birds often warn of environmental degradation. EDF Letter, Environmental Defense Fund, October; 1989.

Yen, J. Predatory feeding behavior of an Antarctic marine copepod, *Euchaeta antarctica.* Polar Research (in press).

Yen, J.; Lenz, P.H.; Gassie, D.V.; Hartline, D.K. Mechanoreception in marine copepods: electrophysiological studies on the first antennae. Journal of Plankton Research; 14(4) (in press).

Yen, J.; Sanderson, B.G.; Strickler, J.R.; **Okubo, A.** Feeding currents and energy dissipation by *Euchaeta rimana,* a subtropical pelagic copepod. Limnology and Oceanography; 36; 1991.

Yen, J.; Nicoll, N.T. Setal array on the first antennae of a carnivorous marine copepod *Euchaeta norvegica.* Journal of Crustacean Biology; 10(2):327-340; 1990.

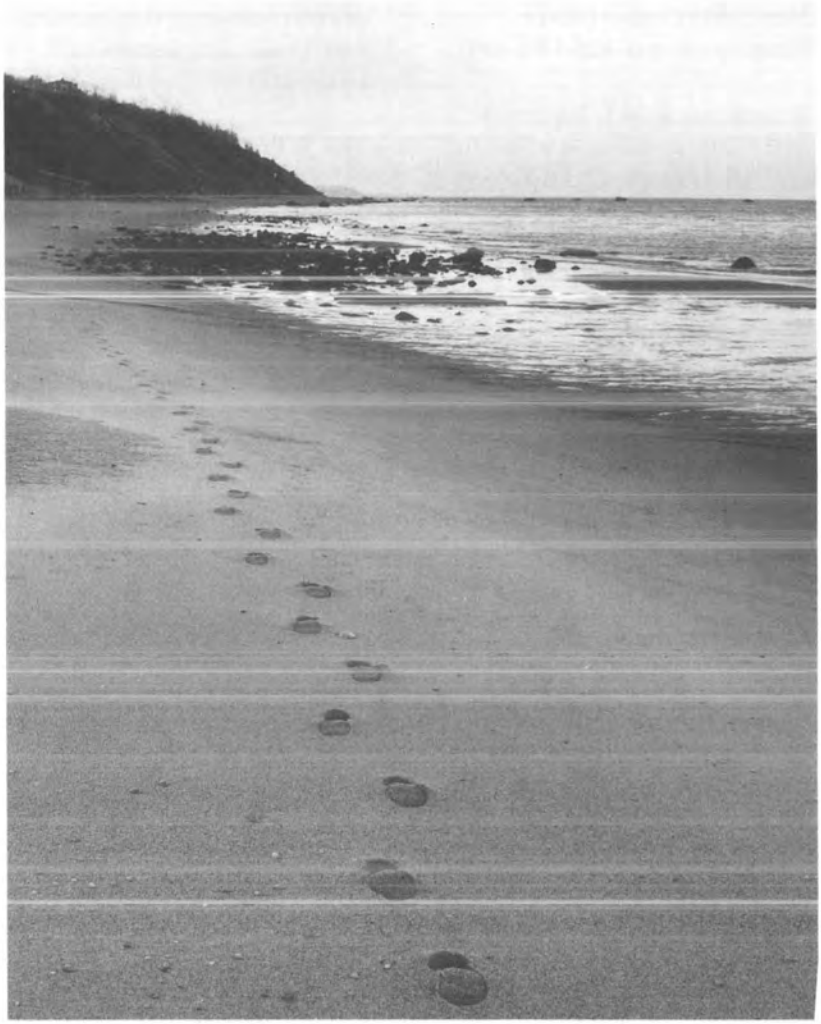
Kirhstein, J.D.; Paerl, H.W.; **Zehr. J.** Amplification, cloning, and sequencing of a *nifH* segment from aquatic microorganisms and natural communities. Applied and Environmental Microbiology; 57:2645-2650; 1991.

Zehr, J.P.; Ohki, K.; Fujita, Y.; Landry, D. Unique modification of adenine in genomic DNA of the marine cyanobacterium *Trichodesmium* sp. Strain NIBB1067. Journal of Bacteriology; 173-7059-7062; 1991.

Zehr, J.P.; Limberger, R.J.; Ohki, K.; Fujita, Y. Antiserum to nitrogenase generated from an amplified fragment of *nifH* from natural populations of *Trichodesmium* spp. Applied and Environmental Microbiology; 56:3527-3531; 1990.

Zehr, J.P.; McReynolds, L. The use of degenerate oligonucleotides for amplification of a *nifH* gene from the marine cyanobacterium *Trichodesmium thiebautii.* Applied and Environmental Microbiology; 55:2522-2526; 1989.

Bedforms—
Topographic features of sea and lake bottoms created by the force of currents flowing over muddy sediment.



Palmer photo

geological oceanography

With the addition of new faculty members, the geological oceanography program at MSRC has expanded its investigation of sedimentary processes in the coastal ocean. These processes are being examined in coastal environments stretching from shallow to deep water, and located both in New York State and at distant points of the globe. In this way our faculty and students can develop a full understanding of coastal processes and build a world-class research program at Stony Brook. At the same time we have maintained research efforts in the coastal waters of New York State, as well as increased understanding of these waters.

The geological oceanographers tackle problems in estuarine waters of Long Island Sound and New York Harbor as part of several environmental studies to improve the quality of local waters. Other studies have a focus on sedimentation in the Great Lakes, which serve as good laboratories for developing technological tools to investigate the relatively deep portions of continental margins.

Other ongoing research involves studies of beach sediments and groundwater in the closest possible oceanic setting to MSRC, along the south shore of Long Island, and studies in the most distant possible setting—an investigation of glacial-marine sedimentation in the Ross Sea of the Antarctic and an investigation of sedimentation on the continental shelf at the mouth of the Amazon River.

An important emphasis at MSRC is the transport of sediment across the shoreline. The study of ripples and dunes, both on land and on the sea floor, is critical to this research.

Rowland photo

Research Programs

Henry Bokuniewicz
suspended sediment dispersion

Field investigations in Long Island Sound under the EPA's National Estuaries Program-Long Island Sound Study have ended, and Henry Bokuniewicz and his colleagues are integrating these results into a regional database. The database will be used to analyze and synthesize the Sound Study field data.

The researchers have prepared maps and reports showing temporal and spatial patterns of water density, dissolved oxygen concentrations, and suspended sediment distributions in Long Island Sound. Ultimately the database will also include observations from the New York Bight, where Bokuniewicz is working to develop a system for use with a Geographic Information System (GIS) for the selection and management of ocean disposal sites.

Bokuniewicz's research has also involved developing methods for estimating the degree of sediment dispersion at different sites, based on such parameters as wave and current energy, grain size, cohesiveness of bottom sediment and evidence of ***bedforms***. In conjunction with this effort, he was a co-convener of an international workshop in

Cohesive sediment—Fine-grained sediments.

Submarine fans—Large areas of thick sediment, deposited in an array like a fan, where rivers empty into the deep ocean.

Belgium in 1990 on fine-grained sediments and, as an outcome, has been investigating comparative techniques for various estimates of resuspension rates.

In light of this research, Bokuniewicz has begun to re-examine the resuspension and transport of fine-grained sediment in the Hudson River and New York Harbor. New understanding of these processes will lend to better control of the pollution problems that plague coastal waters.

Bokuniewicz has continued work on monitoring the behavior of Long Island's beaches. With 13 years of data at East Hampton, he now has the longest active profiling program in the U.S. As part of this work, he is assisting the state in developing a comprehensive program to monitor shore erosion on New York's coast.

Bokuniewicz is also exploring a relatively new aspect of coastal geology—the coupling of watersheds to the coastal ocean. This research on the interaction of fresh and saline ground water at the shoreline has important implications. Pollutants in our aquifers can also seep into adjacent bays and estuaries; thus, there is an increasing realization of the importance of groundwater flows on the quality of the coastal ocean.

As a member of the International Committee for Exploration of the Sea's offshore mining committee, Bokuniewicz has contributed to an international code of practices and a cooperative research report on mining of sand and gravel. Some of this work has been applied to an investigation of the physical impacts—changes in circulation, sedimentation, and shore erosion—associated with mining sand in New York Harbor.

Roger Flood
bedforms and submarine fans

Roger Flood is presently studying sedimentation in several marine and freshwater environments. His current research interests focus on processes in active sedimentary environments, including the deep sea, continental margins, large lakes, and estuaries. These studies help to understand the complex flow sediment interactions that cause and maintain bedforms in ***cohesive sediments***, as well as potential bedform-animal interactions.

Flood has conducted bedform studies along the U.S. continental margin, in the Argentine Basin, in Lakes Superior and Ontario, and in the Hudson River. Bedforms created by fluid flows can be used to understand both local and regional sediment transport and long-term depositional patterns, as well as give insights into long-term contaminant fate and dispersal. Recently, he and his students have been studying the structure and development of ***submarine fans*** on the

Dooley photo

▲ *Roger Flood*

continental margin. These major sediment bodies contain much of the sediment eroded from continents during sea-level lowstands. Their intensive geophysical and sedimentological studies have revealed some of the complexity of these systems and helped to clarify processes responsible for fan development.

To provide new insights into sedimentary processes, Flood uses an array of high-resolution methods, including geophysical techniques (side-scan sonar, seismic profiling, shear-wave analysis, and bathymetry); photography; submersible and diver sampling; and sediment analysis.

Charles Nittrouer

sediments at the mouth of the Amazon

As Chuck Nittrouer has been finishing field and lab work in the Yellow Sea, he has accelerated work on two other diverse continental margins. A Multidisciplinary Amazon Shelf Sediment Study (AmasSeds) has included a series of four cruises, each about two months in duration, to the continental shelf near the mouth of the Amazon. This work has been done in conjunction with other US and Brazilian scientists, as well as with MSRC geochemists and biologists.

Nittrouer's portion of the research has been to understand how the active physical, biological, and chemical processes are being recorded in shelf strata. This has included the examination of strata on the scales of microns to tens of meters through coring and seismic profiling. He has examined sedimentary characteristics such as particle size and structure, along with rates of sedimentary processes, such as accumulation and mixing.

Ross Sea sediments

Nittrouer has been involved in another interdisciplinary program underway in the Ross Sea of the Antarctic continent. The glacial-marine sediments accumulating in the Ross Sea are a complex mixture of material derived from the Antarctic continent (lithogenic) and particles formed by biological processes in the ocean (biogenic), and the origin of these materials is poorly understood.

The research program involves cruises during several austral summers to examine the cycling of biogenic materials, such as silicon and carbon, by biological and chemical processes and the fate of glacially supplied sediment. Interacting with other scientists, who are focused on processes of biological

productivity and chemical uptake and dissolution, Nittrouer's part in the study is to examine the transport of particulates through the water column and their accumulation in the seabed.

Jim Rine

sediments at the mouth of the Amazon River

Jim Rine's research effort during 1990 primarily centered on examination of sediment dispersal, accumulation, and erosion near the mouth of the Amazon River as part of the AmasSeds Project (A Multidisciplinary Amazon Shelf Sediment Study).

In connection with this project, he has performed months of field and laboratory work, both in Brazil and at MSRC. In addition to this research, Rine was involved in logistic administration and coordination of the AmasSeds group at MSRC and the more than a dozen other United States, Canadian, and Brazilian universities involved.

Preliminary new findings from the research point towards spatial (greater than kilometer-scale) and temporal (greater than seasonal to decade scale) variability in sediment accumulation on the Amazon shelf near the river mouth.

J. R. Schubel

coastal sedimentation processes and problems

The Dean and Director of the Marine Sciences Research Center continues to be active at the state, national, and international levels in identifying priority areas for research on coastal sedimentation processes and problems. Over the past two years, he has been a member of the Governor's Task Force on Coastal Resources, the National Research Council's Committee on the Coastal Ocean, and the National Research Council's Marine Board.

Schubel is currently involved in the design of a large international, multidisciplinary study of the environmental effects of development of the Chang-Jiang (Yangtze) River in China.

Palmer photo

the geological oceanography faculty

H. J. Bokuniewicz
R. D. Flood
C. A. Nittrouer
J. M. Rine
J. R. Schubel

funding sources

Long Island Regional Planning Board; National Oceanic and Atmospheric Administration; National Science Foundation; New York Sea Grant Institute; U.S. Army Corps of Engineers; U. S. Environmental Protection Agency.

publications

Bokuniewicz, H.J.; McTiernan, L; Davis, W. Measurement of sediment resuspension rates in Long Island Sound. Geomaine Letters; 11:159-161; 1992.

Gayes, P.T.; **Bokuniewicz, H.J.** Estuarine paleoshorelines in Long Island Sound, NY. Journal of Coastal Research, Special Issue No. 11:39-54; 1992.

Kim, B.H.; **Bokuniewicz, H.J.** Estimates of sediment fluxes in Long Island Sound. Estuaries; 14:237-247; 1991.

Bokuniewicz, H.J.; Pavik, B. Groundwater seepage along a barrier island. Biogeochemistry; 10:257-276; 1990.

Manley, P.L.; **Flood, R.D.** Paleoflow history determined from mudwave migration: Argentine Basin. Deep-Sea Research (in press).

Mello, G.A.; **Flood, R.D.**; Orsi, T.H.; Lowrie, A. Sedimentary processes and features in the southern Brazil Basin: implications for continental rise evolution. In: Poag, C.W., ed. Geological Evolution of Atlantic Continental Rise; New York: Von Nostrand-Reinhold (in press).

Viekman, B.; **Flood, R.D.**; Wimbush, M.; Faghri, M.; Asaho, Y.; Van Leer, J. Sedimentary furrows and organized flow structure: the Lake Superior study. Limnology and Oceanography (in press).

Flood, R. D.; Manley, P.L.; Kowsmann, R.O.; Appi, C.A.; Pirmez, C. Seismic facies and late quaternary growth of Amazon submarine fan. In: Weimer, P; Link, M.H., eds. Seismic Facies and Sedimentary Processes of Modern and Ancient Submarine Fans. New York: Springer-Verlag; 1991: pp. 415-433.

Stoll, R.D.; Bryan, G.M.; Mithol, R.; **Flood, R.D.** Field experiments to study seafloor seismoacoustic response. Journal of the Acoustical Society of America; 89:2232-2240; 1991.

Alexander, C.R.; DeMaster, D.J.; **Nittrouer, C.A.** Sediment accumulation in a modern epicontinental-shelf setting: the Yellow Sea. Marine Geology; 98:51-72; 1991.

Alexander, C.R.; **Nittrouer, C.A.**; DeMaster, D.J.; Park, Y.A.; Park, S.C. Macrotidal mudflats of the southwestern Korean coast: a model for interpretation of intertidal deposits. Journal of Sedimentary Petrology; 61; 1991.

DeMaster, D.J.; Brewster, D.C.; McKee, B.A.; **Nittrouer, C.A.** Rates of particle scavenging, sediment reworking, and longitudinal ripple formation at the HEBBLE site based on measurements of Th-234 and Pb-210. Marine Geology; 99:423-444; 1991.

DeMaster, D.J.; Harden, S.L.; Pope, R; **Nittrouer, C.A.**; Pierson, G. Biogeochemical fluxes in Ross Sea continental shelf sediments. Antarctic Journal of the U.S.; 25; 1991.

DeMaster, D.J.; Nelson, T.M.; Harden, S.L.; **Nittrouer, C.A.** The cycling and accumulation of biogenic silica and organic carbon in Antarctic deep-sea and continental margin environments. Marine Chemistry; 35:489-502; 1991.

Harden, S.L.; DeMaster, D.J.; **Nittrouer, C.A.** Developing sediment geochronologies for high-latitude continental shelf deposits: a radiochemical approach. Marine Geology; 1991.

Diagenetic processes—Processes that are subject to any modification in a sediment between the times of its deposition and its metamorphism.

Anoxic—Without oxygen.

Pore water—Water that fills the small holes, or pores, between sediment particles.

Kuehl, S.A.; Hariu, T.M.; Sanford, M.W.; **Nittrouer, C.A.**; DeMaster, D.J. Milllimeter-scale sedimentary structure of fine-grained sediments: examples from continental margin environments. In: Bennett, R.H.; Bryant, W.R.; Hulbert, M.H., eds. Microstructure of Fine-Grained Sediments; New York: Springer-Verlag; Ch. 3: 33-45; 1991.

Nittrouer, C.A. An Amazon shelf sediment study; Earth in Space; 3:8-9; 1991.

Nittrouer, C.A.; DeMaster, D.J.; Figueiredo, A.G.; **Rine, J.M.** AmasSeds: an interdisciplinary investigation of a complex coastal environment. Oceanography; 4:3-8; 1991.

Nittrouer, C.A.; Kuehl, S.A.; **Rine, J.M.**; Figueriedo, A.G.; Faria, L.E.C.; Dias, G.T.M.; Silva, M.A.M.; Allison, M.A.; Pacioni, T.D.; Segall, M.P.; Underkoffler, E.C.; Borges, H.V.; Silveira, O.F. Sedimentology and stratigraphy on the Amzaon continental shelf. Oceanography; 4:33-38; 1991.

—— A multidisciplinary Amazon shelf sediment study. EOS; 71(45): 1771-1777; 1990.

Sanford, M.W.; Kuehl, S.A.; **Nittrouer, C.A.** Modern sedimentary processes in the Wilmington Canyon area, U.S. East Coast. Marine Geology; 92:205-226; 1990.

Nittrouer, C.A.; **Rine, J.M.** and DeMaster, D.J. A multi-disciplinary Amazon shelf study—the river, ocean, and research. EOS, Transactions of American Geological Union; 1990.

Pacioni, T.D.; Kuehl, S.A.; **Nittrouer, C.A.; Rine, J.M.;** Figueiredo, A.G. Temporal variation of surface mixed-layer thicknesses on the Amazon continental shelf. EOS, Transactions of the American Geological Union; 1990.

Rine, J.M.; Tillman, R.W.; Culver, S.J.; Swift, D.J.P. Generation of late Holocene sand ridges on the middle continental shelf of New Jersey, USA—evidence for formation in a mid-shelf setting based on comparisons with nearshore ridges. Spec. Publications. Int. Ass. Sediment; 14:395-423; 1991.

chemical oceanography

Research in chemical oceanography at MSRC focuses on geochemistry, the study of cycles of elements in the ocean, such as carbon, nitrogen, and iron. Understanding the processes that control the fate of important chemical elements requires an interdisciplinary approach, since they are influenced by physical, geological, and biological processes.

Marine geochemists at MSRC investigate chemical processes in both the water column and the sediments, and thus, frequently interact with scientists from other fields to better understand these systems. For example, benthic organisms can change the chemistry of the sediments during their daily feeding and burrowing activities. Collaboration with benthic ecologists can, therefore, aid in investigations of how organisms living on the sea floor can influence elemental cycles. The knowledge that a benthic ecologist has about these activities may help to explain data collected by chemical analyses.

MSRC chemical oceanographers have active field programs in a number of coastal areas, locally in Flax Pond on Long Island's northern shore and Long Island Sound, and nationally in Florida, Georgia, and Washington. International programs are based in the productive coastal Peru upwelling area and the Amazon River delta. Several faculty members also investigate geochemical processes in the open ocean from cruise ships belonging to the national fleet of oceanographic vessels.

research programs

Robert Aller

diagenetic processes

Many reactions that occur in sediments soon after they are deposited are related to the decomposition of organic matter, such as decaying plankton, which drifts down to the ocean floor. The continuing decomposition on the surface of the sediments controls redox (reduction-oxidation) reactions, which in turn, controls the cycling of many metals.

Redox reactions are most intense and rapid in the upper meter of marine sediment, and especially in the upper 10 centimeters. The chemical, biological and physical changes that occur when sediments are first being formed at the surface of the sea floor—early diagenetic processes—are the research interests of Bob Aller.

Many metals in the ocean, along with organic matter, typically are attached to particles. When buried with the particles, oxygen in the surrounding sediment environment is used up as the organic material is decomposed by bacteria. The oxidation state of certain metals like iron and manganese is then changed from an oxidized state to a reduced one, and they become soluble, dissolving in the sea water.

Eventually, these dissolved metals will react with other compounds. For example, iron will react with sulfides present in **anoxic pore water** to form iron sulfides. Thus, one class of mineral is driven by organic decomposition to form another class, and the characteristic of the different classes determines what metals will be buried with particles and what will be

Robert Aller (R.) with graduate student Mark Greene. ▼

Stupakoff photo

Trace metals—Metals present in minute quantities, generally less than one milligram per liter of water.

Anaerobic metabolism—A type of metabolism in which organic compounds are broken down and energy released without the intake of atmospheric oxygen.

Radionuclides—A contraction of "radioactive nuclide"—a particular type of atom having characteristic chemical properties, but which is unstable and spontaneously changes into another atom by the phenomenon of radioactive decay. Carbon 14 is a radionuclide of Carbon

dissolved. Understanding diagenetic processes can help to answer such questions as, Where will a ***trace metal*** go and how fast? What are the various mineral phases and how fast does the trace metal change from one to the other?

It is in the zone where diagenetic processes occur that most benthic organisms live and interact with sediments and where exchange of material between sediment and overlying water is largely determined. Aller is investigating how benthic animals influence these processes. The results show that fauna transport material from zones where oxygen is present to where it is absent and speed up and change the relative rates of reactions—much like earthworms move, mix, and alter garden soil.

Aller is currentiy studying selected aspects of sediment diagenesis and exchange rates of dissolved material across the sediment-water interface in coastal and deep sea marine areas, including South Carolina, Georgia, Florida Bay, the Amazon shelf, and the Panama Basin. Each region has its own, distinct geological environment.

Amazon shelf study

Aller is studying the Amazon shelf as part of the multidisciplinary AmasSeds project at the mouth of the Amazon River in Brazil. Along with biological oceanographer Josephine Aller, geological oceanographer Charles Nittrouer, and researchers from other Brazilian and U.S. universities, Aller is finishing studies on cycles of elements and large-scale diagenetic patterns on the Amazon shelf. These scientists are especially interested in the reactions of highly weathered, lateritic, (iron oxide-rich and aluminum-oxide rich) soil debris during burial in the marine environment.

Iron oxides are recycled during intense physical reworking of shelf sediments in the course of weathering. During this process, iron-based ***anaerobic metabolism*** dominates much of the chemical properties of Amazon shelf muds. Most other shelf sediments of comparable organic matter content off temperate coasts are dominated by sulfur-based anaerobic metabolism beneath the surface oxidized zone (about one centimeter).

Kirk Cochran

natural radionuclides

Kirk Cochran, Research Scientist David Hirschberg, and colleagues from Woods Hole Oceanographic Institution participated in the initial Joint Global Ocean Flux Study (JGOFS) cruises, carried out in 1989 in the Northeast Atlantic. JGOFS has as its general goal an increased understanding of the ways dissolved carbon is extracted from sea water by plants and cycled through the oceanic food web. The goal of the initial study—the North

Rowland photo

◀ *Kirk Cochran with postdoctoral fellow Christina Barnes.*

Atlantic Bloom Experiment—was to observe the development of the spring phytoplankton bloom at sea.

The naturally occurring isotopes of thorium associate strongly with particles as does Pb-210. These ***radionuclides*** can thus be used as tracers for the fate of particles and associated carbon. Cochran and Hirschberg are using naturally occurring isotopes of thorium to determine the rate at which particles and associated carbon sink out of the surface oceans.

The method is independent of other methods, such as sediment traps, for measuring these fluxes. The next phase of JGOFS will involve a series of cruises in the equatorial Pacific in 1992.

Cochran and his research group also are interested in the fate of particle-associated contaminants in coastal waters and are using natural radionuclides as tracers for particles in estuaries such as Long Island Sound. One of the key questions regarding contaminant input to estuaries is the relative importance of the atmosphere as a pathway by which contaminants are added to coastal waters. Cochran, Hirschberg, and graduate student Jing Wang are using salt marsh deposits to determine the atmospheric flux of trace metals to Long Island Sound.

Because the marshes sampled are exposed to the atmosphere most of the time, they receive principally the atmospheric flux of metals. Comparing the distribution of a radioactive form of lead, 210 Pb, with stable lead in salt marshes and Long Island Sound sediments, Cochran and coworkers can determine the chronology of metal input, as well as the total amount of metal in the deposits. Results suggest that much of the lead found in Sound sediments has been added from the atmosphere.

Cochran and Postdoctoral Research Associate Christina Barnes are using geochemical tracers to study the fate of particles (and associated carbon) within an Arctic shelf-slope environment. This work is part of a multidisciplinary study of the Northeast Water (NEW) Polynya, a region of reduced ice cover, which recurs over the northeast continental shelf of Greenland each spring and summer.

One goal of the project is to define the role the polynya plays in modifying and enhancing organic carbon fluxes to shelf-slope systems in the Arctic. In July and August 1992, Cochran and Barnes will collect samples and use thorium and Pb-210 particle tracers to estimate carbon fluxes within the NEW Polynya and to evaluate the importance of the polynya as a sink for particle-associated chemical species.

Methanogenesis—The production of methane by bacteria.

Marie de Angelis
methane flux in rivers and estuaries

Coastal Marine Scholar Marie de Angelis is interested primarily in the production and consumption of reduced trace gases in aquatic environments. One such gas is methane, a greenhouse gas that plays an important role in controlling the earth's climate.

De Angelis is currently working with MSRC's Mary Scranton on the methane budget of the Hudson River and estuary. In addition to surveying methane concentrations along the length of the river from Albany to Manhattan, they are examining the role of microbially mediated methane oxidation in controlling the levels of methane dissolved in the river throughout the year. They have found that microbial methane oxidation is responsible for removing up to 70% of the methane in the river during the summer months, while the wind-driven flux of methane from the water to the atmosphere is more important in the winter.

The high level of methane oxidation activity in rivers makes them ideal systems in which to study the environmental parameters that control the loss of methane via microbial oxidation. This knowledge can be applied to other aquatic ecosystems such as wetlands, which supply large amounts of methane to the atmosphere.

De Angelis is investigating the effects of temperature, salt, turbidity, particles, and nutrients on aquatic microbial methane oxidation. One result of this research is that salt and certain nitrogen nutrients are major inhibitors of methane oxidation. This suggests that major anthropogenic sources of methane to aquatic systems — sewage treatment plants, for example— would best be located in freshwater portions of rivers rather than in brackish or saline estuaries.

De Angelis, in collaboration with chemical oceanographer Cindy Lee, is also examining microbial methane production by zooplankton in coastal and upper oceanic waters. Large, unexplained maxima in methane in the upper 100 meters of the water column have been attributed to anaerobic methanogenic or methane-producing bacteria in the guts of small marine invertebrates such as copepods.

De Angelis and Lee have demonstrated methane production by a large copepod collected from Long Island Sound and are currently investigating ***methanogenesis*** associated with other zooplankton, as well as the effects of different types of algal food on this process. Different algae are known to produce a wide variety of potential precursors of methane, such as di- and trimethylamine and dimethylsulfide. By measuring production of these compounds by specific algae and correlating methane

production by zooplankton which are fed these algae, de Angelis and Lee hope to determine the major precursors of methane in the upper water column.

Cindy Lee
sinking organic matter

Cindy Lee and her students are investigating the production and fate of organic compounds in the ocean. They are interested in following these compounds from the time of their formation by microscopic plants in the surface waters of the ocean—where light can penetrate and photosynthesis occurs—to their eventual demise or "storage" deeper in the water column or in sea bottom sediments.

Boekhoudt photo

◀ *Cindy Lee (L.) with graduate student Ningli Zhu.*

As part of the international Joint Global Ocean Flux Study (JGOFS), Lee and her research group are investigating the transport of organic compounds on particles that sink to the floor of the sea. Large, rapidly sinking particles are responsible for transporting most of the material that reaches the ocean bottom. The researchers collect these large particles in sediment traps—suspended containers of various sizes and at various depths in the ocean.

Use of these traps to properly measure the flux of sinking material has stirred considerable controversy within the oceanographic community. Several methodological questions remain to be answered, and Lee's group hopes to unravel this controversy by examining how well the traps collect the sinking particles and if the organic compounds are degraded in the trap before or after collection.

Lee's research is also seeking to answer a number of important questions related to the sinking particles: How much of the organic matter produced in surface waters reaches the sea floor and how much is decomposed by organisms in the water column? What is the food value of the organic material reaching the sea floor? Is this material nutritious for animals living there, or is it degraded or resistant to further degradation, with little nutritional value when it arrives at the bottom?

A major process affecting the distribution of organic compounds in the ocean is adsorption—uptake onto particle surfaces. Whether or not a compound is strongly adsorbed determines whether it will prefer the dissolved or particulate state.

Since very little is presently known about the adsorptive properties of organic compounds in the oceans, Lee is currently investigating the partitioning of these compounds between the dissolved and particulate phases and how adsorption affects the biological degradability of the compounds. In some cases, the adsorption of a compound onto a particle may help preserve it on its way through the water column to the sediments.

Labile—Having the tendency to undergo displacement in position or change in nature, form, or composition; unstable.

Anoxic—Without oxygen.

James Mackin
computer aided research

As an outgrowth of the Long Island Sound Study, Jim Mackin has developed a computer program which permits chemical oceanographic data to be entered on a spreadsheet in the field or laboratory and displayed on a map of the area being studied.

Mackin is also developing computer graphics which will be used in a series of videos about Long Island Sound that will be produced jointly by film makers John Stevens and Elizabeth Irwin and the Marine Sciences Research Center. He has also been developing animated computer images as educational aids for teaching undergraduate oceanography courses.

Mary Scranton
methane and hydrogen gas

Mary Scranton's research group is studying the biogeochemical cycling of a number of chemical species, including methane, hydrogen, fatty acids and low molecular weight amines. Methane is an important greenhouse gas whose concentration in the atmosphere is increasing with time. Since methane concentration increases may contribute to global warming, it is important to understand sources and removal processes of the gas.

Hydrogen, fatty acids, and methylamines are important decomposition products of organic matter, and their cycling—their movement among the atmosphere, water column, biota, and sediments—is important to living organisms. To date almost nothing is known about patterns of cycling or distribution in the water column of these chemical species.

Her group is currently working on two projects, the first of which is a study of methane geochemistry in the Hudson River and estuary. Together with MSRC Coastal Marine Scholar Marie de Angelis, Scranton is interested in determining the processes that control methane concentrations in the Hudson.

Previous workers found that methane concentrations were generally higher in narrow portions of the river than in wider sections and were generally higher during winter months than in summer (even though biological activity is lower in winter). They speculated that the dominant control on methane distributions was dissolution of bubbles rising from the sediments.

Scranton and de Angelis are extending this previous work to include a survey of methane distributions from the Battery in lower Manhattan up the Hudson River to Albany, together with measurements of methane oxidation rates and air-river gas fluxes.

These data have led them to conclude that the higher river concentrations in winter are caused by dramatically lowered methane loss rates. In winter, methane loss from the river is controlled by gas loss to the atmosphere, and bacterial removal is very slow. In summer, methane oxidation by bacteria is very rapid in most of the river, and measured oxidation rates are among the fastest ever seen in nature.

Methane concentrations in the river in 1991 were a factor of three or more lower than in 1975, perhaps representing a reduction in sewage effluent discharged to the river over this period.

Scranton's second major research program, a collaborative effort with scientists from University of Rhode Island, is a study of the cycling of a number of ***labile*** compounds (including methane, hydrogen, acetate, and low molecular weight amines) in the waters of a permanently ***anoxic*** basin (the Pettaquamscutt River estuary). The study site is an extremely productive system and is characterized by abundant populations of bacteria with a variety of different modes of metabolism, many of which are present only in relatively restricted depth zones.

In the anoxic portions of the water column, methane concentrations vary daily by a factor of two, with higher concentrations occurring at night. These variations may be caused by variations in methane oxidation rate within the anoxic zone, possibly coupled with photosynthetic oxygen production. If this hypothesis is correct, the study will have important implications for understanding oxidation processes in similar systems.

Scranton and her students are also measuring concentrations and cycling rates of hydrogen, fatty acids (especially acetate), and methylamines in the oxic and anoxic zones of the Pettaquamscutt system in Rhode Island. Since there has been much debate in the literature over whether organic decomposition is intrinsically slow in the absence of oxygen, they are trying to determine whether oxidation rate constants are significantly different in oxic and anoxic zones and whether any variations are coupled to variations in specific bacterial populations.

▼ *Mary Scranton*

Palmer photo

the chemical oceanography faculty

Robert Aller
Bruce Brownawell *
Kirk Cochran
Marie de Angelis
Christina Barnes
Cindy Lee
James Mackin
Mary Scranton

** also part of the WMI faculty (see WMI research programs, pages 82-95, for description of his research)*

funding sources

Environmental Protection Agency; Hudson River Foundation; National Oceanic and Atmospheric Administration; National Science Foundation: Chemical Oceanography, Biological Oceanography, Ocean Sciences, Polar Programs; Office of Naval Research; U. S. Geological Survey

publications

Aller, R.C.; Aller, J.Y. Meiofauna and solute transport in marine muds. Limnology & Oceanography (in press).

Rude, P.D.; **Aller, R.C.** Fluorine mobility during early diagenesis of carbonate sediment: an indicator of mineral transformations. Geochimica et Cosmochimica Acta; 55:2491-2509; 1991.

Aller, R.C., Bioturbation and manganese cycling in hemipelagic sediments. Phil. Trans. R. Soc. Lond. A 331:51-68; 1990.

Aller, R.C.; **Mackin, J.E.** Open-incubation, diffusion methods for measuring solute reaction rates in sediments. Journal of Marine Research; 47:411-440; 1989.

Rude, P.D.; **Aller, R.C.** Early diagenetic alteration of lateritic particle coatings in Amazon continental shelf sediment. Journal of Sedimentary Petrology; 59; 1989.

Barnes, C.; **Cochran, J.K.** Geochemistry of uranium in Black Sea sediments. Deep-Sea Research (in press).

Barnes, C.; **Cochran, J.K.** Uranium removal in oceanic sediments and the oceanic U balance. Earth and Planetary Science Letters; 97:94-101; 1990.

Buesseler, K.O.; Bacon, M.P.; **Cochran, J.K.**; Livingston, H.D. Carbon and nitrogen export during the JGOFS North Atlantic Bloom Experiment estimated from Th-234:U-238 disequilibria. Deep-Sea Research (in press).

Cochran, J. K. The oceanic chemistry of the U- and Th-series nuclides. In: Ivanovich, M.; Harmon, R., eds. Uranium series disequilibrium-application to environmental problems. Oxford University Press; 1991.

Cochran, J. K.; McKibbin-Vaughan, T.; Dornblaser, M.M.; Hirschberg, D.; Livingston, H.D.; Buesseler, K.O. Pb-210 scavenging in the North

Atlantic and North Pacific Oceans. Earth and Planetary Science Letters; 97:332-352; 1990.

Landman, N.H.; **Cochran, J.K.**; Chamberlain, J.A.; Hirschberg. D.J. Timing of septal formation in two species of *Nautilus* based on radiometric and aquarium data. Marine Biology; 102:65-72; 1989.

Lilley, M.D..; **de Angelis, M.A.**; Olson, E. CH_4 concentrations and estimated fluxes from Pacific Northwest Rivers. Society of Theoretical and Applied Limnology (in press).

de Angelis, M.A.; Reysenbach, A.-L.; Baross, J.A. Surfaces of hydrothermal vent invertebrates: sites of elevated microbial CH_4 oxidation activity. Limnology and Oceanography; 36:570-577; 1991.

de Angelis, M.A.; Baross, J.A.; Lilley, M.D. Enhanced microbial methane oxidation in water from a deep-sea hydrothermal vent field at simulated in situ hydrostatic pressures. Limnology and Oceanography; 36:570-577; 1991.

Lee, C. Controls on organic carbon preservation: the use of stratified water bodies to compare intrinsic rates of decomposition in oxic and anoxic systems. Geochemica et Cosmochemica Acta (in press).

Lee C.; Henrichs, S.M. How the nature of dissolved organic matter might affect the analysis of dissolved organic carbon. Marine Chemistry (in press).

Lee, C.; Wakeham, S.G. Organic matter in the water column. Future research challenges. Marine Chemistry (in press).

Wakeham, S.G.; **Lee, C.** Production, transport, and alteration of particulate organic matter in the marine water column. In: Engel, M.H.; Macko, S., eds. Organic Geochemistry. Plenum Press (in press).

Hicks, R.E.; **Lee, C.**; Marinucci, A.C. Loss of recycling of amino acids and protein from *Spartina alterniflora* litter. Estuaries; 14: 1991.

Lee, C.; Hedges, J.I.; Wakeham, S.G.; Zhu, N. Effectiveness of poisons and preservatives in retarding bacterial activity in sediment trap material. Limnology and Oceanography; 37: 117-130; 1992.

McNichol, A.P.; Druffel, E.R.M.; **Lee, C.** Carbon cycling in coastal sediments: 2. An investigation of the sources of ΣCO_2 to pore water using carbon isotopes. In: Baker, R.A., ed. Organic substances and sediments in water. Processes and Analytical. Chelsea, MI: Lewis Publishers. 2:249-272; 1991.

Sun, M.; **Aller, R.C.**; **Lee, C.** Early diagenesis of chlorophyll-*a* in Long Island Sound sediments: a measure of carbon flux and particle reworking. Journal of Marine Research; 49:1-23; 1991.

Wang, X-C; **Lee, C.** The distribution and adsorption behavior of aliphatic amines in marine and lacustrine sediments. Geochimica et Cosmochimica Acta; 54:2759-2777; 1990.

Wakeham, S.G.; **Lee, C.** Organic geochemistry of particulate matter in the ocean: the role of particles in oceanic sedimentary cycles. Organic Geochemistry; 14:83-96; 1989.

Mackin, J.E. Relationships between Si, Al, and Fe deposited on filter-covered glass substrates in marine sediments and in suspensions of sediments and standard clays. Marine Chemistry; 25; 1989.

Mackin, J.E.; **Aller, R.C.** The nearshore marine and estuarine chemistry of dissolved aluminum and rapid authigenic mineral precipitation. Reviews of Aquatic Science; 1:537-554; 1989.

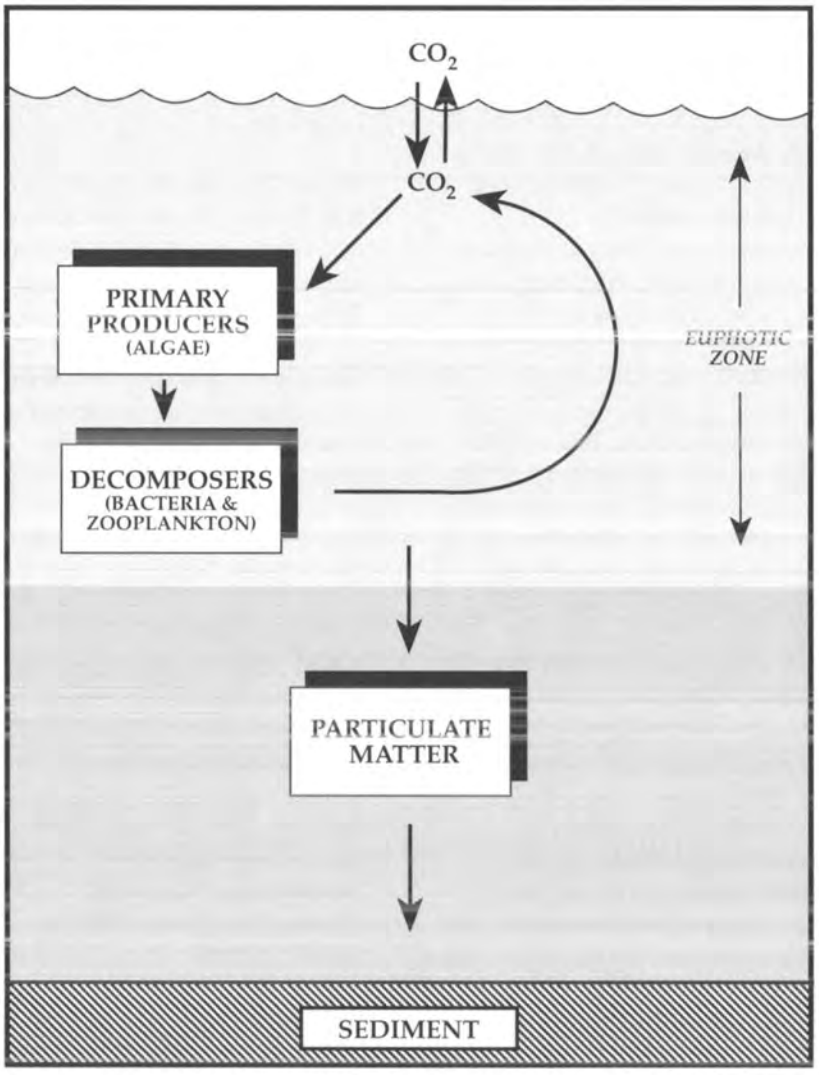
Mackin, J.E.; Swider, K.T. Organic matter decomposition pathways and oxygen consumption in coastal marine sediments. Journal of Marine Research; 4; 1989.

Fronts—The dividing surface between two dissimilar water masses; a boundary surface or transition zone.

Scranton, M.I.; McShane, K. Methane fluxes in the southern North Sea: the role of European rivers. Continental Shelf Research; ll:37-52; 1991.

Michelson, A.R.; Jacobson, M.E.**; Scranton, M.I.**; **Mackin, J.** Factors controlling the distribution of acetate in anoxic marine and estuarine sediments. Limnology and Oceanography; 34:747-757; 1989.

The oceanic carbon cycle. Phytoplankton fix CO_2 into organic (carbon-containing) compounds during photosynthesis. The organic compounds are mainly recycled by bacteria and zooplankton in the euphotic zone (zone of sun penetration). But a portion of these compounds escapes recycling and reaches the sea floor, most likely as part of large, rapidly sinking particles. ▼



physical oceanography

The physical oceanographer's task is to identify, to investigate, and to describe the various forces of nature which drive and control the structure, motions, and mixing of the oceans, its coastal seas, and its estuaries. Their approach is to combine theory, observations, and numerical models to arrive at an understanding, albeit incomplete, of these oceanic processes.

Physical oceanographic research at MSRC covers a wide spectrum of activities. Seven full-time faculty and two professors emeriti have interests in circulation and mixing in estuaries; the dynamics of flows in coastal sea straits; fine-scale mixing; ***fronts***; water mass formation; global heat and salt balances; flow around islands; tides on the continental shelf; diffusion; and numerical modeling of a wide variety of estuarine, continental shelf, and oceanic processes.

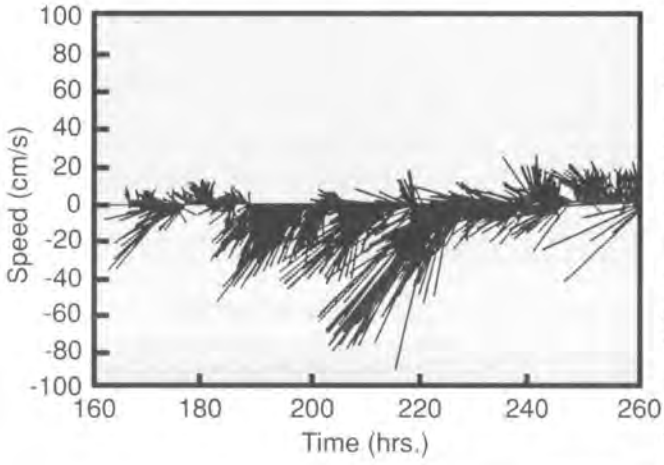
The most recent addition to the MSRC physical oceanography group is Kamazima Lwiza. A native of Tanzania, Lwiza received his Ph.D. from the University of Wales in 1991, where he worked on the applications of acoustic Doppler technology to the study of tidal mixing fronts in the North Sea. He brings to MSRC a wealth of experience in the applications of this new technology.

As new generations of sophisticated instruments become available, MSRC physical oceanographers adapt these tools to design innovative experiments to gain new insights. Examples include the use of satellite remote sensing imagery, electromagnetic current meters, turbulence probes, and acoustic Doppler current profilers (ADCPs). "Smart" instruments, controlled by microchips and placed on the sea floor, record measurements according to a predetermined timetable, store the data in memory, release themselves at the end of the survey, pop to the surface, relay the data to satellite, and radio their position for pickup from a waiting ship.

The staff of MSRC's Ocean Instruments Facility works with the physical oceanographers to design, construct, calibrate, and operate these instruments. MSRC computing facilities provide fast computing tools for the oceanographers: a large VAX computer, part of a network of research computers at Stony Brook and around the world, the very fast SUN Sparkstation, and a large number of personal computers in various configurations.

Plans for the near future include the development of a remote sensing facility for the direct reception and processing of oceanographic data from weather satellites and the acquisition of a state-of-the-art high frequency broadband ADCP specifically designed for shallow water observations.

The physical oceanographers interact with other MSRC marine scientists informally and in interdisciplinary project collaborations. This provides a useful team approach towards understanding how the physical environment influences and often controls other ocean processes, for example, biological production



◀*Stick plot of ocean currents south of the Caribbean island of Barbados (13° 10'N, 59° 30' W) during April 1991. The stick plots are measurements taken every five minutes of the current's direction, represented by the angle of the stick, and its speed, represented by the length of the stick. The diagram shows a complex mixture of tidal and wind driven currents.*

Eddies—Circulating cells of water imbedded in ocean currents. Their size may range from small whirlpools a few meters across to large gyres several hundred kilometers in diameter.

Geostrophic—Controlled by the rotation of the earth (the Coriolis effect); deep ocean currents and large eddies are often geostrophic.

at various trophic levels, sediment transport, dispersion of contaminants, oxygen levels in stratified waters, atmosphere-ocean interactions, climate change, and dispersal of eggs and larvae of many marine organisms.

research programs

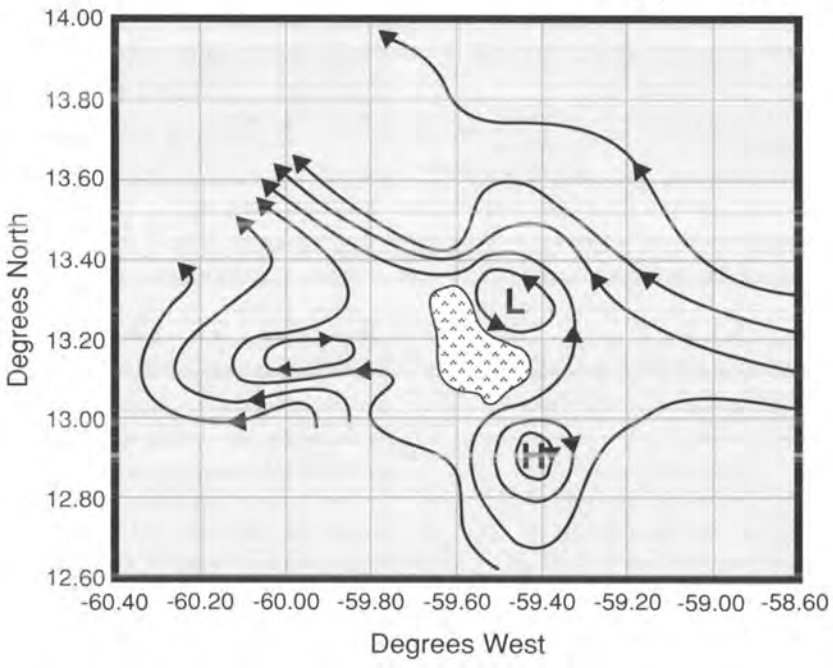
Malcolm Bowman
dynamics of oceanic flow around islands

Ocean currents interact with obstacles in their path in a variety of ways. In the case of islands, for example, interactions depend on many factors, including the size and shape of the island, its proximity to the mainland, its latitude, whether or not it has a continental shelf, the speed of the current, tidal mixing near to shore, the stratification of the water column, and whether or not there are nearby seamounts or other islands that impede and divert the upstream and downstream flows.

In some encounters with steeply sloping islands lacking a continental shelf, the currents will sweep gracefully past the island with little disturbance to the flow. In other situations, particularly for those islands that have broad, shallow continental shelves, ***eddies*** may form behind the island from frictional drag over the bottom.

If the current is strong enough, these eddies will grow larger, eventually detaching themselves from the island, and will be entrained into the island wake and swept away. Others may become trapped behind the island and continue

Geostrophic streamlines with respect to 500 decibar (the upper 500m. of water) near the Caribbean island of Barbados, for the period April 25 to May 2, 1991. ▼



to circulate until a major flow disturbance dislodges them, releasing the eddies to drift away downstream.

Malcolm Bowman is collaborating with MSRC fisheries biologist Robert Cowen in an international, interdisciplinary study of island wake effects near Barbados, West Indies. They are interested in learning how current patterns and eddies near the island control the dispersal of tropical fish eggs and larvae away from their natal reefs, and their subsequent recruitment as juveniles, one to three months later, back into the fringing reefs—movements on which their early life survival depends. Results from two cruises in April and May 1990 and 1991 have shown that the flow field around Barbados is indeed rich in eddies, which likely play an important role in the retention of larvae and juvenile fish near the island.

Barbados was selected for its size and location. It is a small island, whose coastal seas may be efficiently studied with one ship. It is situated in the strong equatorial Guiana Current, which was expected to spin off eddies near the island.

Barbados is located upstream of other islands in the Lesser Antilles chain. If the study island had been located downstream from other islands, the flow might have been disturbed, and the study island might have been inoculated with larvae from the upstream islands. Barbados also has an established marine research facility—the Bellairs Research Laboratory—which provides logistic support and scientific interaction.

Bowman's work has shown that the eddies are ***geostrophic*** in nature, rather than frictional. Several nearby unnamed seamounts, which penetrate from the deep-sea floor up to a few hundred meters from the surface, also appear to have an influence on the way the currents approach and depart from the island.

During the 1991 cruise an extensive low salinity plume front passed by the island. This surface spreading plume most likely had its origin in the Amazon River outflow, some 2000 km distant. The passage of this front past Barbados may have had major ecological implications by sweeping juveniles away from the island at a critical time when they were ready to recruit back to the reef. However, the plume is quite shallow (10-30 m), and only organisms in the upper water column would be affected. Bowman and his students are continuing to analyze the physics of the front and how important occasional frontal passages are to the local ocean environment.

Rountree photo

▲ *Kamazima Lwiza*

Kamazima Lwiza
mapping sea bottom topography by radar

Science is supposed to pave the way for technology, but there are cases where the reverse is true. The technology used in the research conducted by Kamazima Lwiza, the newest faculty member of the physical oceanography group, is one of these cases.

Early satellite images from synthetic aperture radar (SAR) showed patterns in sea surface topography which correspond well with ocean floor features. The most spectacular scenes are those showing mid-oceanic ridges. Apart from submarine topographic features, the SAR also can detect small-scale oceanographic processes, for example, internal waves and oceanic fronts.

Remote sensing scientists were intrigued by this phenomenon, but the theory behind it was not well understood. The scientists wanted to know *how* the radar captures the submarine topographic features. The imaging was difficult to quantify, since the scientists did not know whether the patterns

Drogue—An instrument that measures water currents by drifting with the current.

seen on the images corresponded to submarine features directly, or if they were just seeing "shadows."

A theory based on the interaction of surface water waves and the underlying current has been proposed for coastal waters. When a current passes over a relief feature, for example, a sand bar, in order to maintain the same transport of water, the speed increases. The increase in speed is reflected at the surface by relaxing or compressing the waves depending on the direction of travel. The relaxation and compression of the surface waves changes the sea surface roughness, which is the signature the radar measures.

Currently, Lwiza is using a multi-sensor approach to test this theory in the North Sea near the coast of Holland where the sea floor is characterized by sand waves of up to 4 m high. He is collaborating with John Matthews from the School of Ocean Sciences at the University College of North Wales in the United Kingdom and other scientists from Holland and Germany on the European Community's Marine Science and Technology campaign called "Mapping of the Sea Bottom Topography in a Multi-sensor Approach for Morphodynamic Studies."

The experimental equipment ensemble consisted of a helicopter-borne scatterometer (a type of radar); an aircraft-borne optical sensor to take sunglint images; a ship equipped with downward-looking sonars (to map the sea floor) and upward-looking sonars to map the sea surface; an acoustic Doppler current profiler (ADCP) to measure currents; a conductivity, temperature, and depth probe (CTD) assembly with a fluorometer to measure the amount of chlorophyll; and a transmissometer to measure water turbidity.

Under certain hydro-meteorological conditions, the researchers observed clear modulation of the surface current, which was related to sea bottom topographic features. Similar bottom-related changes ocurred in surface temperature, beam transmittance, fluorescence, and backscatter from the upward-looking sonar. Initial analysis of the sunglint images showed submarine features observed from ship measurements. The researchers are still processing radar data, but so far, the data from the campaign support the theory that sea bottom topography can be detected by surface features, including remote sensing.

Akira Okubo
chaos and fractals in oceanic dispersion

Akira Okubo has been applying the theory of chaos to physical oceanography. Within the framework of this theory, he is investigating Lagrangian chaos, that is, oceanic dispersion induced by chaos. This motion plays an important role in dispersing not only

Palmer photo

▲ *Hartmut Peters*

physical particles such as ***drogues*** but also eggs and larvae.

Chaos arises from deterministic nonlinear processes with sufficient degrees of freedom and a large value of system parameters. Since oceanic motions are inherently nonlinear and three-dimensional, they are potentially capable of generating chaotic motion. Even if the oceanic motion is regular in the view of a fixed observer, the motion of particles embedded in the flow tends to be very complex and, in fact, chaotic.

Another interesting manifestation of chaos is the fractal nature of the chaotic motion in the ocean. In this regard, Akira Okubo collaborated with former MSRC student Brian Sanderson, an oceanographer with the Bureau of Meteorology, State of Victoria, Australia, to analyze the motions of clusters of drifters.

They found that the fractal dimension of relative trajectories between a pair of drifters is 1.34, averaged over separation scales ranging from 10 m to 4 km. However, the fractal dimension of particular pairs fluctuates over a wide range, from 1.12 to 1.59.

This suggests the possible multifractal nature of diffusing particles in the sea. The observed mean fractal dimension of 1.34 is close to 4/3, which suggests that Richardson's 4/3 power law of pair diffusivity might be reinterpreted in terms of fractal dimension.

Hartmut Peters
turbulent mixing

Since his Ph.D. work, Hartmut Peters has been interested in oceanic processes of small scales, turbulent mixing, and internal waves. He is continuing to analyze observations from the Equatorial Undercurrent of the Pacific, work that he began while a postdoctoral investigator at the University of Washington before joining the faculty at MSRC.

Measurements with a spatial resolution of a centimeter allow a quantification of turbulent mixing. Thus, Peters can estimate vertical turbulent fluxes of momentum, heat, and nutrients. He is analyzing the role of mixing in the flow dynamics and in the environment and is working towards an improved representation of mixing processes in numerical models of the tropical circulation.

At MSRC, Peters has shifted his emphasis towards shallow waters, especially to estuaries, without changing the overall scientific goals. He is preparing field work in the Hudson estuary that will encompass measurements of the basic flow, using acoustic Doppler current profilers, as well as of the small-scale turbulent fluctuations, using high-resolution CTDs (conductivity-temperature-depth probes) and custom-designed fast-response velocity sensors. Imaging echo soundings make turbulent overturning as well as internal

Halocline—Region in the water column within which there is a rapid increase in salinity with depth. It is typically bounded above and below by mixed regions in which salinity changes slowly with depth.

wave activity visible. The work will help to improve our understanding of the estuarine dynamics and the effect of the physical conditions on the environment.

In collaboration with Robert Wilson, Peters will directly compare numerical models that incorporate an advanced treatment of turbulent mixing ("second moment closure") with the turbulence observations in an attempt to advance capabilities to realistically model estuarine flows.

Dong-Ping Wang
numerical ocean modeling

Dong-Plng Wang has focused his numerical modeling efforts on internal tides. He is using a sophisticated three-dimensional model to predict the generation and propagation of internal tides in the Strait of Gibraltar. His study is complemented by a large database collected during the Gibraltar Experiment, a multinational field program in 1985-1986.

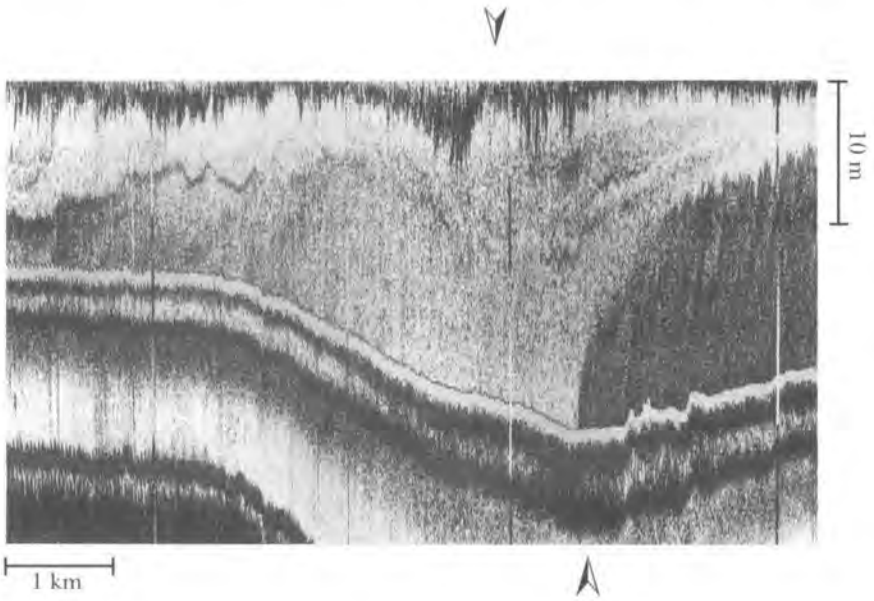
Large-amplitude internal tides dominate mixing and transport of salt and nutrients in the strait. Through a careful numerical model study, Wang is able to integrate the field data to address the important issue of material exchange between the Atlantic Ocean and the Mediterranean Sea.

Wang and his students also are exploring several novel modeling ideas. In collaboration with MSRC marine biologist Darcy Lonsdale, Wang is modeling zooplankton population dynamics in several estuarine environments. The model which incorporates both biological and physical processes will be used to identify the impacts of changing physical environments on zooplankton recruitment and life cycles.

In collaboration with Yuefan Deng, a mathematician, Wang is experimenting with the massively parallel computing, a next-generation supercomputing environment. The advent of massively parallel computing will revolutionize the large-scale ocean modeling. Wang is studying the feasibility of adapting this exciting new technology to his ocean modeling.

Peter Weyl
environmental stability

When working as a physicist in the chemistry department of a petroleum exploration research laboratory, Peter Weyl was asked to study what made some sedimentary rocks porous and permeable. He soon discovered that this was the wrong question since sediments start out that way. Instead, he reasoned that one had to understand the mechanisms by which the porosity and permeability of sediments is reduced as they are converted into sedimentary rocks. Studies of that question led to a theory of pressure solution and to pioneering investigations on



Echo sounding image (200kHz) obtained going downstream through the Verrazano Narrows in the Hudson estuary (from left to right on graph) during strong ebb tide on 3/28/91. Darker portion of graph is approximately 4 psu more saline than lighter part. Stationary bottom front (lower arrow) is shown seaward of the Verrazano Narrows bridge (upper arrow), positioned to move upstream rapidly (to left in graph) on the incoming tide. This is the first evidence of this phenomenon in a partially mixed estuary.

the solubility of carbonate sediments.

Today, the causes of environmental change are receiving much attention, raising such questions as, Why have some life-forms become extinct?

According to Weyl, however, we should be asking the more fundamental questions, How has the Earth's surface environment remained sufficiently stable in the past to permit continued evolution? How has the surface of our planet remained hospitable to life in spite of cosmic disturbances, a changing geography of land and sea, and changing biogeochemical interactions at the surface of our planet? Are the natural processes adequate to continue to maintain stability, in spite of greatly enhanced human intervention resulting from mechanization?

To formulate appropriate questions to study this problem, Professor Weyl is examining the wealth of oceanographic data about the world ocean that has recently become available in microcomputer format. By testing a variety of ideas against the accumulated data about the world ocean, he hopes to clarify some of the mechanisms by which the ocean has stabilized our environment.

Robert Wilson
estuarine hydrodynamics

Estuaries are a part of the marine environment where there can be strong topographic influences, very strong density gradients produced by the presence in estuaries of salt and fresh water, and very strong tidal forcing. This combination of factors contributes to a complex environment. The current research interests of Robert Wilson relate to observations and modeling of estuarine hydrodynamics and mixing.

Observations in the Hudson estuary show that modulations in the semidiurnal tide, for example, lead to an abrupt breakdown in stratification from neap to spring tides, especially during high river flow. This neap-spring variability produces important changes in the structure of the outflow through the mouth of the estuary and the internal circulation within the estuary. This affects the transport of dissolved or suspended material, including plankton.

Density structure at the mouth of the estuary changes significantly from the stratified neap tide conditions to the well-mixed spring tide conditions. In the former, there is a strong elevation in the ***halocline***, and in the latter, an arrested bottom front is formed. Relaxation of these halocline configurations at the beginning of flood tide produces a bore intrusion in the former case and a bottom

Turbidity maximum—Region of very high suspended solids concentration, which tends to be related to vertical mixing and the saltwater intrusion.

Barotropic—Characterized by an atmospheric condition in which surfaces of equal pressure coincide with surfaces of equal density.

gravity current in the latter. In 1991, Wilson observed this arrested front for the first time, by using a 200 kHz echo sounder.

His discovery provides insight into the mechanisms for saltwater intrusion up into the lower Hudson River. This is an important mechanism for resuspension and transport in the river of fine-grain sediment particles, including those with adsorbed contaminants, and for the establishment of a ***turbidity maximum***. Recent observations have shown, in fact, that a relatively well defined turbidity maximum is located at approximately the upstream limit of gravity current intrusion.

Sedimentation rates on the sides of the channel in the vicinity of the turbidity maximum have been found to be extremely high. Ongoing numerical simulations will facilitate an interpretation of field observations which Wilson is collecting in this study. He intends to elucidate the interaction of ***barotropic*** and internal tides at the mouth of the estuary.

In a related study, Wilson and his students are now making observations and simulations of the movement of particles in the gravity current flows described above. Specifically, they are looking in more detail at how these strong internal flows resuspend and transport particles, including fine-grain sediments. This involves both acoustic echo sounding imaging and acoustic current profiling.

the physical oceanography faculty

Malcolm Bowman
Kamazima Lwiza
Akira Okubo
Hartmut Peters
Dong-Ping Wang
Robert Wilson
Peter Weyl

funding sources

Cornell National Supercomputing Facilities; Hudson River Foundation; National Science Foundation; Office of Naval Research.

publications

Bowman, M.J.; Visser, A.W.; Crawford, W.R. The Rose Spit Eddy: evidence for its existence and underlying dynamics. Atmosphere-Ocean (in press).

Visser, A.W.; **Bowman, M.J.** Lagrangian tidal stress and basin-wide residual eddy dynamics in coastal sea straits. Geophysics and Astrophysics Fluid Dynamics; 59:113-145; 1991.

Visser, A.W.; **Bowman, M.J.**; Crawford, W. R. Dynamics of tidally forced basin-wide coastal eddies. In: Cheng, R., ed. Residual currents and long-term processes in shallow estuaries and bays. Coastal and Estuarine Studies; New York: Springer-Verlag; 1990.

Lwiza, K.M.M.; Bowers, D.G.; Simpson, J.H. Residual and tidal flow at a tidal mixing front in the North Sea. Continental Shelf Research; 11(11): 1379-1395; 1991.

Lwiza, K.M.M.; Bigendako, P.R. Kunduchi tides. Tanzania Journal of Science; 14: 65-76; 1988.

Yan, H-H.; **Okubo, A; Schubel, J.R.; Pritchard, D.W.** An analytical model for remote sensing determination of the mixed layer depth. Deep-Sea Research; 38:267-286; 1991.

Craig, C.L.; **Okubo, A.** Physical constraints on the evolution of ctenophore size and shape. Evolutionary Ecology; 4:115-129; 1990.

Mitchell, J.G.; **Okubo, A.**; Fuhrman, J.A. Gyrotaxis as a new mechanism for generating spatial heterogeneity and migration in microplankton. Limnology and Oceanography; 35:123-130; 1990.

Okubo, A. Crecimiento de al organizacion biologica en ambientes turbulentos (Growth of biological organization in turbulent environments). In: Wagensberg, J., ed. Sobre la Imaginacion Cientifica. Barcelona: Tesquets Editors; pp. 121-137; 1990.

Sanderson, B.G.; Goulding, A.; **Okubo, A.** The fractal dimension of relative Lagrangian motion. Tellus; 42A:550-556; 1990.

Okubo, A.; Levin, S. A. A theoretical framework for data analysis of wind dispersal of seeds and pollen. Ecology; 70:329-338; 1989.

Okubo, A.; Maini, P.K.; Williamson, M.H.; Murray, J.D. On the spatial spread of the grey squirrel in Britain. Proceedings of the Royal Society of London; B 238:113-125; 1989.

McPhaden, M.J.; **Peters, H.** On the diurnal cycle of internal wave variability in the equatorial Pacific Ocean: results from moored observations. Journal of Physical Oceanography (in press).

Peters, H.; Gregg, M.C.; Sanford, T.B. Equatorial and off-equatorial fine-scale and large-scale shear variability at 140° W. Journal of Geophysical Research; 96(16); 913-916, 928; 1991.

Peters, H.; Gregg, M.C.; Toole, J.M. Meridional variability of turbulence through the undercurrent. Journal of Geophysical Research; 94; 1989.

Chen, D.; **Wang, D.-P.** Simulating the time-variable coastal upwelling during CODE 2. Journal of Marine Research; 48:335-358; 1990.

Chern, C.-S.; Wang, J.; **Wang, D.-P.** The exchange of Kuroshio and East China Sea shelf water. Journal of Geophysical Research; 95:16017-16024; 1990.

Tintore, J.; **Wang, D.-P.**; Laviolette, P. Eddies and thermohaline intrusions on the shelf-slope front off the northeast Spanish coast. Journal of Geophysical Research; 95:1627-1633; 1990.

Wang, D.-P. Models of mean and tidal flows in the Strait of Gibraltar. Deep-Sea Research; 36:1535-1548; 1990.

Wang, D.-P.; Chen, D.; Sherwin, T.J. Coupling between mixing and advection in shallow sea fronts. Continental Shelf Research; 10:123-136; 1990.

Wilson, R.E.; Chant, R. Fronts associated with hydraulic transitions at the mouth of a stratified estuary. Estuaries (in press).

Wilson, R.E., Wong, K.-C.; Carter, H.H. Circulation and exchange in Great South Bay. In: Schubel, J.R.; Bell T. M.; Carter, H.H., eds. The Great South Bay; Albany, NY: SUNY Press; 9-21; 1991.

Wilson, R.E.; Filadelfo, R; Gomez-Reyes, E. Subtidal Eulerian currents in the upper and lower East River tidal strait. Journal of Geophysical Research; 96(15):217-215, 226; 1991.

Koutitonsky, V.G.; **Wilson, R.E.**; El-Sahb, M. Seasonal response of the lower St. Lawrence Estuary to buoyancy forcing. Estuarine, Coastal and Shelf Science; 31:359-379; 1990.

Recruitment—The number of juvenile organisms arriving at a habitat where they will grow and live for an extended period of time.

Living Marine Resources Institute

research programs
LIMRI faculty

Robert Cerrato
growth patterns and age of bivalves

Over the past several years, Bob Cerrato's research has centered primarily on population studies using information from structural and morphological features of bivalve shells. One of these structural features is microgrowth lines in the shells, which form in patterns depending on their physiology or environmental influences.

Cerrato has been able to correlate patterns in the shells of the soft-shell clam *(Mya arenaria)* with patterns in tides and seasons. He has also been investigating the microgrowth patterns in shells of larval and postlarval hard clams and has analyzed deep-sea Vesicomyid clams, found at hydrothermal vents, for age-structure and growth. By using microgrowth lines in shells taken from middens, Cerrato also has been working with archaeologists to reconstruct shellfish seasonal harvesting patterns by prehistoric hunter-gatherers of Shelter Island (between Long Island's North Fork and South Fork).

Cerrato continues studies of the population dynamics of two commercially important species — hard clams (*Mercenaria mercenaria)* and surf clams *(Spisula solidissima*). In the near future, he plans to examine more closely the relationship between bivalve shell microgrowth patterns and physiological rate processes in *Mya arenaria.*

Dooley photo

◀ *Robert Cerrato*

Robert Cowen

fish recruitment

Robert Cowen's research group is presently working on three separate projects, each involving the biological and physical factors influencing ***recruitment*** of nearshore fish populations. Using a very integrated approach — concurrently studying the biology of the organisms, their larval distribution, and the physical oceanography — Cowen and his students are investigating the various mechanisms that coastal fish species use to return their larvae from the open sea to coastal and reef habitats.

One project is focused on the oceanic transport of larval fish, particularly bluefish, within the Middle Atlantic Bight. The researchers are looking at both cross-shelf transport and larger scale processes involved in the transport of fish from south of Cape Hatteras into the local New York waters.

Another project, a collaboration with MSRC physical oceanographer Malcolm Bowman, concerns the retention of larval fish in the lee of islands, particularly Barbados. They are testing whether or not eddies are important in the entrapment and eventual return of larval fish to the reef habitat; and if not, then what features of the local current regime are important in the retention of larvae.

Dooley photo

▲ *Steven Morgan*

Along with this offshore study, the team is examining settlement patterns of the coral reef fish in this part of the Caribbean in relation to offshore and nearshore availability of larvae. They are interested, as well, in the length of time that various larvae are capable of remaining in their pelagic phase. By examining the microstructure of fish larvae otoliths (small ear bones), Cowen can determine the duration of the various larval developmental stages and then compare these among species with respect to their offshore distribution.

The third project, which Cowen and his students are just beginning, examines the movement and size of patches of larval fish just prior to their settlement inshore on coral reefs in St. Croix, U.S. Virgin Islands. This project compliments the work in Barbados since St. Croix is located within a chain of islands, providing it with a variety of larval sources, unlike Barbados, which has no upstream source.

Steven G. Morgan

morphology and life history adaptations that aid survival

Steven Morgan examines how selective forces operating in the plankton may shape the life histories of marine organisms. During the last several years, he has investigated how the morphologies, or body shapes, of larval crabs, the timing of larval release, and the patterns of their dispersal throughout the water are related to their predators and physical factors (tides and currents).

The large abundance of planktivorous fishes in estuaries make the planktonic larvae of estuarine crabs particularly vulnerable to

predation. Thus, the larvae are likely to hatch just prior to ebb tides, which flush them into comparatively safe coastal waters to develop. Alternatively, crabs whose larvae are well defended from attacks by fishes remain in estuaries throughout development, but spend less time in the water column.

Morgan has studied the hatching rhythms of populations of crabs from various tidal regimes throughout the Pacific, Gulf, and eastern coasts of the U.S., as well as in the tropics, to demonstrate that the rhythms are readily changeable and respond to local environmental cues. These cues have evolved as a set of rules for each species, depending on the vertical zonation of adults on the shore and the vulnerabilities of larvae to predatory fishes.

In collaboration with Robert Cowen, Morgan is examining the interaction of behavior and physical processes such as currents on larval transport and recruitment. The investigators plan to examine mechanisms that regulate movement of crab, lobster, and fish larvae across the continental shelf and into inshore waters.

LIMRI-sponsored research by other faculty

LIMRI also sponsors other faculty to conduct research on issues of import to fisheries and aquaculture.

brown tide

Recent research on another aspect of this mysterious blooming algae may add another piece to the brown tide puzzle. This study by Elizabeth Cosper and Darcy Lonsdale examines the role of zooplankton (algae grazers) by asking the question, How does the brown tide organism grow to bloom stage in the presence of large numbers of zooplankton?

Zooplankton, the smallest marine animals, are generally capable of eating massive amounts of phytoplankton, but seem to reject the small brown tide phytoplankton as food. This, at least partially, explains why the brown tide organism can grow to such large numbers in the local bays. But the fact that they do grow to such large numbers, causing other phytoplankton species to be virtually excluded, adds to the puzzle of what the zooplankton eat during these times.

The interactions between phytoplankton and the herbivores that graze on them have never been thoroughly studied in the eastern Long Island bays before. Now Lonsdale and Cosper are analyzing two summers' worth of data on these interactions and, when the final analysis is completed, they hope to offer new insights about its role in the ecosystem of the bays, and perhaps explain its persistence.

the LIMRI faculty

William Wise, Director
Robert Cerrato
Robert Cowen
Stephen Morgan

funding sources

Foster-Davis Foundation; Hudson River Foundation; National Oceanic and Atmospheric Administration (National Undersea Research Program); National Science Foundation; New York Department of Environmental Conservation; New York Sea Grant Institute; Northeast Regional Aquaculture Center; Suffolk County Department of Health Services; Town of Brookhaven; U.S. Army Corps of Engineers; U.S Environmental Protection Agency.

publications

Cerrato, R.M.; Wallace, H.V.E.; Lightfoot, K.G. Tidal and seasonal patterns in the chondrophore of the soft-shell clam *Mya arenaria*. Biological Bulletin; 181:307-311; 1991.

Cerrato, R.M. Interpretable statistical tests for growth comparisons using parameters in the von Bertalanffry equation. Canadian Journal of Fisheries and Aquatic Sciences; 47:1416-1426; 1990.

Bokuniewicz, H.J.; **Cerrato, R.**; Ellsworth, J. Siting containment islands in New York Harbor. Working Paper No. 32, Ref. 89-01. Marine Sciences Research Center, State University of New York at Stony Brook, NY. 30 pp.; 1989.

Cerrato, R.M.; Bokuniewicz, H.B.; Wiggins, M.H. A spatial and seasonal study of the benthic fauna of the Lower Bay of New York Harbor. Marine Sciences Research Center Special Report No. 84. State University of New York, Stony Brook, NY; 1989.

Lightfoot, K.G.; **Cerrato, R.M.** Regional patterns of shellfish harvesting along the Atlantic Coast of North America. Archaeology of Eastern North America; 17:31-46; 1989.

Cowen, R.K.; Bodkin, J.L. Interannual and spatial variation of the fish fauna at San Nicolas Island, California. In: Recent advances in California islands research. Proc. of the 3rd California Islands Symposium, 1988, Santa Barbara Museum of Natural History (in press).

Cowen, R.K.; Chiarella, L.; Gomez, C; Bell, M. Distribution, age and lateral plate variation of larval sticklebacks *(Gasterosteus)* off the Atlantic coast of New Jersey, New York and southern New England. Canadian Journal Fisheries and Aquatic Science; 48:1679-1684; 1991.

Cowen, R.K. Variation in the planktonic larval duration of the temperate wrasse *Semicossyphus pulcher*. Marine Ecology Progress Series; 69:9-15; 1991.

Cowen, R.K. Sex change and life history patterns of the labrid, *Semicossyphus pulcher*, across an environmental gradient. Copeia; 1990(3):783-791; 1990.

Castro, L.R.; **Cowen, R.K.** Growth rates of bay anchovy *(Anchoa mitchilli)* in Great South Bay under recurrent brown tide conditions: 1987 and 1988. In: Cosper, E.M.; Carpenter, E.J.; Bricelj, V.M., eds. Novel phytoplankton blooms: causes and impacts of recurrent brown tides and other unusual blooms. Coastal and Estuarine Studies, Vol. 35. Berlin: Springer-Verlag; pp. 665-676; 1989.

Shima, M.; **Cowen, R.K.** Potential change in the distribution of larval fish within Great South Bay, New York in response to recurrent phytoplankton blooms. In: Cosper, E.M.; Carpenter, E.J.; Bricelj, V.M., eds. Novel phytoplankton blooms: causes and impacts of recurrent brown tides and other unusual blooms. Coastal and Estuarine Studies, Vol. 35. Berlin: Springer-Verlag; pp. 649-664; 1989.

Morgan, S.G. Impact of planktivorous fishes on the dispersal, hatching and morphology of estuarine crab larvae. Ecology; 71:1639-1652; 1990.

Morgan, S.G. The adaptive significance of spination in estuarine crab zoeae. Ecology; 70:464-482; 1989.

Fly ash—Particles that are carried off an incinerator grate by turbulence, or volatilized material that condenses in the flue gas into particles during the process of incineration.

Dioxins—A family of chlorinated chemicals, some of which are toxic to animals under certain exposure and dosage conditions.

Furans (polychlorinated dibenzofuran)—A compound very similar to dioxins, both in molecular structure and physiological effect.

Waste Management Institute (WMI)

research programs

WMI's staff, faculty, and director are chemical, biological, and physical oceanographers with expertise in waste stabilization and behavior of pollutants in the environment.

In addition to its own excellent faculty, WMI has ties to key campus faculty from many disciplines. Being situated at MSRC, the Institute has access to some of the country's top marine scientists — geologists, chemists, ecologists and physicists. The large, diversified campus presents collaboration and consultation opportunities with health scientists, toxicologists, meteorologists, economists, sociologists, engineers, hydrologists, mathematicians and statisticians.

secondary materials

Secondary materials consist primarily of one or more waste materials or by-products that have been diverted or recovered from the solid waste stream and converted to a new physical form. The new products serve uses other than those of the original materials. Examples of secondary materials include plastic lumber made from mixed plastic residues, reinforcing bars made from mixed scrap metals, and insulation materials made from newspapers.

Secondary materials are different in several ways from products made of virgin materials. They cannot be recycled as virgin materials in a manufacturing process nor reused, as in the refilling of a bottle. Impurities in the materials, the potential for less desirable engineering properties, the possible presence of environmental contaminants, and reduced aesthetic properties mean that these products may be of lesser quality, in lower demand, and of greater environmental concern than those made from virgin materials. However, as virgin materials diminish in supply or become more costly to extract, process, or manufacture into a product, the more important the products from secondary materials may become to society.

The Waste Management Institute has been actively involved in secondary materials research as a major waste management strategy. Some of these research programs are discussed in the next few pages.

municipal solid waste incineration ash

With the closure of landfills in many municipalities, including closure by law of those on Long Island, municipalities are redesigning their solid waste management strategies. These plans call for reducing the size of the waste stream through source reduction and recycling and, for many municipalities, incinerating the remainder.

▼ *A*

Breslin photos

▼ *B*

▼ *C*

A. Recyclable plastic items.

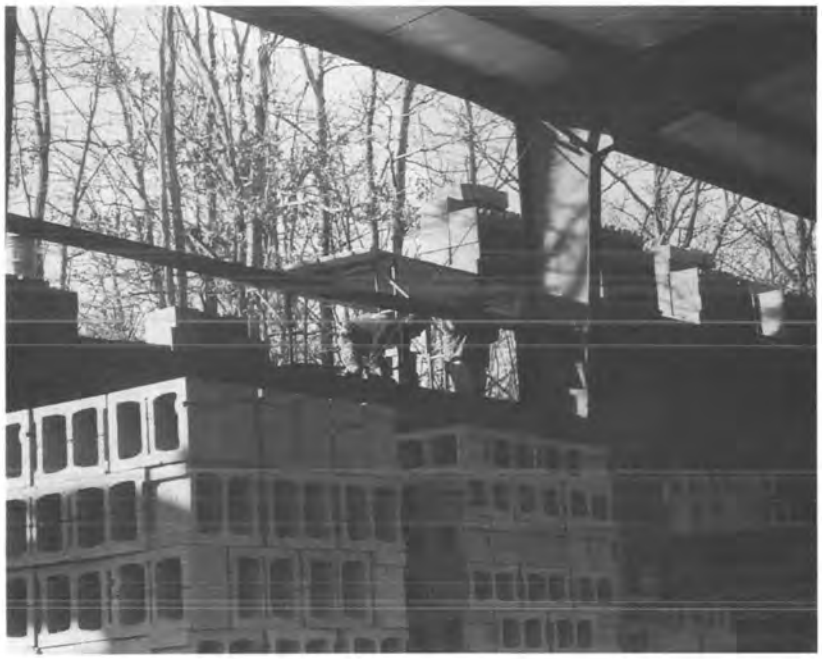
B. Mixed plastic pellets from A can be extruded in different forms, including plastic lumber.

C. Bench made from plastic lumber.

These state-of-the-art municipal solid waste (MSW) incinerators generate an ash by-product that contains contaminants of concern to the public because of potential effects on health and the environment. Much of the WMI research associated with this residual ash has focused on understanding its physical and chemical properties and behavior in the environment.

The Long Island Regional Planning Board, with support from the New York State Energy Research and Development Authority (NYSERDA), and funding from every town on Long Island, has instituted a comprehensive investigation of the properties of MSW incineration ash. WMI's **Frank Roethel** and **Vincent Breslin**, along with Warren Chesner, an engineer from the private sector, have collected ash samples from a diverse array of incineration facilities and examined their chemical and physical properties. Preliminary findings suggest that most of the ash from these plants could be used in a number of beneficial applications.

The team found that bottom ash, the coarser fraction of ash produced by incineration, contains a lower concentration of metals than the finer ***fly ash*** and nearly undetectable amounts of compounds such as chlorinated ***dioxins*** and ***furans***. The encouraging results of this first phase of the study have prompted a consortium of agencies within New York and



Palmer photo

▲ *MSRC Boathouse under construction*

New Jersey to evaluate the acceptability of using ash in the production of asphalt for roadway paving.

Current plans call for a section of highway in New Jersey to be paved with an ash-asphalt material in 1992. Following construction, Roethel and Breslin will begin an assessment of the physical and chemical properties and environmental impacts of this new product.

The first demonstration project to evaluate the use of MSW incineration ash was the placement of a small artificial reef in a bay of Long Island Sound in April 1987, and later, a second reef, both constructed of stabilized MSW incineration ash. After nearly five years of submersion, testing has revealed that the stabilized ash blocks maintained their structural integrity, and metals of environmental concern, particularly lead and cadmium, and organic compounds such as dioxins and furans have been safely retained within the blocks.

building blocks of ash

While evaluating the potential for incineration ash in the construction of artificial reefs, **Frank Roethel**, **Vincent Breslin**, and visiting scientist **Hong Fu Xin** from the People's Republic of China expanded their research to evaluate this technology in land-based applications. With some additional processing, the ash can be substituted for aggregate in the production of construction-grade blocks.

Working with Long Island contractors, WMI developed a method of using MSW incineration ash to manufacture construction grade cement blocks. Following extensive engineering testing by scientists at other SUNY campuses and independent laboratories, the researchers had 14,000 of these blocks made that were used in building the boathouse on the MSRC campus.

Now WMI scientists, with funding from the U. S. Environmental Protection Agency (EPA), have launched a multidisciplinary investigation of the environmental and public health acceptability of using ash in building construction. With assistance from the New York State Department of Health, the WMI team is observing whether the presence of the ash blocks adversely affect the air quality in the boathouse. Over the next few years, this study will also provide information on the chemistry of the soils surrounding the boathouse and an evaluation of the structural integrity of the blocks.

ash-containing structures to fight erosion

To prevent further erosion of our beaches, Long Island needs to consider the best method of armoring its shores. Typically, concrete structures placed offshore and designed to disperse wave energy are used to stabilize the shoreline. But WMI scientists are examining the potential use of MSW ash to produce marine-grade poured structures for shore protection.

Using funding from the New York State Center for Hazardous Waste Management at SUNY Buffalo, **Frank Roethel**, WMI Director **Larry Swanson**, and **Hong Fu Xin** have been exploring the uses of MSW incineration ash in manufacturing shore protection modules such as tetrapods for the past two years. They have been able to produce a concrete material, using ash as a substitute for natural aggregate, and are now planning to demonstrate the potential for protecting Long Island beaches while saving taxpayers the costs of shipping ash as a waste to distant landfills.

multidisciplinary assessment of secondary materials

The more that materials have been recycled, the greater the chance for impure, contaminated, poorly engineered and aesthetically undesirable secondary products to enter the marketplace and the waste stream. And the farther these materials move from their initial introduction in the manufacturing process to the final product, the greater such problems are likely to be.

The New York State Legislature through NYSERDA has sponsored a research program for WMI to assess the engineering, energy, economic, and social issues surrounding lumber made from plastic residues and construction blocks made from municipal solid waste incineration residues.

Larry Swanson, **Vincent Breslin**, MSRC Director **J.R. Schubel**, and **Sheldon Reaven**, who holds a joint position with WMI and Stony Brook's Department of Technology and Society, and graduate student Marci Bortman, worked with colleagues Michael Schwartz of Stony Brook's Institute of Social and Behavioral Sciences and Michael Zweig of the Department of Economics to determine the engineering, social, economic, and environmental characteristics of these materials.

The researchers compared the products made of secondary materials with standard products made from virgin materials, including a determination of the energy required to make the products and whether or not people would be willing to use such products to help reduce the overall waste stream. This latter question depends to some degree on people's perception of the products and their cost competitiveness. Some of their findings, include the following:

construction blocks

High quality, environmentally safe construction products can be made using ash from incineration of MSW.

Cost of these products can be competitive with existing construction materials.

People are concerned about long-term health and

It is extremely important that manufacturers not exploit the public's enthusiasm for waste reduction and waste management endeavors by touting products that may prove to be poor investments or environmentally undesirable.

environmental effects (20-30 years).

More ash will be generated on L.I. than can be used in terrestrial building applications.

plastic lumber

Long-term engineering properties of plastic lumber made from mixed plastics is unknown.

The costs of these products are currently excessive.

From the perspective of energy alone, making secondary materials from plastic is not efficient.

The public is more willing to accept that secondary materials made from plastic are more environmentally safe and engineered more soundly than secondary materials made from ash. This is true despite the fact that there has been positive results from extensive testing of stabilized ash products and virtually no testing on plastic materials.

recommendations for future planning

The results of this assessment have led the researchers to recommend the following considerations for future plans with secondary materials.

If society is to successfully adopt reuse, recycling, and use of secondary materials, government and environmental organizations must encourage businesses to design, develop, test, and market more innovative, useful secondary products that are soundly engineered.

It is reasonable to expect that government may at some time develop standards and criteria for testing and labeling, perhaps by specifying limits for use, mandating materials identification, and offering disposal strategies. In the meantime, manufacturers must determine potential health and safety hazards of these products, the threats they pose to the environment, their expected durability, recycling or reuse potential, and appropriate disposal strategy. And this information must be conveyed to the consumer.

It is extremely important that manufacturers not exploit the public's enthusiasm for waste reduction and waste management endeavors by touting products that may prove to be poor investments or environmentally undesirable.

floatables wastes

Floatable debris continues to be a problem along the coasts of Long Island and New Jersey, but certainly to a lesser extent than in 1976, 1987, and 1988. In part, the quantity of debris, which comes from combined sewer overflow (CSO), storm sewers, and other sources, has been reduced by the harbor floatables removal program conducted by the EPA, U.S. Army Corps of Engineers, the states of New York and New Jersey, and New York City.

Director **Larry Swanson** and graduate student Arnoldo Valle, who continue to evaluate and predict floatable

Palmer photo

◀ *Floatable wastes*

wash-up events based on meteorology and physical oceanography, found that in 1989 and 1990, much of the floatable material that escaped the harbor collection program was transported offshore and dispersed. However, in the summer of 1991, more frequent onshore winds following a few significant rainfall events caused more wash-ups than the previous two years.

To further aid understanding wind-induced transport, they have conducted experiments on patterns of scattering of floatable medical wastes as a function of cross-sectional area exposed to the wind and the wind speed. In connection with this, **Dr. William Greene** of the Division of Infectious Control of the University's Health Sciences Center, continues to advise WMI on the public health aspects of floating debris.

Anne West-Valle, assistant to the director, and **Larry Swanson**, in conjunction with the EPA and as part of the NY-NJ Harbor Estuary Characterization Study, are helping to develop long-term management plans for floatables reduction and to raise public awareness about what individual citizens can do to reduce floatables. Following the summer of 1991, it is more evident than ever that reducing floatables prior to their reaching marine waters is more effective than cleaning them up once in the water or stranded along our coasts.

hypoxia in the Bight

Hypoxia and anoxia were documented in the New York Bight in the mid-1970s. Depleted oxygen is often associated with classical upwelling regions in open coastal areas, but the Bight does not fall into this category. Consequently, when the problem was observed—the first such documented occurrence from similar regions around the world—it generated considerable concern and interest. Research and monitoring in an attempt to relate cause and effect, have been ongoing in the intervening years.

MSRC biological oceanographer Elizabeth Cosper, **Larry Swanson**, and **Anne West-Valle**, continue to conduct research in this region of the coastal ocean, particularly to understand how natural environmental processes and anthropogenic input contribute to the problem. In 1990 and 1991, following the cessation of more than 60 years of ocean dumping of sewage sludge at the 12-mile dump site, these researchers, along with Tom Brosnan of the New York City Department of Environmental Protection, monitored the decline of the summertime bottom dissolved oxygen concentrations.

In 1991, atmospheric warming produced a well stratified water column by late spring. By early August bottom dissolved oxygen concentrations averaged over

Subaerial—The part of the marsh that is only flooded during spring and storm tides.

Bioremediation—Control or cleanup of polluted environments with bacteria or other microorganism, which have the ability to degrade or transform contaminants.

the apex of the Bight were lower than they had been since the anoxic event in 1976 that killed large numbers of benthic organisms. The 1991 values were well within the historical range, however. These observations are significant since one of the major sources of oxygen demand, ocean dumping of sewage sludge, had been eliminated.

Anoxic conditions did not develop in 1991. Hurricane Bob, unlike Hurricane Belle in 1976, mixed the water column, and by early September the bottom dissolved oxygen concentrations had improved slightly. These studies, being continued by WMI, are important in producing the information needed for management of coastal waters over the long-term.

organic contaminants

Bruce Brownawell's research involves the sources, transport, and reactions of organic contaminants in aquatic environments. He is particularly interested in the processes which affect the fate of low solubility organic compounds (e.g., aromatic and chlorinated hydrocarbons, and detergents) which have a tendency to associate with sediments, soils, and organisms.

Brownawell's group is studying the chemical partitioning and transport of PCBs (polychlorinated biphenyls) in the Hudson River estuary. They are focusing on determining how changes in salinity along the axis of the estuary control the uptake and release of PCBs by sediments.

A new project in the Hudson estuary is aimed at exploring the release of PCBs from the sediment bed back to the overlying water. Because upstream sources of PCBs have been dramatically reduced, much of the sediment deposits that were acting as sinks of PCBs in the past are now serving as sources to the ecosystem.

In another study, Brownawell's group is working with MSRC geochemists Kirk Cochran and Dave Hirschberg to examine the use of peat cores from ***subaerial*** salt marsh environments as a tool to understand historical atmospheric inputs of PCBs, chlorinated pesticides, and polycyclic aromatic hydrocarbons to western Long Island Sound. Preliminary findings suggest that atmospheric sources of PCBs may dominate inputs into Long Island Sound. These studies have important implications for management plans to reduce the input of toxic substances to the harbor and estuaries near the New York metropolitan area.

A new project with microbiologists from Woods Hole Oceanographic Institute involves searching for bacteria from highly stressed marine environments, such as those from natural oil seeps, that readily degrade aromatic hydrocarbons such that they

Dooley photo

▲ *Bruce Brownawell*

might ultimately be useful in contaminant ***bioremediation***. Brownawell and biological oceanographer Nicholas Fisher have been interpreting the historical data base for potentially toxic chemicals in Long Island Sound as part of EPA's Long Island Sound Study.

Other new projects of Brownawell's include further studies of atmospheric inputs of pollutants to Long Island Sound, in collaboration with Larry Swanson, and another collaboration with MSRC geological oceanographer Roger Flood to study storm-induced resuspension of contaminated sediment in an area of Lake Ontario that has been heavily contaminated with toxic substances from the Niagara River.

toxic metals

Nicholas Fisher and his research group, together with MSRC biological oceanographer Glenn Lopez and Jeffrey Levinton of Stony Brook's Department of Ecology and Evolution, are investigating the rate and pattern of release of cadmium from the sediments of Foundry Cove. Foundry Cove is a severely contaminated embayment in the Hudson River, which has been designated by the EPA as a Superfund site.

They are also investigating the subsequent uptake of cadmium by blue crabs (*Callinectes sapidus*). Their results indicate that although the net flux of cadmium to the river in the dissolved phase is negligible, a large amount of cadmium on fine particles is suspended and transported by tidal currents. They estimate a net export of 500 to 1000 kilograms of cadmium from Foundry Cove to the Hudson River each year.

Using radiotracer techniques, Randy Young, a graduate student in Fisher's laboratory, determined that cadmium release from sediments is directly proportional to the salinity of overlying waters. Young is also investigating the effects of burrowing worms on cadmium release from sediments and the accumulation of cadmium by juvenile blue crabs through ingestion of contaminated food and from the dissolved phase.

Fisher and his students are also engaged in research to assess the transfer of toxic metals in marine food webs, particularly on quantifying the efficiency with which different animals assimilate ingested elements and on delineating the sources for select contaminants in marine animals. In recent experiments, Fisher has employed radiotracer techniques to facilitate experimentation with environmentally realistic metal concentrations in bivalve species, which are commonly used as sentinel organisms in

These findings show that although the starch-based plastic film composites are designed to deteriorate primarily through the action of microorganisms, deterioration is actually due to the interaction of biological, chemical, and physical processes.

national marine pollution monitoring programs.

degradable plastics

In 1988 plastics were estimated to constitute some 8% by weight of the nation's municipal solid waste stream. Many of the physical and chemical properties of plastics make them ideal materials for a variety of products and applications. Plastics can be manufactured to be durable, lightweight, rigid, flexible, impermeable, transparent, or opaque. They are widely distributed and typically degrade very slowly in the natural environment, and as a result, are often considered to be contaminants.

The recent development by industry of starch-based plastic composites is an effort to make plastics more susceptible to biological degradation in the environment. This would increase their rate of degradation and lessen their impacts on the environment. But the factors controlling their degradation in the environment are not well known.

In addition to comprising up to 50% starch by weight, these plastic composites may also contain catalysts to oxidize the polymer to lower molecular weight by-products

Graduate student Arnoldo Valle (foreground) and professor Vincent Breslin removing degradable plastic samples from cage at the beach strawline. This was one of several sites chosen to test the effects of various environmental conditions on degradability. ▼

Stupakoff photo

which may then be metabolized by microorganisms. If the incorporation of additives increases the product's susceptibility to deterioration in the environment, such impacts to marine animals as gut blockage and entanglement may be diminished.

Vincent Breslin, **Larry Swanson**, and **Sheldon Reaven** initiated a study to measure the rate and extent of deterioration of starch-based compared to non-starch-based (control) plastics in the environment. They examined degradation of the plastics over a two-year period when buried in a municipal solid waste landfill, in compost, and in soil; submerged in seawater; and placed at the strawline of a marsh. They measured changes in tensile properties, weight loss, starch content, and morphology of plastic samples retrieved from the exposure sites to determine deterioration.

Results of physical testing generally showed that starch-based plastic *weakened* at an accelerated rate compared to the corresponding control plastics following two years in the exposure sites. But, with the exception of samples placed in the strawline site, the starch-based plastics did not *fragment or lose mass* during the observation period.

Deterioration of both starch-based and control films in the strawline was rapid and primarily initiated by photodegradation. Starch-based films buried in compost also rapidly weakened, compared to corresponding control films, primarily due to high temperatures, high moisture, and high biological activity.

In contrast, lower rates of deterioration were measured for both starch-based and control films weathered in seawater, soil, and landfill. Samples weathered in these sites experienced cooler ambient temperatures, moderate biological activity, and reduced quantities or no solar radiation — each factor contributing to the lower observed rate of deterioration. These findings show that although the starch-based plastic film composites are designed to deteriorate primarily through the action of microorganisms, deterioration is actually due to the interaction of biological, chemical, and physical processes.

thermoplastic stabilization of incineration ash

In a research program complementary to the MSW incineration ash research, **Vincent Breslin** and his coworkers are investigating the feasibility of stabilizing incineration residues using waste plastic, called thermoplastic stabilization. This process involves mixing the incineration residues with the plastic resins at elevated temperature. After mixing the components, the molten mixture may then be poured or extruded into forms to cool.

The recovery of waste plastics prior to their incineration in mixed municipal solid waste could provide a continuous source of plastic for this stabilization technology. If the plastic-residue mixtures can be easily molded or extruded, useful products may be produced and marketed.

Thermoplastic stabilization technologies may compare favorably to the current cement-based stabilization technologies for incineration residues, and even offer several distint advantages. For example, one advantage is that the stabilization process results in the isolation by encapsulation of the material from its surroundings, thus mitigating leaching of contaminants. The thermoplastic coating may also provide a strong and chemically inert encapsulating material.

The research program is designed to develop stabilized ash-plastic products and to evaluate them for environmental acceptability. Included in this investigation will be the development of a variety of mix designs using different ratio of ash residue to plastic. The environmental acceptability of these manufactured ash-plastic mixes will then be examined through a series of leaching and physical testing protocols.

solid waste composting

Long Island's Towns have all been required to develop new solid waste management programs that

Soil amendment—An additive that improves the physical or chemical properties of the soil.

take into account the official closing of Long Island landfills in December 1990. In an effort to limit the amount of waste destined for landfills, several of the towns' proposed solid waste management plans now include a solid waste composting component.

Composting has been defined as controlled biological decomposition of organic materials. Since it is basically a natural biological process, it is often assumed to be environmentally compatible. But Long Island's mixed waste composting plans have raised concerns among health and environmental regulatory agencies about the potential environmental impacts of the proposed uses of compost products.

Although solid waste composting has been proven successful in reducing the volume and mass of municipal solid waste by 50%, solid waste composting may prove to be undesirable. Many toxins that enter the solid waste stream may also be present in the resultant compost product. Relatively little data is available addressing the environmental acceptability of mixed waste compost. Therefore, WMI is conducting research to determine the physical and chemical properties of solid waste compost to evaluate its suitability for use as a ***soil amendment***

Vincent Breslin and **Larry Swanson**, in collaboration with **Theodore Goldfarb** of Stony Brook's Department of Chemistry, are conducting the composting study, which is designed to evaluate environmental acceptability of mixed waste compost. They will try to determine the physical and chemical properties of compost sampled from operating mixed waste composting facilities and the inorganic and organic composition of solid waste compost leachates. They will also assess the suitability of mixed waste compost for use as a soil amendment and identify possible uses and markets for mixed waste compost.

Jamaica Bay study

WMI's **Anne West-Valle** and **Larry Swanson**, along with graduate student Cynthia Decker, completed a report for the EPA entitled "Use Impairments of Jamaica Bay." This report chronicled the changing conditions of the bay's environment, habitat, and biota over the last century, relating them to changing uses of the bay.

There were distinct stages of use, including use as a fishery, commercial and industrial development along its fringes, as a recreation site, and most recently, as a wildlife sanctuary. It is clear that past industrial development and associated modifications were not compatible with today's vision of what the bay should be or the function it should serve. It is important, however, to examine the bay in hindsight, as it raises questions of how the next generation will value our current visions and management goals.

professional and public relations

WMI has sponsored a number of workshops and symposia dealing with such issues as management of incineration ash, construction and demolition debris, and tires. These meetings were arranged with the idea of bringing state government together with local governments and private industries to better understand the nature of the waste problem, as well as the roles, management responsibilities, and problems of government and industry.

The workshops were also intended to identify important research issues that need to be undertaken. For example, the towns of Babylon, Brookhaven, East Hampton, Islip, North Hempstead, and Southold, as well as the New York State Department of Environmental Conservation, unanimously agreed at a WMI retreat that research on MSW composting would be one of the more important research activities for long-term management of solid waste on Long Island.

WMI has also played an important role in helping to assess many of the pressing waste issues on the Stony Brook campus. MSRC Director Jerry Schubel organized and chaired Project Prometheus, in which WMI personnel participated.

The project was an introspection of energy and water usage, medical waste and MSW generation on campus. Alternatives to present practices were explored with the idea of identifying and implementing low-cost efforts that would conserve energy and water resources and reduce the waste stream. **Larry Swanson** chaired the working group on water and sewage, Sheldon Reaven the MSW group, **Anne West-Valle** served on the medical waste group, as well as the water and sewage groups.

education

In 1989, WMI through the School of Continuing Education developed and implemented an 18-credit Waste Management Certificate Program. The program is primarily for university graduates who are now working on waste management issues for industry, business, government, and environmental groups, as well as for the general public. This diversity of students' backgrounds adds to the dialogue and the overall educational experience.

Course work includes new technologies in solid waste, environmental law, public health, history of waste management, marine and groundwater pollution, and case studies in marine and solid waste management. The first graduates received their certificates in June 1991. Anne West-Valle administers the program, one of the first such programs in the United States, and Adjunct Professor **Martin Garrell** has worked to expand the program to other educational centers.

the Waste Management Institute faculty

R. Lawrence Swanson, Director
Vincent Breslin
Bruce Brownawell
Nicholas Fisher
Martin Garrell
Theodore D. Goldfarb
William H. Greene
Frank Roethel
Sheldon Reaven
J.R. Schubel
Hong Fu Xin

staff

Barbara A. Vallely
Staff Assistant

Anne West-Valle
Editorial Associate

funding sources

WMI is currently funded by New York State and grants from the following sources: Akzo Salt, Inc.; Archer Daniels Midland Co.; Dynamac; Hudson River Foundation; Long Island Regional Planning Board; National Oceanic and Atmospheric Administration; National Science Foundation; New Jersey Institute of Technology; New York State Center for Hazardous Waste Management; New York State Department of Environmental Conservation; New York State Energy Research and Development Authority; New York Sea Grant Institute; NKF Engineering, Inc.; Office of Naval Research; Old Dominion University; the Towns of Hempstead, Islip, and Brookhaven; U.S. Environmental Protection Agency; West Palm Beach (Florida) Solid Waste Authority; Wheelabrator Environmental Systems.

publications

Breslin, V.T. Stony Brook researchers investigate uses for incineration residues. Waste Management Research Report; 2(2):3-8; Summer, 1990.

Breslin, V.T.; **Swanson, R.L.**; **Reaven, S.** Investigations of the degradability of a cornstarch-based plastic. Interim report submitted to Archer Daniels Midland Company, Decatur, IL; May, 1990.

Brownawell, B.J. Methods for isolating colloidal organic matter from seawater: general considerations and recommendations. In: Hurd, D.C.; Spencer, D.W., eds. Marine particles: analysis and characterization; Geophysical Monograph 63; American Geophysical Union; pp. 187-194; 1991.

Brownawell, B.J.; Chen, H.; Zhang, W.; Westall, J.C. Adsorption of surfactants. In: Baker, R.A., ed. Organic substances and sediments in water. Vol. 2, Processes and Analytical; Chelsea, MI: Lewis Publishers; pp. 127-147; 1991.

Brownawell, B.J.; Chen, H.; Collier, J.M.; Westall, J.C. Adsorption of organic cations to natural materials. Environmental Science and Technology; 24:1234-1241; 1990.

Luoma, S.N.; Johns, C.; **Fisher, N.S.**; Steinberg, N.A.; Oremland, R.S.; Reinfelder, J.R. Absorption of organo-selenium and elemental selenium via ingestion in the bivalve *Macoma balthica*. Environmental Science and Technology (in press).

Schoonen, M.A.A.; **Fisher, N.S.**; Wente, M. Gold sorption onto pyrite and goethite: a radiotracer study. Geochimica et Cosmochimica Acta (in press).

Fisher, N.S.; Nolan, C.V.; Fowler, S.W. Assimilation of metals in marine copepods and its biogeochemical implications. Marine Ecology Progress Series; 71:37-43; 1991.

Fisher, N.S.; Nolan, C.V.; Fowler, S.W. Scavenging and retention of metals by zooplankton fecal pellets and marine snow. Deep-Sea Research; 38:1261-1275; 1991.

Fisher, N.S.; Nolan, C.V.; Gorsky, G. The retention of cadmium and zinc in appendicularian houses. Oceanologica Acta; 14:427-430; 1991.

Schubel, J.R.; **Swanson, R.L.**; **Fisher, N.S.** The world ocean as waste space; the case for equal opportunity. In: Haley, S.D.; Abel, R.B., eds. Coastal Ocean Space Utilization; pp. 261-268; 1990.

Harrad, S.J.; Malloy, T.A.; Khan, M.A.; **Goldfarb, T.D.** Levels and sources of PCDDs and PCDFs, chlorophenols and chlorobenzenes in composts from a municipal yard waste facility. Chemosphere; 23:181; 1991.

Goldfarb, T.D.; Maertz, M.; **Roethel, F. J.**; Iden, C.R.; Rieger, R. PCDDs and PCDFs in incineration ash from several types of facilities in the Northeastern United States. Chemosphere; 20:1833; 1990.

Goldfarb, T.D.; Harrad, S.J. Consideration of the volatilization of PCDD and PCDF from deposited particulates in combustion source risk assessments. Dioxin 90/EPRI Seminar Short Papers; 1: 529, Bayreuth, FRG: Ecoinforma Press; 1990.

Marchese, J.T.; Marshall, G.B.; LaValle, R.F.; **Greene, W.H.** Regulated medical waste disposal at a university and university hospital: future implications. Proceedings, 3rd International Conference on Nosocomial Infections; Atlanta; August, 1990.

Reaven, S.J.; Tonjes, D.J. Waste avoidance in the restaurant industry. Waste Management Research Report: news from State University of New York at Buffalo and Stony Brook, and Cornell University; 3 (1): 15-16; 1991.

Reaven, S.J. Choosing among risk management alternatives for mitigating groundwater pollution. In: McTernan, W., ed. Groundwater risk assessment for pollution control. New York: American Society of Civil Engineers; pp. 225-245; 1989.

Reaven, S.J. New frontiers: science and technology at the fair. In: Bletter, R; Dickstein, M.; Miller, M.; Reaven, S., eds. Remembering the future: the New York World's Fair from 1939 to 1964. New York: Rizzoli Press; pp: 75-103; 1989.

Roethel, F.J.; Breslin, V.T. Leaching characteristics of MSW combustor residues. In: Proceeding of the 4th International Conference on Municipal Solid Waste Combustor Ash Utilization; 12-13 November; Arlington, VA; 1991.

van der Sloot H. A.; **Woodhead, P.M.J.**; Hockley, D.; **Roethel, F.J.** The long-term behavior of stabilized coal ash in the sea. Proceedings of American Coal Ash Association's 9th International Coal Ash Symposium, January 22-25. Orlando, FL.; 1991.

Roethel, F.J.; **Breslin, V.T.** Stony Brook's MSW combustor ash demonstration programs. In: Proceedings of the 3rd International Conference on Ash Utilization and Stabilization. November 13-14; Arlington, VA; 1990.

Roethel, F.J.; Breslin, V.T.; Aldous, K. Mobility of dioxins and furans associated with stabilized incineration residues in the marine environment. In: Proceedings of the 16th Annual EPA Hazardous Waste Research Symposium; 3-5 April; Cincinnati, OH; 1990.

Swanson, R.L. Concern about ocean pollution can distort perception of waste management issues. Waste Management Research Report; 3(2):1-2; 1991.

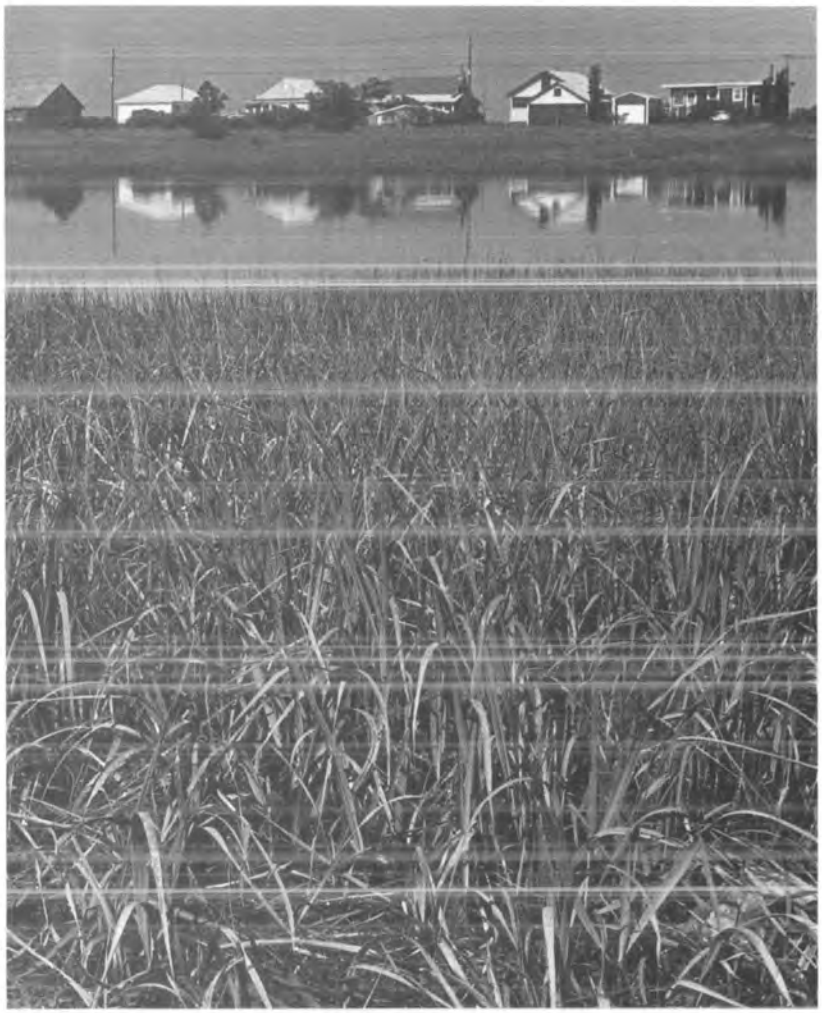
Anadromous— Moiving from seawater to fresh water to spawn.

Swanson, R.L.; Bell, T.M.; Kahn, J.; Ohla, J. Use impairments and ecosystem impacts of the New York Bight. Chemistry and Ecology; 5:99-127; 1991.

Valle-Levinson, A.; **Swanson, R.L.** Wind-induced scattering of medically-related and sewage-related floatables. Marine Technology Society Journal; 25(2):49-56; 1991.

Swanson, R.L. Secondary materials deserve a chance. Waste Management Research Report; 2(2): 1-2. 1990.

Swanson, R.L.; Zimmer, R.L. Meteorological conditions leading to the 1987 and 1988 washups of floatable wastes on New York and New Jersey beaches and comparison of these conditions with the historical record. Estuarine, Coastal and Shelf Science; 30:59-78; 1990.



Hicks photo

The COAST Institute

The Coastal Ocean Action Strategies (COAST) Institute was introduced in our last Biennial Report, and since that time, has taken a leading role on a number of new initiatives with the environment as the ultimate beneficiary.

The goal of COAST is to ensure that the best scientific and technical information is included in the development of strategies to conserve and, when necessary, to rehabilitate the coastal ocean. The way COAST achieves this goal is by forming effective linkages among environmental groups, the scientific community, lawmakers, regulators, and managers to tackle issues that affect our coastal environment. The typical vehicle for linking the groups and the issues is a forum or workshop structured and facilitated by the Institute.

projects

San Francisco estuary program

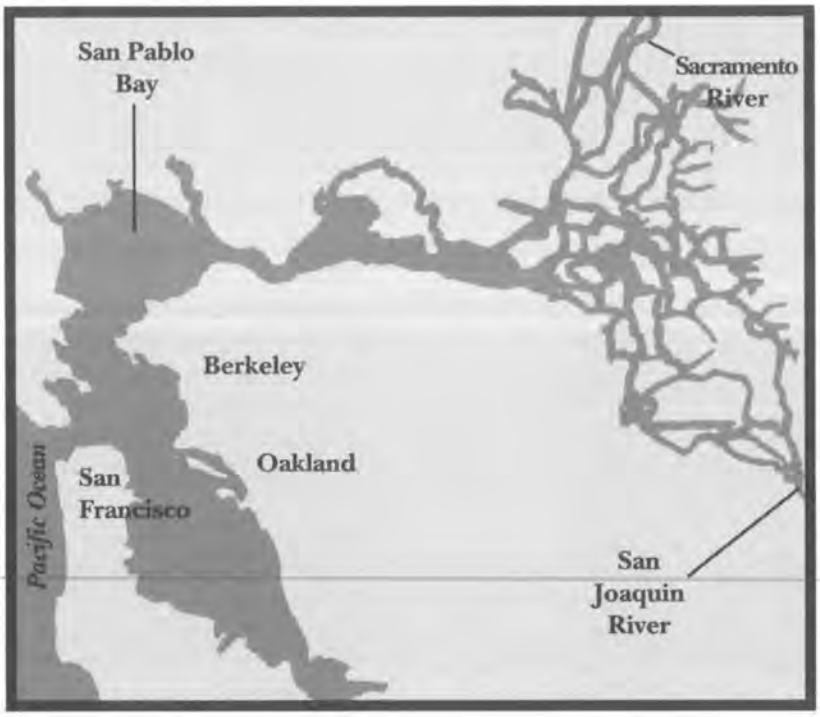
Since 1800 approximately half of the river flow to San Francisco Bay from the Sacramento and San Joaquin Rivers has been diverted for agricultural and urban uses. The drought that has gripped California for the past five years has increased the pressure to divert even more water.

Much of the water is diverted through a complex system of pumps and channels in the delta region at the head of the estuary. As withdrawal increases, salt penetrates further up the bay and into the Delta. In the spring, striped bass, Delta smelt and other ***anadromous*** and semi-anadromous fish must move farther upstream to spawn. After spawning, the adults move back down into the more saline waters, but the eggs and larvae remain behind to develop.

Since the increase in freshwater diversion, the eggs, larvae, and juveniles of these fishes are found farther upstream within the Delta region. This increases the chances that they will be entrained with the water that is diverted for agriculture and urban use and killed.

Estuarine scientists and environmental organizations have grown increasingly concerned about declines in anadromous fish stocks and the loss of tidal freshwater habitat. The farmers and the cities can easily document when they need more water and what the economic benefits are of providing it. On the other hand, the benefits of fresh water to the estuary are more difficult to quantify, but are no less real.

▼ *San Francisco Bay-Delta Estuary*



"One of the best ways to make a compelling case for the value of basic research to management is to demonstrate, by example, how scientific knowledge and improved understanding of natural systems can be utilized in formulating effective management strategies..."

Furthermore, environmental responses to changes in freshwater inflow are not routinely measured. As a result, there is no equivalent of the "canary in the coal mine" to alert managers when more fresh water is needed to protect the Bay's ecology. In this game of competing interests for the water, the estuary has been a consistent loser.

In an effort to help make the case for the estuary's critical water needs, COAST Institute director **J.R. Schubel**, designed and conducted workshops in California with managers, scientists, environmental agencies, and citizens' groups. These led to the selection of a standard for the Bay, based on salinity and how far upstream salt penetrates into the Bay. A standard will be developed for each season to manage freshwater inflows to protect fish and the estuarine ecosystem.

Delaware estuary program

In 1990, **Schubel** and COAST faculty member **William Eichbaum** were asked by the leaders of the Delaware Estuary Program, part of the National Estuary Program, to organize and facilitate two workshops to help shape the research agenda. The Delaware Bay estuary exhibits a large range of impacts, having a central section that passes through a major urban area and a southern section that is dominated by wetlands and wildlife. The estuary is bordered by Pennsylvania, Delaware, and New Jersey, and the Delaware River drainage basin also includes New York. Multiple jurisdictions, regulations, and visions for the estuary's use came into play in deciding its future.

The first workshop brought together a diverse group of users of the Delaware estuary: artists, naturalists, boaters, commercial and recreational fishermen, shippers, power plant operators, sport operators, sewage treatment plant operators, and many others. The objective of this workshop was to have the participants identify the values society places on the estuary and how people in the region want to use it in the year 2020. Some of the topics addressed were population growth and development; resources uses such as fisheries, aquaculture, wildlife, agriculture, and forestry; shipping, transportation and port development; and recreation.

The second workshop brought together a broad spectrum of scientists with key managers. This workshop was designed to determine whether the existing body of scientific and technical knowledge was adequate to formulate management programs that could accommodate these values and uses, and if not, to identify what additional research was needed.

The project produced two widely distributed reports. The report from the first workshop outlined major

points of agreement and existing and potential issues of conflict, which called for further investigations and clarification. The second report integrated the results of both workshops, identifying the required scientific and technical data needed to ensure the values and uses desired for the estuary of 2020.

Acknowledging that a sustained program of fundamental research is critical to improving understanding of estuarine processes and that the National Estuary Program was not designed to provide such sustained support, one major recommendation included in the report by COAST Institute facilitators was stated as follows:

"One of the best ways to make a compelling case for the value of basic research to management is to demonstrate, by example, how scientific knowledge and improved understanding of natural systems can be utilized in formulating effective management strategies..."

assessing potential hypoxia effects on L.I. Sound fauna

In collaboration with Darcy Lonsdale and Robert Cerrato of MSRC and William T. Peterson of National Oceanic and Atmospheric Administration, **Doreen Monteleone**, the John M. Olin Fellow for the COAST Institute, developed a report entitled "Abundance and seasonality of key resource species and their forage species in Long Island Sound." The information in this report will be used to characterize and assess potential impacts of hypoxia on forage species in the Sound.

Stupakoff photo

▲ *Doreen Monteleone with graduate student Woong-Seo Kim (2nd from R.), Larry Swanson (2nd from L.) and J. R. Schubel (3rd from L.) with Brookhaven Town officials at opening of marina recycling booth.*

The report includes an extensive review of existing data sets on the lower trophic level organisms in Long Island Sound. The data were analyzed to determine abundance, distribution, and species composition of phytoplankton, microplankton, zooplankton, ichthyoplankton, forage fishes, and benthic organisms. This information was combined with extensive reviews by MSRC's Peter Woodhead and Maryann McEnroe of SUNY, Purchase of the physiology and ecology of these organisms and benefits of attaining state water quality standards for dissolved oxygen. The team also noted gaps in data and recommended future research and monitoring for a better understanding of low dissolved oxygen effects on lower trophic level organisms of Long Island Sound.

public education

marina recycling

Boaters dumping garbage and trash overboard contribute to floatables that litter the water and beaches. Federal and international regulations enacted in the late 1980s prohibited discarding plastics at sea anywhere, and prohibited discarding all wastes overboard in coastal waters. But writing regulations is often not enough to change behavior. Educating boaters and commercial mariners and providing services for easy trash disposal are also needed.

During summer 1990 COAST initiated a marina recycling project at Port Jefferson Harbor, a popular yachting stopover port on the north shore of Long Island. With the Town of Brookhaven, New York State Department of

Environmental Conservation, and Waste Management Institute, COAST Institute's **Doreen Monteleone** set up a shed for collection of recyclables with brochures about waste disposal and recycling.

Besides educating marina users about recycling and encouraging proper boat waste disposal, project staff also surveyed recreational boaters to determine the major types of trash generated on a typical outing and characterized and weighed recyclable wastes collected at the marina.

Between Memorial Day and Labor Day, 460 pounds of newspaper and 640 pounds of drink containers were collected. Over the summer, the weight of recyclables increased each week, indicating that marina users may have become more aware of the center. Brookhaven Town decided to continue this successful program each summer.

national beach cleanup

Doreen Monteleone has coordinated beach cleanups, co-sponsored by New York Department of Environmental Conservation and WBLI-FM Radio, at Smith Point County Park over the past two years. Cleaning up a beach is the basic goal, but another goal of this initiative is to make the public more aware of the dominant types and sources of debris polluting local beaches. At Smith Point this past year, cigarette filters and assorted plastic food service items originating from the beach's concession stand were the most common items collected.

the COAST Institute faculty

J. R. Schubel, Director

Harold Berger, Adjunct Professor; Regional Director (Retired), Region I, New York Department of Environmental Conservation.

John C. Bierwirth, Stony Brook Professor; Chairman, Board of Trustees, Nature Conservancy, Long Island Chapter; Chairman (Retired) Grumman Corporation

William Eichbaum, Adjunct Professor, The Conservation Foundation/World Wildlife Fund

Doreen M. Monteleone, John M. Olin Postdoctoral Fellow

publications

Monteleone, D. M.; Swanson, R. L.; Wise, W. How does coastal development impact the marine environment? In: Schubel, J.R.; Monteleone, D.M., eds. Critical problems of New York's marine coastal zone. Marine Sciences Research Center Working Paper No. 44, Ref. No. 90-9, II-7-10; 1990.

Wise, W.; Colvin, G.; **Monteleone, D.M.** New York Project 2000, Fisheries and Aquaculture. Marine Sciences Research Center Working Paper No. 51, Ref. No. 91-08; 1991.

Schubel, J.R. An assessment of the entrapment zone and other estuarine surrogates for managing freshwater inflow to the San Francisco Bay estuary. Report of a workshop held at the Bay Conference Center, Tiburon, California, 22-27 August. Marine Sciences Research Center Special Report No. 94, Ref. No. 91-13; 1991.

Schubel, J. R. An identification and preliminary assessment of alternatives to enhanced nutrient removal and sewage treatment plants for alleviating hypoxia in western Long Island Sound. Report of a workshop 21 August. Marine Sciences Research Center Working Paper No. 53, Ref. No. 91-11; 1991.

Schubel, J.R. New York Project 2000, Marine Resources: 2000. Marine Sciences Research Center Working Paper No. 51, Ref. No. 91-08; 1991.

Schubel, J.R. On development of an estuarine science-management paradigm. Report of a workshop 23-24 April; Marine Sciences Research Center Working Paper No. 50, Ref. No. 91-07; 1991.

Schubel, J.R. The second phase of an assessment of alternatives to biological nutrient removal at sewage treatment plants for alleviating hypoxia in western Long Island Sound. Report of a workshop 21-22 November; Marine Sciences Research Center Working Paper No. 56, Ref. No. 91-19; 1991.

Schubel, J.R. The urban environment and waste disposal. Notes prepared for the Consiglio Nazionale Delle Richerche, New York State Conference on Public-Private Partnership for Urban Revitalization, 6-8 November; Marine Sciences Research Center Working Paper No. 54, Ref. No. 91-16; 1991.

Schubel, J.R. "Long Island Sound: Facing Tough Choices." EPA Journal article; 16(6):26-28; November/December, 1990.

Schubel, J. R., Bell, T. M. and **Monteleone, D. M.** On the identification of strategies to eliminate the causes of floatables on beaches. Marine Sciences Research Center Working Paper No. 42, Ref. No. 90-7; 1990.

Schubel, J.R.; Eichbaum, W.M. Recommendations for a research program responsive to management needs for information to ensure the values and uses desired for the Delaware Estuary in 2020. Marine Sciences Research Center Special Report No. 92, Ref. No. 90-14; 1990.

Schubel, J.R.; Eichbaum, W.M.; Schubel, S.E. The Delaware Estuary program. Informal report of a workshop held 30-31 March 1990 to identify uses and values for the Delaware Estuary in 2020. Marine Sciences Research Center Working Paper No. 43, Ref. No. 90-8; 1990.

Schubel, J. R.; **Monteleone, D. M.** Critical problems of New York's marine coastal zone. Marine Sciences Research Center Working Paper No. 44, Ref. No. 90-9; 1990.

Schubel, J. R. and **Monteleone, D. M.** Floatables and medical wastes on the region's beaches 1989 vs. 1988. What were the differences and their causes? Marine Sciences Research Center Working Paper No. 37, Ref. No. 89-10, 49 pp.; 1989.

resources and facilities

MSRC occupies four one-story buildings on the University's south campus, one-half mile from the main campus. The central core of each building contains ample, well-equipped laboratories or classrooms, with offices, conference rooms, and dry laboratories along the perimeter.

In 1992 a fifth building for shops and laboratories will be completed—constructed of blocks made of stabilized municipal solid waste incineration ash. Air and soil samples from within and around this experimental building will be sampled over an 18-month period to determine if the blocks release, or leach, contaminants. Results of benchtop experiments analyzed to date indicate virtually no release of contaminants. If this remains the case in construction application, the building will be used for MSRC's technical and field operation support shops and for general storage.

Flax Pond Marine Environmental Laboratory

Located approximately five miles from the Center, on a tidal salt marsh preserve flushed by Long Island Sound, is the Flax Pond Marine Laboratory. This 8,000-square-foot research facility is equipped with running seawater circulating through more than 20 sea tables and aquaria and an 800-square-foot greenhouse.

Flax Pond, a 146-acre salt marsh preserve and nature trail on Long Island's north shore, is host to a rich variety of marine plants, shellfish and fish. The pond and the adjacent Flax Pond Marine Laboratory provide MSRC students and faculty easily accessible field research opportunities and laboratory facilities with fresh running seawater. The laboratory is also

▼ *Flax Pond*

Hicks photo

a research resource for a number of scientists and teachers from other university departments and institutions in the community, as well as an educational resource for school children and other visitors who come to learn about the salt marsh environment.

In October 1991, Charles James joined the MSRC staff as manager of Flax Pond Marine Laboratory. With his strong aquaculture background and experience in marine laboratory management, MSRC hopes to enhance the facilties and programs at the lab.

Stupakoff photo

▲ *R.V.* ONRUST

equipment and instrumentation

MSRC has a major commitment in staff, equipment, and instrumentation to provide researchers with the most recent technology to conduct experiments both in the lab and at sea. Equipment is often specially designed for individual needs by the ocean instruments staff. Equipment and instruments obtained by individual faculty through research grants include some of the most sophisticated instrumentation used in the marine sciences today.

Within the year, MSRC will have a dedicated laboratory featuring sophisticated, state-of-the-art analytical instrumentation that is too costly for a single faculty member to purchase and maintain. This new resource will be available to augment the needs of all MSRC faculty, staff, and students.

research vessels

At the head of MSRC's fleet of research vessels is the 60-foot steel-hulled *ONRUST* (Dutch for "restless"), built specifically for MSRC. The *ONRUST* is completely equipped for coastal oceanographic research with 168 square feet of wet laboratory, 21 linear feet of bench and sink space, and a hydraulic A-frame on the 240-square-foot aft work deck.

A recent addition to our fleet is the 48-foot trawler yacht, the *Lord Jim*, used as a floating classroom and meeting room. The Center also maintains four small boats and support vehicles for field research in sheltered waters around Long Island: the R/V *Siome*, a 24-foot shallow draft cabin cruiser; two 17-foot Boston Whalers; and a 24-foot open workboat.

Recently, a new 24-foot Sun Runner fiberglass boat was donated to the Center by a resident of Long Island and friend of MSRC, Dr. Frederick A. Forrest, to be used for field research at the Center.

computer facilities

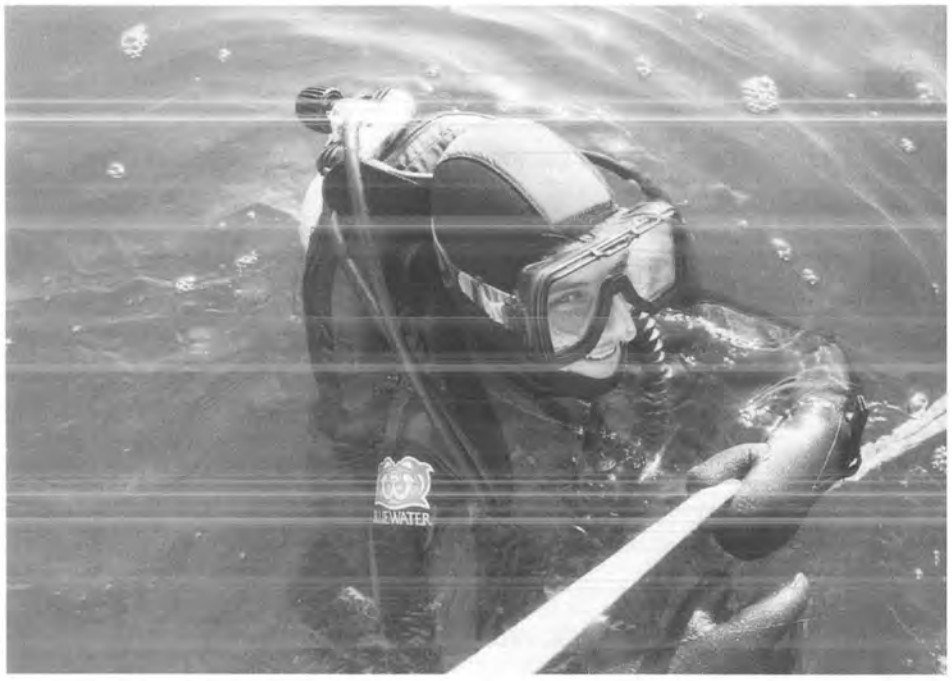
The Center maintains two microcomputing laboratories with IBM PCs and Apple Macintoshes for student use, a remote sensing laboratory with a VAXstation II/GPX, and a graphic lab with a Calcomp 910/563 and Calcomp 907/1051. There is also a terminal lab with four

VT100 CRT terminals and two LA120 hardcopy terminals; a workstation lab with six VAXstation 2000s; and a VAX 8530 minicomputer.

reference room

The newly expanded reference room, under the direction of a professional librarian, has holdings in all the marine sciences disciplines, including important marine science core journals, beginning and advanced books and texts, MSRC Master's theses and doctoral dissertations, MSRC special reports, nautical charts and maps, and a general science reference collection.

Our reference room computer capabilities include the Aquatic Sciences and Fisheries Abstract Database on CD-ROM, STARS (the on-line NOTIS catalog for all of Stony Brook's branch libraries), and the ability to search over 400 international databases through Dialog Information Services. Additional materials for study and research are available at the University main library and in departmental libraries of Earth and Space Sciences, Biology, Physics and Mathematics, and Chemistry.



Stupakoff photo

human resources

professors emeriti

H. H. Carter
J.L. McHugh
Donald W. Pritchard

core faculty

Josephine Y. Aller, Associate Research Professor; Ph.D., 1975, University of Southern California. Marine benthic ecology, invertebrate zoology, marine microbiology, biogeochemistry.

Robert C. Aller, Professor; Ph.D., 1977, Yale University. Marine geochemistry, marine animal-sediment relations.

Henry J. Bokuniewicz, Professor; Ph.D., 1976, Yale University. Nearshore transport processes, coastal sedimentation, marine geophysics.

Malcolm J. Bowman, Professor; Ph.D., 1970, University of Saskatchewan. Coastal ocean and estuarine dynamics.

Vincent Breslin, Research Assistant Professor; Ph.D., 1986, Florida Institute of Technology. Chemical behavior of combustion wastes in seawater; rate and extent of degradation of biodegradable plastics.

V. Monica Bricelj, Assistant Professor; Ph.D., 1984, State University of New York at Stony Brook. Molluscan physiological ecology, benthic ecology.

Bruce Brownawell, Assistant Professor; Ph.D., 1986, Massachusetts Institute of Technology/Woods Hole Oceanographic Institution. Biogeochemistry of organic pollutants in seawater and groundwater.

Edward J. Carpenter, Professor; Ph.D., 1969, North Carolina State University. Nitrogen cycling among plankton and ambient seawater; phytoplankton and zooplankton ecology.

Robert M. Cerrato, Associate Professor; Ph.D., 1980, Yale University. Benthic ecology, population and community dynamics.

Jeng Chang, Research Assistant Professor; Ph.D., 1989, State University of New York at Stony Brook. Phytoplankton physiology and ecology, species-specific growth rates, cell cycle analysis.

J. Kirk Cochran, Professor; Ph.D., 1979, Yale University. Marine geochemistry, use of radionuclides as geochemical tracers; diagenesis of marine sediments.

David O. Conover, Associate Professor; Ph.D., 1982, University of Massachusetts. Ecology of fish, fisheries biology.

Elizabeth M. Cosper, Associate Research Professor; Ph.D., 1981, City University of New York, City College. Phytoplankton physiology and ecology, resistance of microalgae to pollutants.

Robert K. Cowen, Associate Professor; Ph.D., 1985, University of California at San Diego/Scripps Institution of Oceanography. Fishery oceanography, nearshore fish populations, fish ecology.

Nicholas S. Fisher, Professor; Ph.D., 1974, State University of New York at Stony Brook. Marine phytoplankton physiology and ecology, biogeochemistry of metals, marine pollution.

Roger D. Flood, Associate Professor; Ph.D., 1978, Massachusetts Institute of Technology/Woods Hole Oceanographic Institution. Marine geology, sediment dynamics, continental margin sedimentation.

Valrie A. Gerard, Associate Professor; Ph.D., 1976, University of California, Santa Cruz. Marine machrophyte ecology and physiology.

Cindy Lee, Professor; Ph.D., 1975, University of California at San Diego/Scripps Institution of Oceanography. Marine geochemistry of organic compounds; organic and inorganic nitrogen-cycle biochemistry.

Darcy Lonsdale, Assistant Professor; Ph.D., 1979, University of Maryland, College Park. Zooplankton ecology, with special interest in physiology; life history studies.

Glenn R. Lopez, Professor; Ph.D., 1976, State University of New York at Stony Brook. Marine benthic ecology, animal-sediment interactions.

Kamazima Lwiza, Assistant Professor; Ph.D., 1990, University of Wales. Structure and dynamics of shelf-seas and remote sensing oceanography.

James E. Mackin, Associate Professor; Ph.D., 1983, University of Chicago. Geochemistry of suspended sediment-solution interactions.

Steven Morgan, Assistant Professor; Ph.D., 1986, University of Maryland at College Park. Early life history dynamics of marine invertebrates and fishes.

Charles Nittrouer, Professor; Ph.D., 1978, University of Washington, Seattle. Geological oceanography; continental margin sedimentation.

Akira Okubo, Professor; Ph.D., 1963, The Johns Hopkins University. Oceanic diffusion, animal dispersal, mathematical ecology.

Hartmut Peters, Assistant Professor; Ph.D., 1981, University of Kiel, Germany. Small-scale processes such as turbulent mixing; interaction of small- and larger-scale mixing.

Frank J. Roethel, Lecturer; Ph.D., 1982, State University of New York at Stony Brook. Environmental chemistry, behavior of coal waste in the environment, solution chemistry.

J. R. Schubel, Dean and Director; Ph.D. 1968, The Johns Hopkins University. Coastal sedimentation, suspended sediment transport, coastal zone management.

Mary I. Scranton, Associate Professor; Ph.D., 1977, Massachusetts Institute of Technology/Woods Hole Oceanographic Institution. Marine geochemistry; biological-chemical interactions in seawater.

R. Lawrence Swanson, Director, Waste Management Institute; Ph.D., 1971, Oregon State University. Recycling and reuse of waste materials; waste management.

Gordon Taylor, Assistant Professor; Ph.D., 1983, University of Southern California. Marine microbiology; interests in microbial ecology, plankton trophodynamics, and marine biofouling.

Dong-Ping Wang, Professor; Ph.D., 1975, University of Miami. Coastal ocean dynamics.

Peter K. Weyl, Professor; Ph.D., 1957, University of Chicago. Coastal zone planning, physical oceanography, paleoceanography.

Robert E. Wilson, Associate Professor; Ph.D., 1974, The Johns Hopkins University. Estuarine and coastal ocean dynamics.

Peter M.J. Woodhead, Research Professor; B.Sc.Hon. 1 Cl., 1953, Durham University, England. Behavior and physiology of fish, coral reef ecology, ocean energy conversion systems.

Charles F. Wurster, Associate Professor; Ph.D., 1957, Stanford University. Effects of chlorinated hydrocarbons on phytoplankton communities.

Jeannette Yen, Assistant Professor; Ph.D., 1982, University of Washington, Seattle. Marine zooplankton ecology, predator-prey interactions, sensory perception and lipid metabolism of copepods.

Jonathan Zehr, Research Assistant Professor; Ph.D., 1985, University of California, Davis. Molecular aspects of ecology of marine microbes.

joint faculty

Theodore D. Goldfarb
Department of Chemistry, Associate Professor. Chemically induced environmental effects; interactions between science and public policy.

William H. Greene, Division of Infectious Control, Health Sciences Center. Clinical Associate Professor of Medicine. Hospital-acquired infections, including infection prevention methods for health-care workers.

Herbert Herman, Department of Materials Science and Engineering, Professor. Ocean engineering, undersea vehicles, marine materials.

Richard Koehn, Department of Ecology and Evolution, Professor. Evolutionary genetics of natural populations and evolution of physiological variation in marine bivalves and mice.

L. E. Koppelman, Center for Regional Policy Studies, Professor. Coastal zone management, planning, policy studies.

W. J. Meyers, Department of Earth and Space Sciences, Associate Professor. Carbonates, sedimentology.

Sheldon Reaven, Department of Technology and Society, Associate Professor. Energy and environmental problems and issues, especially waste management.

Lawrence B. Slobodkin, Department of Ecology and Evolution, Professor. Theoretical ecology, marine ecology.

Franklin F.Y. Wang, Department of Materials Science and Engineering, Professor. Ocean engineering, ocean structures, energy.

postdoctoral fellows

Christina Barnes
Francisco Borrero
Marie deAngelis, Coastal Marine Scholar
Per Hall
Patrick Hassett
Doreen Monteleone, John M. Olin Postdoctoral Fellow
Joseph Schubauer
Eric Schultz, Coastal Marine Scholar
Tess Present
Tracy Villareal, Coastal Marine Scholar

adjunct faculty

Harold Berger, Director (retired) Region 1, New York Department of Environmental Conservation. Waste management, environmental management.

William Crawford, Institute of Ocean Sciences, Canada. Continental shelf and slope dynamics microstructure; tidal dynamics.

William Eichbaum, Conservation Foundation and World Wildlife Fund. Environmental management.

Paul Falkowski, Brookhaven National Laboratory. Marine phytoplankton ecology and physiology.

Gene Feldman, NASA, Goddard Space Flight Center. Remote sensing, satellite oceanography.

Charles Flagg, Brookhaven National Laboratory. Continental shelf dynamics, acoustical oceanography.

Martin Garrell, Department of Physics, Adelphi University. Physical processes and properties relative to marine environmental problems.

Sarah Horrigan, National Association of Universities and Land Grant Colleges. Marine policy; plankton ecology.

Garry Mayer, National Oceanic and Atmospheric Adminstration. Estuarine processes; marine environmental restoration.

Larry Noonan, Office of the Provost, University at Stony Brook. Management, policy, budgeting, and fiscal analyses.

Joel O'Connor, U.S. Environmental Protection Agency. Environmental assessment, policy, and quality indicators; marine ecology.

Scott Siddall, Kenyon College. Benthic ecology, aquaculture, animal-flow interactions; computer applications to ecological problems.

Sharon Smith, Brookhaven National Laboratory. Plankton ecology, nutrient regeneration by zooplankton.

Dennis Suszkowski, Hudson River Foundation. Estuarine sedimentology; ocean and estuarine policy and management.

Jay Tanski, New York Sea Grant Extension Program. Coastal processes, beach dynamics, shoreline management.

Richard Thomson, Institute of Ocean Sciences, Canada. Coastal oceanography, continental shelf waves, slope currents.

James M. Vaughn, Brookhaven National Laboratory. Transport, fate, and effects of viruses in the aquatic environment.

Mario Vieira, U.S. Naval Academy. Estuarine and coastal dynamics and circulation.

Douglas Wallace, Brookhaven National Laboratory. Chemical oceanography; use of freons as oceanic tracers.

distinguished visiting scholors

Kenneth Bruland, University of California, Santa Cruz
Edward Clifton, Stanford University
Edward Goldberg, Scripps Institute of Oceanography
Barry Hargrave, Bedford Institute of Oceanography, Canada
James O'Brien, Florida State University
Robert Warner, University of California, Santa Barbara
Fred Ziegler, University of Chicago

invited speakers

David Archer, Lamont-Doherty
James Bishop, Lamont-Doherty
Wallace Broecker, Lamont-Doherty
Lewis Calder, Conservation and Ecology Center, Armonk, NY
David Checkley, North Carolina University
Mike Connor, Massachusetts Water Resources Authority
W. R. Crawford, Institute of Ocean Sciences, British Columbia
Eugene Domack, Hamilton College
Dominick DiToro, Manhattan College
Michael DuBow, McGill University
James Eckman, Skidaway Institute of Oceanography
Paul Falkowski, Brookhaven National Laboratory
Wojciech Fialkowski, Jagiellonian University, Poland
Charles Flagg, Brookhaven National Laboratory
Kenneth Foreman, Marine Biological Laboratory
Anne Giblen, Marine Biological Laboratory
Fred Grassle, Rutgers University
Charles Greene, Cornell University
Dale Haidvogel, Rutgers University
Nelson Harison, Jr., Cornell University
Jerry Hilbish, University of South Carolina
Eileen Hofmann, Old Dominion University
Holger Jannasch, Woods Hole Oceanographic Institution
Gary M. King, University of Maine
Lisa Lerin, North Carolina University
Yaeko Masuchi, University of Maryland
James McCleave, University of Maine
Anne McElroy, University of Massachusetts, Boston
Sverre Myklestad, University of Troudheim, Norway
Sergei Ostroumov, Moscow State University
Daniel Repeta, Woods Hole Oceanographic Institution
Young Jae Ro, University of Rhode Island
Peter Sale, University of New Hampshire
Brian Sanderson, Memorial University of Newfoundland
Stephen Schwartz, Brookhaven National Laboratory
Kathryn P. Shah, California Institute of Technology
Edward Sholkovitz, Woods Hole Oceanographic Institution
John Sieburth, University of Rhode Island
R.D. Stephens, California Dept. of Health Service, Berkeley
Rudi J. Strickler, University of Wisconsin
Stephen Threlkeld, Conservation and Ecology Center, Armonk, NY
Jefferson Truner, Southeastern Mass University
Sara Twombly, University of Rhode Island
Karen Wishner, University of Rhode Island
Grace Wyngaad, James Madison University

MSRC Visiting Committee

The Visiting Committee is the Center's primary advisory body. Members provide general advice, guidance, and support for strengthening MSRC's existing plans and programs, as well as undertaking new initiatives.

James Simons, Chairman (effective Fall 1991)
Donald Axinn *
Evelyn Berezin
Nicola Biase
John C. Bierwirth
Hon. Hugh L. Carey
Gerald Cohen
E. Virgil Conway
Aaron B. Donner
Charles Entenmann
George J. Gillespie, III
Edward C. Gunnigle
Helen Hays
Robert Johnson
Nick Karas
Walter B. Kissinger
Abraham Krasnoff *
James Larocca
Homer A. Neal
Ronald J. Oehl *
Gordon Ray
Jeffrey A. Sachs
Rosemary Scanlon
Paul Windels, Jr.

* joined the Committee in 1992

Marine geologist Henry Bokuniewicz discusses how he uses the VAX computing facilities in his research for members of the MSRC Visiting Committee (from L.: James Larocca, Walter Kissinger, MSRC computer facilitites manager George Carroll, Visiting Committee Chairman James Simons, and Rosemary Scanlon. Standing behind Simons is Evelyn Berezin with MSRC Director J.R. Schubel.
▼

Palmer photo

staff

Gina Anzalone, Secretary
Trudy Bell, Editorial Associate
David Berg, Flax Pond Laboratory Manager (Acting)
George Carroll, Manager, Computing Facilities
Carol Case, Secretary
Sheila Charnon, Research Support Specialist
James Christie, Research Support Specialist
Louis Chiarella, Senior Research Support Specialist
Joanne Cosgrove, Secretary
Susan Dunham, Research Support Specialist
Paul Egrie, Research Support Specialist
Amir Ehtisham, Research Support Specialist
Maureen Flynn, Secretary
Eileen Goldsmith, Secretary
John Gordy, Research Support Specialist
Henry Harrison, Electronics Technician
Larry Herschenfeld, Librarian*
David Hirschberg, Senior Research Scientist
Clifford Jones, Facilities Manager
Charles James, Flax Pond Laboratory Manager
Mary Ann Lau, Project Staff Associate
David Lucyk, Ocean Instrument Technician
Kathleen McShane, Research Support Specialist
Michele McTernan, Project Staff Associate
Richard Muller, Research Support Specialist
Christine Murillo, Secretary
Maryanne O'Hare, Research Scientist
Lori Palmer, Director of Graphic Arts
Robert Ranheim, Research Support Specialist
Margaret Reeder, Research Support Specialist
Laura Richardson, Graduate Program Coordinator
William Rizzitello, Research Support Specialist
George Rowland, Flax Pond Laboratory Manager*
Jonathan Salerno, Research Support Specialist
Jeri Schoof, Executive Assistant to the Dean and Director
Christopher Stein, Research Support Specialist
Helmut Stuebe, Research Vessel Captain
Helen Ulreich, Secretary
Barbara Vallely, Staff Assistant
David Van Voorhees, Research Support Specialist
Maryann Wente, Research Support Specialist
Mark Wiggins, Field Specialist
Anne West-Valle, Editorial Associate, WMI
Thomas Wilson, Oceanographic Instrumentation Engineer
Susan Wirick, Research Support Specialist
William Wise, MSRC Associate Director; Director, Living Marine Resources Institute
Qing Xia, Research Support Specialist
Bret Zielenski, Small Boats Captain
Mindy Zimmerman, Research Support Specialist

* deceased

1990-1991 Ph.D. recipients and thesis titles

Ahn, In-Young
Effects of the gem clam, *Gemma gemma*, on the settlement and the post-settlement migration, growth, and survival of the hard clam, *Mercenaria mercenaria*.

Barnes, Christina E.
Uranium geochemistry in marine sediments.

Davies, DeWitt S.
Allocating common property marine resources for coastal aquaculture: a comparative analysis.

Decker, Cynthia J.
The relationship between field distributions and feeding behavior in a marine harpacticoid copepod, *Pseudobradya sp.*

Epler, Nathan A.
A multiple tracer study of shallow groundwater from an unconfined aquifer.

Greene, Richard M.
Physiological responses to high-frequency light fluctuations in the red alga, *Chondrus crispus*.

Jacobson, Myrna E.
Constraints on sulfate reduction in nearshore marine sediments.

Lee, SangHoon
Variation of natural bacterioplankton species compositions studied at the DNA level.

Park, Moon-Jin
Transient tidal vorticity in coastal seas.

Proctor, Lita M.
Marine viruses and the fate of bacteria in the ocean.

Rude, Peter D.
Aspects of the marine geochemistry of fluorine.

Tantichodok, Pitiwong
Relative importance of phytoplankton and organic detritus as food sources for the suspension-feeding bivalve *Mytilus edulis* L., in Long Island Sound.

1990-1991 M.S. recipients and thesis titles

Castro, Leonardo R.
Early life history of bay anchovy in Great South Bay, NY: factors affecting recruitment.

Cenni, Serena
Periodicity of growth line formation in larvae and postlarvae of hard clams (*Mercenaria mercenaria*).

Chant, Robert
The barotrophic tide in the Long Island Sound and its response to a rise in sea level.

Cohen, Melissa
An evaluation of the mechanisms of resistance to PCB in a marine diatom.

Fields, David M.
Outer center limits and inner structure: the 3-dimensional flow-field of *Pleuromamma xiphias.*

Garcia-Esquivel, Zaul
A genetic and numerical approach for assessing the taxonomic status of north Atlantic *Laminaria* of the simplices section.

Green, Mark A.
Carbonate dissolution and temporal abundances of foraminifera in Long Island Sound sediments.

Hamukuaya, Hashali
Changes in fishery landings from the New York Bight, 1978-88.

Henry, Diane L.
Characterization of the light-harvesting complex and isolation of a cDNA clone of the marine chrysophyte, *Isochrysis galbana.*

Hince, Eric C.
Evaluation of mineral indices along the south shore of Long Island.

Hutahaean, Walman
Upper layer circulation in the Banda Sea in response to the onset of monsoon winds.

Lagomarsino, Irma
Evolution of sex-determining mechanisms: the transition from environmental to genetic sex determination across a latitudinal gradient in *Menidia menidia.*

Lee, Byeong Gweon
Trace metal uptake by selected marine benthic organisms exposed to incineration ash residues.

Marks, Richard E.
Ontogenetic shift in the diet of spring and summer-spawned bluefish during the oceanic phase of the early life history.

McShane, Kathleen A.
Acute and sublethal bioassay studies of the effects of incineration residues upon marine organisms.

Merkle, Peter B.
A dynamic simulation model of the atmospheric deposition of semivolatile organic compounds.

Milligan, Allen J.
Factors affecting the occurrence and persistence of the "Brown Tide."

Monaco, Cindy M.
Distribution and foraging behavior of northern gannets (*Sula bassanus*) in relation to wind stress in eastern Newfoundland.

Monetti, Matthew A.
The role of different microbial groups in the oxidation of low molecular weight fatty acids in anoxic marine sediments.

Olha, Joseph
Novel algal blooms: common underlying causes with particular reference to New York and New Jersey waters.

Pohle, David G.
The role of eelgrass, *Zostera marina*, as a refuge from benthic predators for juvenile bay scallops, *Argopecten irradians*.

Ranheim, Robert O.
Methane production in the sediments of the Hudson River estuary.

Schubert, Christopher E.
Observations of infragravity wave motion in a tidal inlet.

Seplow, M. Stacey
The influence of groundwater seepage on the pore water salinity in Great South Bay.

Sosebee, Katherine A.
Life history of a southern population of the Atlantic silverside, *Menidia menidia*, and comparisons with other latitudes.

Vigil, Heidi L.
The fate of dissolved oxygen distribution in Long Island Sound.

Wallace, Heather V.E.
A comparison of hard clam population characteristics between high and low density regions within Great South Bay.

Weissman, Penny D.
The effect of peritrich ciliates on the production of *Arcartia* in Long Island Sound.

Wente, Maryann
Mobility of dioxin from stabilized incineration residue in seawater.

Xia, Qing
A study of water quality in Fish Cove, Long Island.

Yang, Xiaohua
Concentrations and biological uptake of methylamines in marine, estuarine and lacustrine waters.

Young, Randall R.
Prevalence and severity of shell disease among deep-sea red crabs of the Middle Atlantic Bight in relation to ocean dumping of sewage sludge.

Zhu, Ningli
Changes in the flux and composition of amino acids and pigment in particles collected in sediment traps under different preservation conditions.

Zimmer, Robert M.
The importance of the beach as a source of dune sand.

December 1989 M.S. recipients and thesis titles

McTiernan, Lawrence
The erosion potential of fine-grained sediments in Long Island Sound.

Shima, Michiyo
Oceanic transport of the early life history stages of bluefish (*Pomatomus saltatrix*) from Cape Hatteras to the mid-Atlantic Bight.

Wong, Saou-Lien
Nitrate effect on growth and storage of inorganic nitrogen (nitrate) in two different age groups of *Laminaria saccharina* (L) Lamour.

The New York Sea Grant Institute

a cooperative program of the State University of New York and Cornell University

bringing science to the shore

New York Sea Grant Institute provides research funds, educational information, and extension advisory services to New Yorkers and others seeking to understand and wisely use the state's marine and Great Lakes coastal resources. Established in 1966 by an Act of Congress, the National Sea Grant College Program was fashioned after the Land Grant College System, which is designed to conserve and protect land for agriculture and recreation.

The SUNY campus at Stony Brook houses the main offices of the Institute, which oversees the research component of New York's Sea Grant program. Sea Grant Extension Advisory Services are coordinated from the Cornell University campus in Ithaca (with satellite offices on Long Island and in the upstate Great Lakes counties).

New York Sea Grant operates under the guidelines of the National Sea Grant College Program within the National Oceanic and Atmospheric Administration (NOAA). Funded in part by NOAA and in part by New York State, Sea Grant interacts with a number of other federal, state, and local governmental agencies, as well as with nonprofit organizations and private industry.

One important aspect of Sea Grant research projects is that they investigate well-defined problems and opportunities relevant to coastal issues affecting our society today. Sea Grant Extension specialists apply the knowledge gained from Sea Grant funded research to specific problems, helping local government, business, industry, and the general public to increase understanding, assessment, development, utilization, and conservation of our fragile coastal resources.

diverse coasts call for diverse research

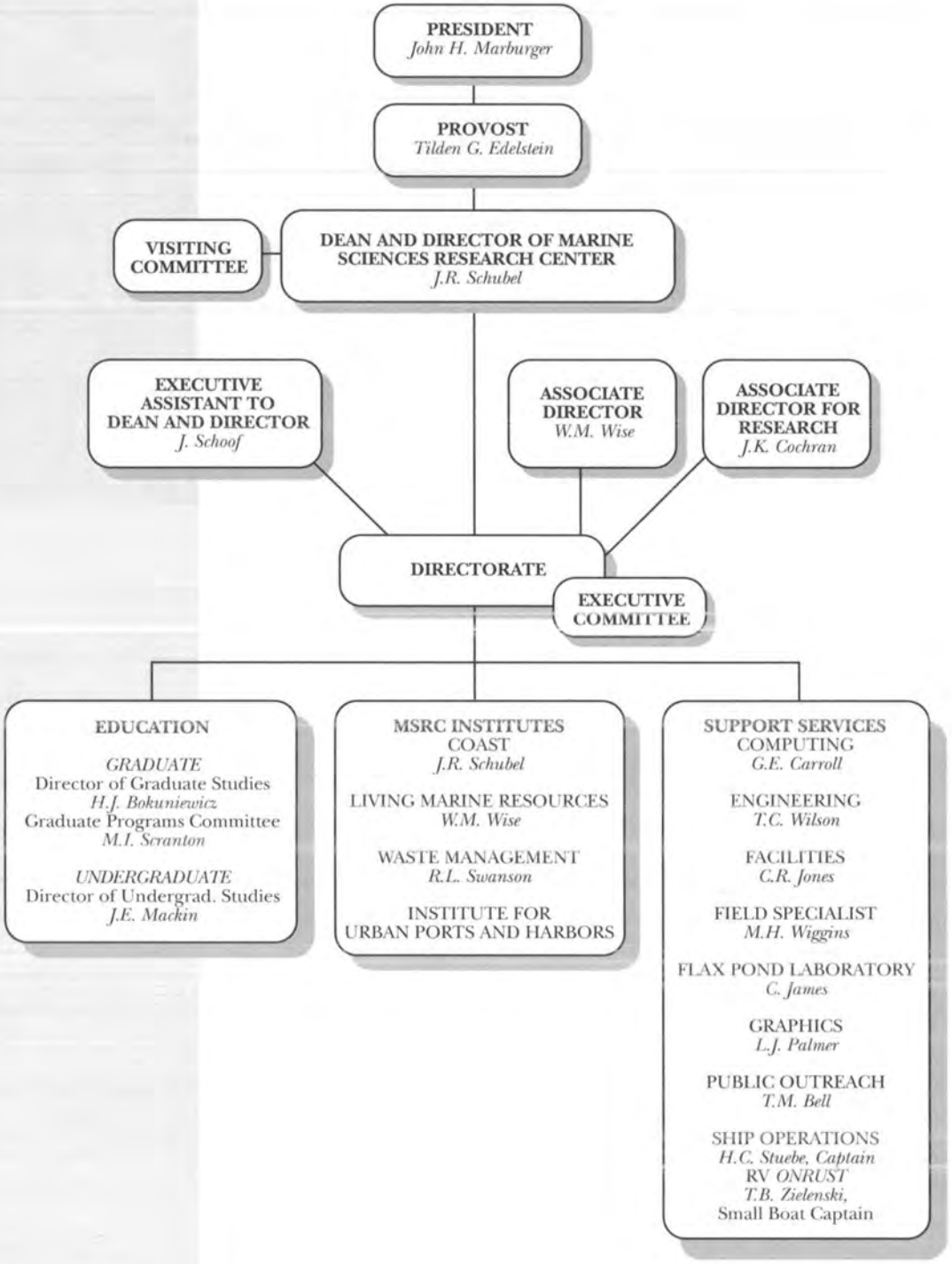
Sea Grant annually funds about 20 research projects throughout New York State, investigating such subjects as marine natural products; diving physiology; fisheries biology and management; aquaculture; seafood safety; factors affecting brown tide; sources and impacts of contaminants in coastal areas; fluid dynamics; and control and mitigation of introduced species such as the zebra mussel.

As part of its commitment to research and education, New York Sea Grant also provides support to Sea Grant Scholars—graduate students who are working toward degrees in the marine sciences, coastal sciences, or related fields. Thirty-four students were supported in 1990 and 33 in 1991.

Rowland photo

▲ *Small scallops that researchers have attached or tethered to artificial eelgrass blades in a Sea Grant funded project.*

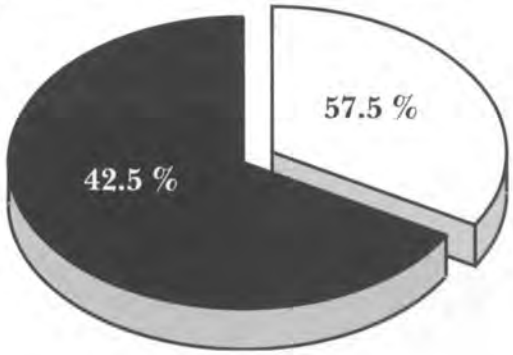
organizational chart



finances

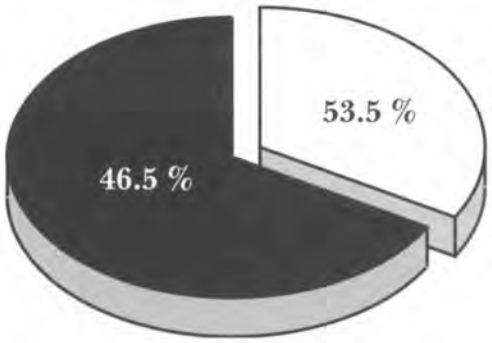
Marine Sciences Research Center Biennial Expenditure Level
Sponsored Research vs All Other Funds 1990, 1991

Total Expenditures $ 6.7 Million



1990

Total Expenditures $ 7.0 Million

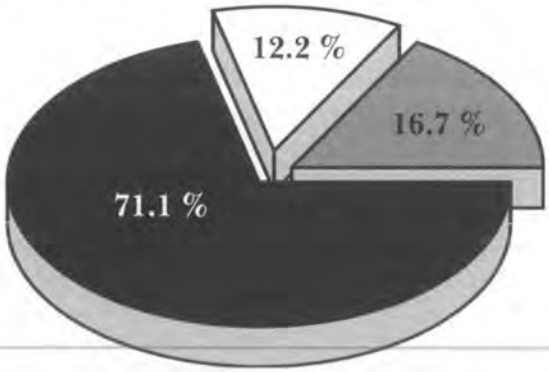


1991

☐ Sponsored research expenditures ■ All other funds expenditures

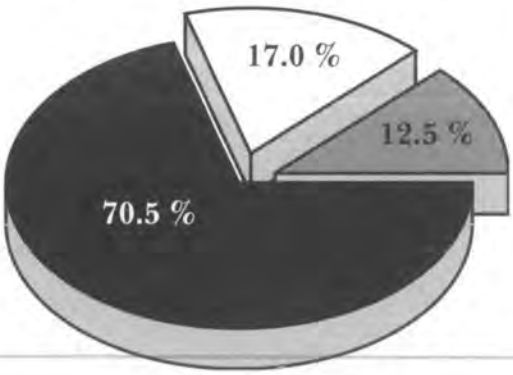
Marine Sciences Research Center Sponsored Research
Expenditures By Source of Funds 1990, 1991

Total Sponsored Research $3,977,868



1990

Total Sponsored Research $3,749,176



1991

■ Federal ■ State, County and Local Governments ☐ Private

in memoriam

Ralph George Rowland
(1941 - 1990)

On December 4, 1990, the MSRC community lost a colleague and friend, R. George Rowland. George began his career at MSRC in 1972, after graduating *cum laude* from Stony Brook the prior year. For the next 13 years, he worked in increasingly important capacities on a series of research projects, principally in the laboratory of Dr. Charles Wurster, examining the impacts of halogenated hydrocarbons on marine phytoplankton assemblages. During 11 years, he coauthored 17 scientific papers. In 1985, George was appointed as manager of the Center's Flax Pond Marine Laboratory, where he served with distinction until his death.

George made many significant contributions to the Center's research and educational programs. A master of advanced techniques in cell biology, he was always willing to share his skills with graduate students and others. At the Flax Pond Laboratory, he instituted important improvements of the research facilities, making the lab a more productive and attractive place to conduct research. George's skills and aesthetic sensitivity were also evident in the many photographs of nature that he took—slides and prints he used to illustrate his lecture-tours for school children visiting Flax Pond and those MSRC used to enhance its publications. Many photos in our last Biennial Report, as well as in this one, were George's.

To his work, George brought competence, a commitment to excellence, and a strong sense of professional responsibility. To our lives, he brought warmth, friendliness, and an unassuming dignity that was recognized and respected by all who knew him.

Lawrence Herschenfeld
(1947 - 1992)

Larry Herschenfeld became the MSRC's first reference room librarian in 1990. His dedicated efforts these past few years have resulted in a remarkable transformation of those facilities. He organized and added to the existing collection over several hundred books, numerous subscriptions to oceanographic journals, and electronic access to abstract database systems, dialog searching, and interlibrary loan.

Before he received his masters degree in library science from the C.W., Post campus of L. I. University, Larry was a successful accountant. But he later found his true calling in a blend of two of his loves, library science and the oceans, applying his librarian skills to serve MSRC.

Larry felt that by learning more about marine sciences, he could serve MSRC better as a librarian. He immediately began taking oceanography courses through the Continuing Education Division, and planned to take all the core MSRC courses, starting with biological oceanography this coming fall.

Larry had many dreams for the continued development of our reference room, but his premature death at age 45 left many of these dreams unrealized. An aid and a friend to MSRC in his short tenure here, he will be truly missed. We will continue building the reference room where he left off.

Constructive

You take a rock, your hand gets hard.
You raise your eyes and there's a pair
of small beloveds, caught in pails.
The monocle and eyepatch correspond.

You take a glove, your hand is soft.
The ocean floor was done in lizardskin;
around a log or snag
the surface currents run

like lumber about a knot. A boat
is bent to sea: we favor the medium
we're in, our shape's around us: shape
takes time. At night,

the bed alive, what teller of truth
could tell the two apart?
Lover, beloved; hope or command;
your hand is given, when you take a hand...

— Heather McHugh