Making the Most of Sea Grant's Investment in Massachusetts

STRATEGIC PLAN

1998-2004

Sea Grant
Woods Hole

Woods Hole Oceanographic Institution

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Steve Heaslip, *Cape Cod Times*

WHOI Sea Grant Program
Woods Hole Oceanographic Institution

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Table of Contents

Sea Grant
Woods Hole

In order to sustain gains in science funding, any increases now or in the outyears must be justified with a coherent, long-term science policy that is fiscally responsible.

The real challenge for Congress and the science community is to make wise science investments and increase the priority of R&D funding relevant to other domestic programs.

Chairman F. James Sensenbrenner, Jr.
Committee on Science
March 20, 1998

Preface

The National Sea Grant College Program, created in 1966, is dedicated to increasing the understanding of the marine environment and promoting the sustainable use and development of marine resources for public benefit. Sea Grant supports research, advisory, and educational activities consistent with these goals.

In its 30-year history, the Sea Grant network has grown to encompass more than 200 universities and other marine organizations that work within a core of 29 Sea Grant colleges and institutions. Sea Grant is part of the National Oceanic and Atmospheric Administration (NOAA).

In November 1995, the national program office completed a planning document, *Sea Grant's Network Plan, 1995-2005,* that identified priority research issues and opportunities for the decade. The areas of research emphasis were entitled Economic Leadership, Coastal Ecosystem Health and Public Safety, and Education and Human Resources.

The Sea Grant Program at the Woods Hole Oceanographic Institution (WHOI) has developed a program plan to address local, regional, and national issues and opportunities over the next several years. The plan identifies marine-related issues of importance, institutional resources, and potential partnerships in the Commonwealth of Massachusetts. In order to continue a successful history of developing collaborative, interdisciplinary research programs, ideas were solicited from the Marine Outreach Guidance Group (see Appendix A for members), and other coastal scientists, managers, regulators, business and environmental group representatives. Consideration was given to scientific merit, degree of community concern, relevance to the National Sea Grant College Program goals, opportunity for interagency collaboration, and degree of public benefit. In addition, issues and opportunities were assessed on the basis of their relevance to other agency goals and strategic plans.

The program plan, *Making the Most of Sea Grant's Investment in Massachusetts*, represents the collective concerns of the Massachusetts marine community at all levels. It is intended to highlight important marine issues and research needs, suggest investigative approaches to resolving these issues, our outreach objectives, and, perhaps most importantly, to serve as a catalyst for creative thinking and identifying new opportunities. The plan is intended to guide the program over the next two proposal cycles. The implementation process is designed to be sufficiently flexible to adjust to changing opportunities and to respond to imaginative ideas.

The Commonwealth of Massachusetts

The Commonwealth of Massachusetts is one of the smallest states in the United States with only 8,257 square miles of total area. It is also the third most densely populated state in the U.S. with a 1990 census of over 6 million people. Thus, it represents a microcosm of many national and global issues with respect to conflicting uses and pressures on coastal ecosystems. The coastline of Massachusetts extends 1,500 miles and includes extensive wetlands, tidal flats, and salt marshes, totaling 12 percent of the land-mass. The Massachusetts coast is one of the most valuable natural and economic resources of the Commonwealth, providing jobs, transportation, and recreation to both citizens of Massachusetts and visitors. There are twenty-seven distinct watersheds within Massachusetts and critical issues related to the protection of these watersheds include wise planning of both land and aquatic resources.

Despite its small geographic size, the Commonwealth of Massachusetts has many diverse communities—cities, colonial villages and native American settlements, historic mill towns, and rustic farmlands. The rich cultural and economic history of the Commonwealth is well reflected in these present-day communities. The economic base of these communities is equally diverse. Central and western Massachusetts have replaced many traditional manufacturing operations with new industries, such as biotechnology and fiber optics development. The northeastern region of the state has seen a transition from the textile mills located on the banks of the Merrimack River to a center for the high-technology electronics industry. The greater Boston area is a center of educational institutions, financial service companies, medical centers as well as advanced technology centers. Southeastern Massachusetts, including Cape Cod and the islands of Martha's Vineyard and Nantucket, is the center of marine science related industries, including marine instrumentation, fishing, aquaculture, and tourism.

All economic indicators for 1996 and 1997 show a strong economy for Massachusetts, with the highest development capacity of the large industrial states and the best technology-related resources and workers in the nation (*1996 and 1997 Development Report Card for the States,* Corporation for Enterprise Development). Some of the factors that contribute to the strength of the Massachusetts economy include:

- Strong Educational and Research Capabilities—There are 120 public and private colleges and universities located in Massachusetts.

In this, the Year of the Ocean, the Sea Grant Program at the Woods Hole Oceanographic Institution plays a vital role in understanding and protecting our marine environment. Through research, outreach, and educational activities, the Sea Grant Program is developing new approaches to better understand and manage ocean resources through local, national and international partnerships.

John Kerry, *U. S. Senator, Massachusetts*

Sandra MacFarlane

AQUACULTURE

Aquaculture, the farming of freshwater and marine animals and plants, is poised to become a significant player in the aquatic food and products industries worldwide. Though the U.S. aquaculture industry lags behind that of many other countries, it is advancing due, in part, to decreasing harvests in wild fisheries and improvements in culture technologies, and disease, predator, and pollution control strategies. These advances boost the probability of aquaculture's success as a business. One of the biggest deterrents to further aquaculture industry growth in the U.S. is a lack of knowledge and understanding of the industry by regulatory and financial agencies that oversee, guide, and fund these developing businesses.

The need to educate the regulatory agencies and financial institutions is apparent. And, though the industry has the expertise to provide the information, it does not have the experience or mechanisms in place to transfer its knowledge to those in need. Sea Grant Extension, however, can serve as the link between the information held by the industry and the needs of the regulatory and financial interests. Sea Grant programs throughout the network have and will continue to serve as clearinghouses for the latest information on aquaculture, ranging from research on culturing techniques to the development of low-cost, high-impact drugs and the administration of those drugs for diseases.

Continued next page

- Highly Skilled Workforce—Massachusetts leads the nation in the number of adults with college degrees and ranks second in the nation in the percentage of residents with advanced degrees in science and engineering.
- Leading Positions in Emerging Technologies—Massachusetts companies are leaders in the developing fields of biotechnology, electronics and communications, and environmental technologies.
- Successful Industry Clusters—As described above, different regions throughout the Commonwealth are focused on the development of new industries and specific clusters serve as "magnets" for emerging industries in photovoltaic applications, biotechnology, environmental technologies, and marine science.

Jeffrey Adams

Marine science related industries are a prominent component of the Massachusetts economy, especially in southeastern Massachusetts, Cape Cod and the Islands, the areas most directly served by WHOI Sea Grant. These industries include fisheries, aquaculture, electronics, marine instrumentation, tourism, biotechnology, and environmental technologies. Many of these industries are in transition as we prepare to enter the twenty-first century. Traditional wild-harvest fisheries, such as cod and haddock, have declined in recent years, and have led to the development of new approaches to fisheries management, alternative species for wild harvest, and expanded opportunities in aquaculture. The decline in the defense industry has been replaced by interest in developing technologies for environmental remediation and expanded opportunities in biotechnology.

Economic Value Per Year of Some Marine-related and Other Industries in Massachusetts

(figures do not reflect associated economic multipliers)

Industry/Activity	Economic Value/Year (Most Current Data Available)	
Tourism	$ 1,000.5	Million (1990)
Recreational Fishing (overall economic impact)	$ 524.6	Million (1996)
Recreational Fishing (angler expenses only)	$ 496.	Million (1996)
Agriculture	$ 440.	Million* (1996)
Forest Products	$ 240.	Million (1995)
Commercial Fishing	$ 231.	Million (1996)
Mining (sand and gravel)	$ 42.5	Million (1996)
Aquaculture	$ 8.6	Million (1994)
Construction	$ 3.5	Million (1996)

* *Cranberries account for 20% of this total*

Sources: *Massachusetts Economic Assessment Report (1996), except for Recreational Fishing data, courtesy of Vishwanie Maharaj, American Sportfishing Association*

Tom Kleindinst, WHOI

Locally, these connections have been initiated through the development of an outreach program by the WHOI Sea Grant Extension Program, in collaboration with agencies from Barnstable County and the Marine Biological Laboratory in Woods Hole. One of the first projects undertaken by this collaborative effort, the "Aquaculture for Regulators" course, enrolled regulators from 11 of the 15 towns on Cape Cod as well as representatives from three educational institutions and two representatives from financial institutions or agencies. The course was a highly successful outreach effort for WHOI Sea Grant: feedback from those attending, as well as industry members who were teaching, indicated that the information provided in the course was exactly what was needed to advance the understanding of aquaculture within regulatory and financial arenas. Efforts are currently underway to organize this course for other regions throughout the northeast and the U.S.

Woods Hole Oceanographic Institution

The Woods Hole Oceanographic Institution (WHOI) serves as the home of WHOI Sea Grant. WHOI is the largest independent oceanographic research laboratory in the world. In 1927 a National Academy of Sciences (NAS) committee concluded that it was time to "consider the share of the United States of America in a worldwide program of oceanographic research." WHOI was established in 1930 with a grant from the Rockefeller Foundation following the recommendations of the NAS committee. Most of the Institution's current operating budget of $90 million is supported by federal research grants, awarded through a competitive process.

Terri Corbett, WHOI

Most of the Institution's investigators are based in five science departments—Applied Ocean Physics and Engineering, Biology, Geology and Geophysics, Marine Chemistry and Geochemistry, and Physical Oceanography. Economists and other social scientists at WHOI's Marine Policy Center assess current national and international oceanic issues, serving as a link between public policy and scientific research.

WHOI recently signed a memorandum of understanding with NOAA to establish a Cooperative Institute for Climate and Ocean Research at the Institution. The institute will focus on three theme areas: coastal ocean and nearshore processes, the ocean's participation in climate and climate variability, and marine ecosystem processes analysis. This agreement should build upon the existing WHOI/NOAA relationship that WHOI Sea Grant has fostered to support, among other things, coastal and fisheries-related projects.

WHOI Sea Grant Program

The WHOI Sea Grant Program began as a Coherent Program in 1973 with a budget of approximately $200,000. During the early years of the program, it was almost exclusively research-based. In 1985 the program achieved Institutional Program status, with a balance of research and outreach activities at a level of 60 percent/40 percent, respectively. Only within the last decade has the program assumed the traditional Sea Grant approach:

the Marine Advisory, or Extension, component was restructured in 1990, and a stand-alone Communications, Public Outreach, and Education program was introduced that same year.

The major goal of the WHOI Sea Grant Program is to bring the Institution's human and physical resources to bear on the objectives of the National Sea Grant College Program, to support the nationwide Sea Grant Network, and to help the nation in development and conservation of its marine resources. Its benefits to WHOI are reflected in the unique integration of science and outreach activities, the large number of WHOI Sea Grant-supported publications (more than 600 publications during the 25-year history of the program), and the wide range of marine extension services and communications programs provided locally and regionally.

Many of the issues that impact the WHOI Sea Grant Program mirror key issues for Sea Grant programs in other coastal states:

- Increasing pressure on coastal resources due to rising coastal population
- Increasing coastal development
- Conflicts between private ownership of the coast and public access
- Recreational demands of the increasing coastal population (boating, fishing, shellfishing, beaches)
- Tourism
- Pollution
- Declining natural fisheries and exploration of alternative fisheries
- Development of aquaculture
- Natural shoreline change (through storms, erosion, coastal processes)
- Human-induced coastal change (alteration of the shoreline for recreational or development purposes)

Because WHOI Sea Grant cannot address all of these issues effectively on its own, the program staff pay close attention to see which of these issues are being addressed by the region's regulatory agencies, organizations, and private programs. In numerous cases, WHOI Sea Grant has joined forces with other groups to address specific research, technology, and outreach issues or problems. The ability to form such collaborations is one of the greatest strengths of our program. They help us leverage our federal funding and increase the scope and impact of our core efforts.

The national document *Sea Grant's Network Plan, 1995-2005* focuses on three major portfolios—Economic Leadership, Coastal Ecosystem Health and Public Safety, and Education and Human Resources. Within these portfolios are major strategic initiatives in advanced technology for commercial products, seafood production, coastal economic development, coastal ecosystem processes, public safety, technology transfer, and public

WHOI's Sea Grant Program has had a major impact on the ability of our scientists and students to initiate and sustain very important projects which other Federal agencies do not sponsor. It has been a remarkable success with respect to the science produced and the communications of the results through public outreach.

Robert Gagosian, *Director*
Woods Hole Oceanographic Institution

outreach. Consistent with the goals of the national strategic plan, WHOI Sea Grant is implementing its strategic plan within four major theme areas:

- Fisheries and Aquaculture
- Environmental Technologies
- Estuarine and Coastal Processes
- Outreach, Education and Human Resources

Selection of these themes and implementation of the plan involves input from several different academic and advisory groups. Identification of major themes is the result of input from the academic research community in the Commonwealth of Massachusetts through our formal proposal solicitation process in addition to workshop participation and consensus building with management agencies. Our Marine Outreach Guidance Group (MOGG) reviews these themes and associated activities. Final approval and revision of the implementation plan is the responsibility of our Senior Advisory Board.

Tracey Crago, WHOI Sea Grant

Within the Sea Grant network, the WHOI Sea Grant Director meets and communicates as appropriate with the other New England Sea Grant Directors on opportunities and issues of mutual interest. Through our Sea Grant Marine Extension Service and MOGG we have continuing interactions with state, county, and local shellfish agencies and associations, and with selectmen and natural resources personnel in local towns. Several of our projects are based on local or regional resources and will provide information of direct use to local groups in addition to scientific generalizations of national, international and/or disciplinary significance.

Dale Leavitt, WHOI Sea Grant

Throughout the evolution of Sea Grant at WHOI, the program has addressed scientific challenges and emphasized research, technological, and educational opportunities for the Commonwealth of Massachusetts, the northeast region of the U.S., the nation, and, in some cases, developing countries. The role of the WHOI Sea Grant program, like that of the national Sea Grant network, is, in a very broad sense, to link marine and scientific research results to various audiences in ways that benefit the user community. Sea Grant provides a critical link between the academic, research community and business/industry, other federal agencies, and the many diverse groups that make use of Sea Grant resources. The WHOI Sea Grant Program considers its ability to network and form important partnerships its strongest attribute. Our partners include other research institutions, funding agencies, interest groups, citizen volunteers, educators, students, and policy makers.

HARMFUL ALGAL BLOOMS (HABS) RESEARCH: STEADY SEA GRANT SUPPORT FOR A GROWING GLOBAL PROBLEM

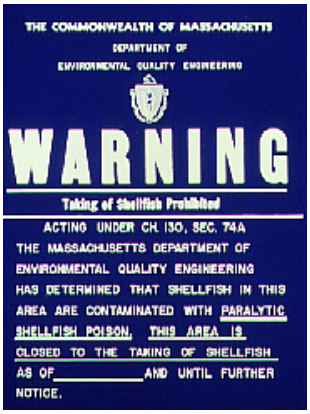
Harmful Algal Blooms (HABs) is a relatively new term used to describe a proliferation, or "bloom," of single-celled marine algae called phytoplankton. Once more commonly referred to as "red tides," these blooms occur when the algae photosynthesize and multiply. While there are thousands of phytoplankton species, only a few dozen are known to be toxic. However, because phytoplankton serve as the base of the marine food web, the impact of these blooms can be devastating for consumers throughout the food web and for other marine flora or fauna in the affected ecosystem. Even blooms of non-toxic species can spell disaster for marine animals since the massive quantities of phytoplankton deplete the oxygen in the shallow waters where most phytoplankton blooms occur.

Recently, the world's coastal waters have experienced an increase in the number and type of HAB events. This is especially true in the United States, where virtually every coastal state is now threatened, in some cases by more than one species.

As to the causes of this trend, scientists say the jury is still out. Possibilities range from natural causes (species dispersal) to human-related causes (nutrient enrichment, shifts in global climate, or transport of algal species by ship ballast water).

The species of marine phytoplankton that cause HABs—and their effects—vary dramatically. While some are toxic only when concentrations reach high densities, others can be toxic at very low densities (only a few cells per liter). Whereas some blooms discolor the water (thus the terms "red tide" and "brown tide"), others are undetectable by even highly sensitive satellite imagery techniques designed to pick up color differences.

The effects of HABs generally fall into two major categories, public health and ecosystem effects and economic impacts. In each category, the outcomes can be devastating.



WHOI

HAB research has been taking place for over two decades. One source of funding that has remained constant throughout the years is the National Sea Grant College Program. Sea Grant's research support, along with a recent influx of federal support from other NOAA agencies and NSF, has seen and will continue to see, better understanding of HABs.

Sea Grant HAB research, to date, has focused primarily on the following:

- Physiology and Behavior of Individual HAB Species and Toxins
- Causes of HABs
- Predicting or detecting the occurrence of HABs and their toxins

Unfortunately, due to the complexities of the individual species and the fact that identical species can behave differently region-to-region or under different environmental conditions, there remain many more questions than answers.


Don Anderson, WHOI
Excessive algae at Nahant Beach.

In 1995, a national, multi-agency research agenda was initiated to increase the understanding of impacts and population dynamics of HABs. The program, called ECOHAB (ECology and Oceanography of Harmful Algal Blooms), is supported by the National Oceanic and Atmospheric Administration (NOAA), the National Science Foundation (NSF), the Environmental Protection Agency (EPA), and the Office of Naval Research (ONR), and is administered by NOAA's Coastal Ocean Program and the National Sea Grant College Program.

Until recently three areas of HAB research have gone largely unexplored, at least in the U.S.:

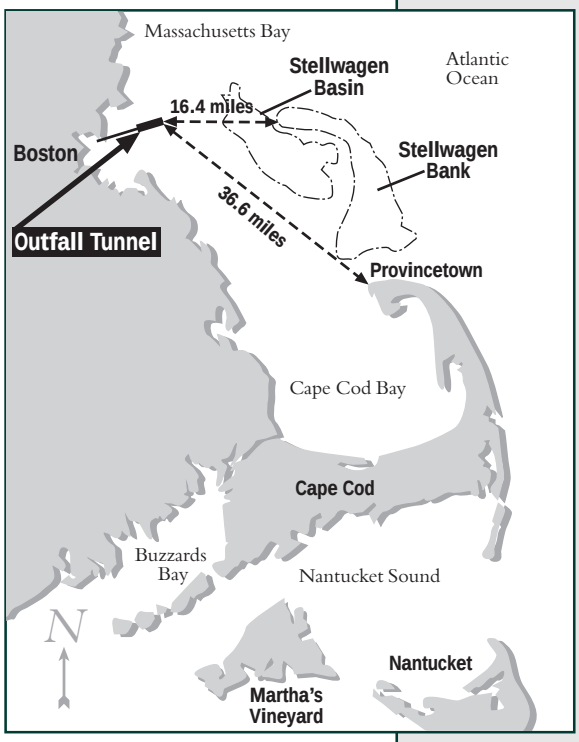
- Management Options for Reducing the Incidence of HABs
- Control of HABs
- Reduction in Economic and Resource Loss and Human Health Risks Associated with HABs

These areas are now the focus of a NOAA initiative aimed at guiding federal, state, and local policy in dealing with the growing problem of HABs.

Continued support from Sea Grant and other funding sources is critical if researchers are to solve some of the many mysteries associated with HABs and to focus efforts on new areas such as those listed above.

SEA GRANT'S LONG TERM RESEARCH COMMITMENT IN MASSACHUSETTS BAY ASSISTS WITH CONTROVERSIAL SEWAGE OUTFALL DEBATE

Since the time of the Boston Tea Party during the American Revolution, Boston Harbor has received a wide range of society's wastes. This history culminated in political debates during the 1988 presidential campaign designating Boston Harbor as the "Harbor of Shame" and the dirtiest harbor in the country. Decades of debate on the best approaches to clean up Boston Harbor resulted in decades of inactivity in solving the emerging water quality and sediment quality problems. In 1985 the Massachusetts Water Resources Authority (MWRA) was created to modernize water and sewer services in the metropolitan Boston area and to spearhead the cleanup of the harbor. Forty-three communities are served by the MWRA sewage treatment facilities. To bring Boston's waste treatment facility into compliance with the Federal Clean Water Act, a court order was issued that mandated specific milestones for the construction of new wastewater treatment facilities. At a cost estimated at $3.5 billion, the Boston Harbor Project includes new primary and secondary sewage treatment plants and a 9.5-mile, 24-foot diameter tunnel that will discharge treated effluent into Massachusetts Bay. Construction of new treatment facilities began in 1989 and will be completed in 1999. Improvements in water quality have already been noted in Boston Harbor, especially with the cessation of sludge dumping in the inner harbor. Some examples of improved conditions include lower levels of contaminants discharged to the harbor, beaches open for swimming, and a more diverse benthic community.



Location of Outfall Tunnel.

The new outfall will be completed in the fall of 1998 and effluent will then be discharged at the Massachusetts Bay site. When the offshore outfall was initially proposed, many questions were raised by local communities on the potential impacts of effluent discharge in the relatively pristine waters of outer Massachusetts Bay and Cape Cod Bay. Some of these concerns included potential for eutrophication and harmful algal blooms, altering food chain dynamics—especially in feeding grounds for the endangered right whale—and relocating contaminants from Boston Harbor to the shores of Cape Cod.

Sea Grant Funds Baseline Data Collection

To address the concerns identified above, WHOI Sea Grant supported several investigations, beginning in 1992, directed at a better understanding of the potential effects that discharges from the new outfall may have on Massachusetts and Cape Cod Bays:

Circulation Studies

Multidisciplinary studies focusing on the circulation in Massachusetts Bay began in 1993. Circulation in the Bay influences the transport of nutrients and other contaminants across the thermocline, the boundary that separates a warm water layer from a cold water layer. Using dye tracer studies to examine the movement of water masses and quantify dilution rates, the vertical mixing of the water column in the vicinity of the outfall site was examined under different environmental conditions.

Results of the first vertical mixing study in Massachusetts Bay revealed a much lower estimate of vertical mixing across the thermocline than was anticipated by the researchers, based on seasonally averaged mixing rates in the bay. This lower rate was determined to be indicative of the pronounced stabilizing influence of stratification, or layering of the water, even in the presence of strong internal tidal motions.

These data were then incorporated into numerical models of the Bay to gain a better understanding of the nutrient dynamics of the Bay and to predict the fate of the effluent, which will be discharged below the thermocline and may be mixed into the upper layer, where it could contribute to excessive phytoplankton production. This study suggested that the rate of transfer is small enough that there should not be excessive vertical exchange.

The first study of mixing in the middle of the Bay prompted a second dye study to look at mixing along the boundary region of Massachusetts Bay. This study yielded important informa-

tion about the predominant water movement in summer conditions—and thus the fate of pollutants introduced at the outfall—a concern to many residents of the South Shore and Cape regions. Results of this study indicate that there is not a dramatic increase in mixing in the near-shore region, but the mixing is enhanced enough that boundary mixing makes a significant contribution to the bay-wide exchange. These results are good news for communities southeast of the outfall, where residents expressed concerns about increased pollutants from the outfall.

These Sea Grant studies complement ongoing activities by the MWRA and the U.S. Geological Survey to provide an independent assessment of environmental concerns.

WHOI

Collecting samples of red tide.

Nutrient Studies

Nutrient enrichment in the offshore environment of Massachusetts Bay and Cape Cod Bay raises concerns for the long-term effects of the effluents on the ecological conditions of these waters including the potential for the increased frequency of harfmul algal blooms and altered food chain dynamics. Ongoing efforts supported by WHOI Sea Grant are focused on understanding the dynamics of toxic dinoflagellate blooms in Massachusetts Bay. Recurrent episodes of Paralytic Shellfish Poisoning (PSP) caused by blooms of the dinoflagellate *Alexandrium* have been reported for this area and pose serious human health, ecological and economic concerns for the region. The PSP toxin can be passed along the food chain and present serious problems for high level consumers including humans and marine mammals. Intensive field efforts are being conducted now to establish baseline conditions before the outfall is "on-line." Once the outfall goes on-line, field sampling will continue to examine nutrient conditions, bloom frequency, and the transfer of PSP toxins through the food chain. In addition, a comparative analysis of twenty-five years of monitoring data for PSP in shellfish populations from coastal embayments will be conducted to develop a statistical model of pre-outfall variability in shellfish toxicity.

Additional studies are directed at examining the benthic processing of sewage inputs into Boston Harbor and offshore waters in Massachusetts Bay. One study confirmed that sewage material does enter marine food webs and that stable isotopes can be used to trace the input of sewage. The study used a dual tracer approach—nitrogen and sulfur stable isotopes—which proved to be especially valuable in Boston Harbor, where both inorganic nutrients and sewage particulates are released. Another study gathered baseline data for Boston Harbor and Massachusetts Bay with regard to benthic oxygen consumption, nutrient release, and denitrification. The cold, deeper waters of Massachusetts Bay tend to stratify, or form layers, thus presenting an environment that may handle sewage-derived nutrients differently than other, previously studied environments. Results from that study revealed that Massachusetts Bay sediments may play a significant role in the nitrogen budget of the bay, removing 25% of the anthropogenic nitrogen entering the bay. The absolute rates of denitrification in Boston Harbor were higher than in the bay, but only remove about 12% of the anthropogenic nitrogen inputs to the harbor because of the much higher nitrogen loading to the harbor. These results could be of use to many coastal communities involved in developing nutrient loading bylaws.

Future Research Studies

When effluents are discharged from the offshore outfall beginning in the fall of 1998, citizen groups will carefully review the results of monitoring programs to ensure that effluents are adequately diluted and adverse conditions do not occur. The MWRA has developed an action plan that identifies key environmental parameters and threshold values that, if exceeded, will require remedial action by MWRA. WHOI Sea Grant will continue to support investigations on fundamental processes in the offshore habitats of Massachusetts and Cape Cod Bays that may explain the natural variability in ecosystem parameters and help explain the trigger points of post-outfall effects.

Note: Additional research in Massachusetts Bay has been supported by MIT Sea Grant and the Massachusetts Bays Program.

A COASTAL EROSION CASE STUDY

Coastal erosion is a natural geological process. It may take place slowly over thousands of years or it may occur dramatically, as with landslides or severe storms. Coastal erosion rates can be accelerated by sea level rise. In the Cape Cod region of Massachusetts, relative sea level is rising at the rate of 10-12 inches per century. Coastal areas of Cape Cod are dynamic systems: barrier beaches and dunes migrate inland as sea level rises, bluffs erode and supply sediment for barrier beaches.

Historically, homes and other structures have been built on dynamic systems which naturally migrate as sea level rises or as wave action erodes the coast. Coastal engineering structures built to protect threatened homes can impede the movement of sand. As a result, coastal dunes and barrier beaches are lost and can no longer buffer coastal areas from storms.

Graham Giese, WHOI Sea Grant

This photo illustrates the slumping of a coastal bluff on the Cape Cod Bay shore of Truro as a result of undercutting by winter storm waves.

As a case in point, consider the Beach Point area of Truro, located along the Cape's inner shore. This area, where the majority of commercial businesses are located, was built on a barrier beach. It is dependent on erosion from coastal bluffs to the south for nourishment. Without sand deposition from the eroding bluffs to the south, many properties on Beach Point would be lost.

Dr. Elazar Uchupi, a WHOI geologist, and Dr. Graham Giese, coastal processes and hazards specialist with WHOI Sea Grant, have recently been studying the geologic depositional and erosional history of the bluff area that serves as the source for Beach Point sand.

The study has shown that the long term erosional rate for the bluffs in the source area averages less than 0.5 foot/year or less than 50 feet/century. While this sounds fairly insignificant, consider that the pattern of erosion is not uniform. Many residents and summer homeowners develop a sense of security when property they have owned for decades has not eroded significantly. However, when the bluffs do erode, they erode much more than 0.5 foot/year; this often catches the homeowners unprepared. The work of Uchupi and Giese suggests that the bluffs may erode 10-15 feet over a two to seven year period and then remain relatively stable for another 40-50 years. If the timing and severity of these erosional events could be predicted, homeowners could be given information on which to base decisions regarding their property; for example, moving structures back from a bluff which is likely to erode in the near future.

In the course of measuring erosional rates of the Truro bluffs facing Cape Cod Bay, Uchupi and Giese have been able to identify characteristics that seem to distinguish non-eroding areas from areas which are eroding or cutting: the cutting areas have lower bars in front of them in Cape Cod Bay than the non-eroding areas. Non-eroding areas have dune terraces protecting them. Though more study is needed, the information could help scientists understand where erosion is cutting away the bluffs and why it is cutting. Such information could then be used to help property owners predict the timing and reduce the economic costs of losses.

If relative sea level continues to rise and if global warming leads to increased severity of weather patterns and storms, coastal residents of Cape Cod and other similar regions can anticipate more rapid erosion of coastal bluffs and shorelines—including locations where homes presently stand.

There is both an obligation to protect our coastal ecosystems and to maintain their sustainability, and an obligation to assist coastal homeowners in protecting their homes in ways that are compatible with coastal processes. By minimizing the number of homes sited in the "danger zone" in the future, costs to society can be reduced. The present work on Truro's Cape Cod Bay shore may provide the basis for evaluation of erosional and depositional patterns in other locations.

Cooperation among federal, state, and local regulatory bodies is required to address the complex issues of coastal erosion and coastal hazards. WHOI Sea Grant has and will continue to assist these agencies in evaluating coastal hazards and to provide technical assistance to address the problems of coastal erosion.

BUILDING RELATIONSHIPS WITH COASTAL DECISION MAKERS

Recognizing the importance of providing unbiased research results and outreach information to coastal decision makers, WHOI Sea Grant recently organized an open house as a way to informally connect with legislators and their staff, and others involved with coastal decision making and management.

Titled "Marine Science and Technology in Woods Hole," the by-invitation event featured informal posters and exhibits highlighting some of the hot topics in marine science, including those especially relevant to Massachusetts. Attendees enjoyed a light breakfast while making their way through the WHOI Visitor Center's permanent exhibits and those created for the event.

Several Sea Grant-funded researchers were on hand to discuss their work. Research posters included: Harmful Algal Blooms, Molecular Effects of Contamination in Whales, Development of Genetic Markers for Bay Scallops, Clams: Keeping an Industry Alive, Genetic Diversity and Reproductive Behavior of Squid, Coastal Decision Making for the Long-term, and Chemicals in the Marine Environment and their Effect on Marine Birds.

Outreach posters and exhibit topics included hurricanes, the illegal harvest of berried female lobsters, a general WHOI Sea Grant display, shellfish habitat, and coastal landform sustainability.

Attendees left with informational packets created for the event, featuring a new series of fact sheets called "Focal Points," WHOI Sea Grant's 1998-2000 Program Guide, and several other articles and flyers. A local horticulturist donated strands of 'Cape' American beachgrass, which was handed out along with an informational card about the beachgrass, its origin and use, and instructions on how to plant it.

The open house provided an important first step toward WHOI Sea Grant's goal of establishing stronger connections with the coastal decision makers of Massachusetts.

Dave Gray, WHOI

State senator Therese Murray and her assistant, Rick Musiol (left), discuss a poster with Graham Giese, WHOI Sea Grant's coastal process specialist, at the open house.

Dave Gray, WHOI

Massachusetts Congressman William Delahunt shown here with WHOI Director Robert Gagosian, in front of the R/V Atlantis.

Sea Grant funding has allowed us to study critical aspects of reproduction as they impact management of the valuable—but fully exploited—New England squid fishery. By studying sexual selection mechanisms of squids, we can begin to determine if targeted fishing of spawning squids has a negative impact on the degree of gene mixing and subsequent recruitment in this very short-lived species.

Roger Hanlon, *Director*
Marine Resources Center
Marine Biological Laboratory

Development of Strategic Plan

The major theme areas of the WHOI Sea Grant Strategic Plan have been identified by three distinct mechanisms:

- Solicitation of research ideas from the academic community and selection of those ideas that best represent scientific excellence and that meet the goals of the National Sea Grant Strategic Plan;
- Through our interactions with our advisory groups, identification of potential products and outreach mechanisms for transfer of information, especially within the context of the management and information needs of the Commonwealth of Massachusetts, in particular southeastern Massachusetts; and
- Interaction with state and federal agencies to transfer technical information into the development of new policies and practices. In each theme area, research progress and application of results determine the identification of milestones.

A. Fisheries and Aquaculture

The southeastern Massachusetts region is the home of the fishing port of New Bedford, the largest fishery port on the U.S. east coast. In addition, the region also consists of a large number of smaller fishing ports, including Chatham, Woods Hole, Rock Harbor, Sandwich, Scituate, Provincetown, and Plymouth. This region of Massachusetts is also the focal point for all of the Commonwealth's marine aquaculture industry, focused primarily on the rearing of two bivalve species, the quahog *(Mercenaria mercenaria)* and the American oyster *(Crassostrea virginica)*. In terms of economic impact, the combined annual income of the fishing industry to this region of Massachusetts was approximately $114 million in 1996 or about 50% of the total Massachusetts landings (see Table, p. 3). For aquaculture products, the regional income was $4.5 million in 1995 or about 53% of the total Massachusetts income. WHOI Sea Grant has identified both the following as priority areas that fit within the capacity of the academic and research environment in the region served by our program: revitalizing our nation's fisheries and the development of sustainable aquaculture. It is our belief that these two priority areas are very closely linked technologically and culturally within New England and thus we are approaching these areas as a unified and coordinated effort. The program elements include:

- Development of technology and programs to promote stock enhancement of natural fish and shellfish resources, including mechanisms to evaluate the efficacy of enhancement programs and the overall effectiveness of such programs;
- Investigation of larval recruitment processes for fish and shellfish and development of means to understand the relationship between recruitment and physical and chemical characteristics of the environment;
- Application of molecular and other biotechnological tools for application to fisheries and aquaculture problems and to enhance current rates of sustainable production;
- Evaluation of models for predicting future trends in natural resource stocks and projecting future production in natural and controlled aquaculture systems;
- Advancement of aquaculture technology through the investigation of new candidates for cultivation and new technologies for increasing commercial production of cultured species;

- Investigation of disease processes in marine organisms with an emphasis on prophylactics and management of diseased stocks to minimize economic losses to the natural fisheries and aquaculture industries;
- Development of training programs to advance technical knowledge in the industry and to educate the general public, legislators, researchers, and regulators on fishery and aquaculture issues; and
- Promotion of business and industrial development through expanding efforts in coastal management and through understanding of the economics of marine related businesses.

Implementation of the strategic plan in Fisheries and Aquaculture has been underway for three years. WHOI Sea Grant currently supports at least one research project in each of the above areas and is developing training workshops and publications to transfer the information to the user community. The efforts of WHOI Sea Grant closely intersect with the efforts of Barnstable County on aquaculture issues. The SouthEastern Massachusetts Aquaculture Center (SEMAC) was recently formed as part of the Commonwealth's Strategic Plan in Aquaculture. This regional aquaculture center is one of four throughout the Commonwealth of Massachusetts designed to serve as experiment stations, synonymous with the agriculture industry experiment station. Dr. Dale Leavitt of the WHOI Sea Grant Extension Program, working in cooperation with the Barnstable County government and the Cape Cod Cooperative Extension, has been closely involved with the formation and operation of SEMAC. Among his contributions to the Center are:

- Editing the newsletter *Blue Horizon,*
- Assisting in the development of promotional materials for the aquaculture industry in Massachusetts,
- Initiating and maintaining nine Aquaculture Resource Centers at libraries throughout southeastern Massachusetts,
- Generating Technical Bulletins on technologies relevant to the regional aquaculture industry,
- Providing resources and expertise for site assessment/evaluation and disease diagnostic services to the local aquaculture industry,
- Organizing and lecturing in technical workshops on aquaculture technologies for the local industry.

I would like to acknowledge WHOI Sea Grant's contributions to the development of shellfish aquaculture in southeastern Massachusetts. The establishment of the Sea Scallop Working Group and the SouthEastern Massachusetts Aquaculture Center (SEMAC) are in part a result of WHOI Sea Grant's vision and commitment to the development of the local aquaculture industry. The scientific expertise, networking skills, and boundless energy of the Sea Grant staff have been significant factors in the success of these organizations.

Richard Karney, *Shellfish Biologist/Director, Martha's Vineyard Shellfish Group, Inc.*

Tom Kleindinst, WHOI

I wish to extend my sincere thanks for lending me the collection of videos related to the coastal environment. The videos, many of which were Sea Grant productions, did a superb job in portraying the broad range of concerns surrounding man's impact on the coastal environment and served as excellent focal points for discussions.

The students in my class are majoring in Marine Safety and Environmental Protection and therefore may well apply the information they acquired from these videos to their future professions.

Alan White, *Associate Professor, Massachusetts Maritime Academy*

B. Environmental Technologies

Coastal ecosystems in southeastern Massachusetts are subjected to many of the same perturbations as other coastal ecosystems:

- Eutrophication
- Habitat modification
- Hydrologic and hydrodynamic disruption
- Exploitation of resources
- Toxic effects of chemical contaminants
- Introduction of non-indigenous species
- Global climate change and variability
- Shoreline erosion and hazardous storms
- Pathogens and toxins affecting human health

In addition to the problems listed above, two Superfund sites are located within the drainage basins of coastal habitats of southeastern Massachusetts. These are:

(1) the Massachusetts Military Reservation, where groundwater contamination threatens drinking water supplies, cranberry harvests, and coastal habitats in several communities on Cape Cod; and

(2) New Bedford Harbor, where PCB (polychlorinated biphenyl) inputs have contaminated sediments, fish and shellfish resources.

Both areas are targeted for remediation in the near future. Because of these activities, public awareness and public concern for environmental problems in coastal ecosystems are very high within local communities of southeastern Massachusetts. In response to these and a wide range of other environmental problems, an Enviro-Tech Center has been located at the Massachusetts Military Reservation. The center fosters the development of innovative technologies by the private sector and encourages partnerships with educators and students to explore educational and economic opportunities associated with environmental technologies. In addition, academic programs are beginning to focus on training students for career opportunities in environmental technologies:

Terri Corbett, WHOI

- Massachusetts Maritime Academy has implemented a four-year degree program in Environmental Sciences for maritime cadets;
- University of Massachusetts-Dartmouth and University of Massachusetts-Boston have expanded their course offerings in environmental sciences and engineering;
- The MIT-WHOI Joint Program in Oceanography has developed a Masters of Engineering Program in Environmental Management;

- Cape Cod Community College is exploring the development of a two-year Associates Degree in Environmental Technologies;
- The Upper Cape Cod Regional Vocational-Technical School recently established an environmental technology/aquaculture program at the secondary level.


Tom Kleindinst, WHOI

It is very appropriate for WHOI Sea Grant to facilitate the interactions necessary to form partnerships to fully develop environmental technologies as an educational and economic opportunity for southeastern Massachusetts. The Environmental Technology theme is focused on:

(1) the initiation of research projects that will develop and deploy innovative technologies to address specific problems in coastal ecosystems; and

(2) the development of extension and outreach activities to foster information transfer and education about the development of new monitoring and treatment technologies.

The WHOI Sea Grant Program in Environmental Technology is based on three components:

- Marine biotechnology, including the development of molecular markers for understanding contaminant effects in the environment and probes for application to ecological processes;
- Remediation technologies, including the development of new approaches to understanding the degradation of contaminants in the environment; and
- Remote technology for monitoring the marine environment.

These components compliment two portfolios within the national strategic plan—Economic Leadership and Coastal Ecosystem Health and Public Safety—by integrating product development leading to a better understanding and prediction of contaminant fate and effects in coastal and estuarine environments. Our current program includes the following elements:

- Development of species-specific probes based on unique genetic or immunological properties and applied to identification of larval dispersal and recruitment patterns of commercially important shellfish stocks, early detection of harmful algal blooms, early detection of disease in fish and shellfish, and examination of genetic diversity in fish and shellfish stocks;
- Application of molecular biology to understanding the effects of organic contaminants on reproduction and development of aquatic species, including fish, marine birds and marine mammals;
- Elucidation of cellular mechanisms of toxicant exposure as sensitive biomarkers of organism response and adaptation to environmental perturbations; and
- Development of predictive models that integrate analytical approaches for identifying contaminant distribution and effects in coastal environments with management approaches for reducing the input and impact of contaminants in the environment.


Peter Wiebe, WHOI

We will continue to solicit new ideas in this theme area, particularly with application to an understanding and management of contaminated harbors.

SHELLFISH DISEASES AND THEIR CONTROL IN THE LOCAL WATERS

Shellfish harvesting, both commercial and recreational, wild and farmed, represents an industry generating in excess of $11 million dollars for the Cape Cod region within the Commonwealth of Massachusetts. One of the important issues with respect to maintaining healthy, harvestable shellfish resources in state waters is the identification and control of potential disease infestations in the shellfish populations. This is particularly true with respect to three diseases that are unique to two important commercial shellfish species, MSX and dermo in the American oyster, and QPX in the quahog.

Dermo (named after the original scientific name of the infecting organism Dermocystidium, now called Perkinsus) and MSX (multinucleated sphere unknown) are both single-cell parasites that invade the oyster's soft body, grow and divide within the tissue, and eventually overwhelm the normal metabolic processes in the shellfish resulting in death of the individual. The combination of these two diseases has devastated the oyster industry in the Chesapeake Bay area and now is slowly moving up the Atlantic coast. MSX was first identified in Massachusetts approximately 15 years ago; dermo was identified in Massachusetts in the early 1990s.

The most recent discovery of a shellfish disease in Massachusetts was made in 1995. A new parasite, it has been infecting and killing both wild and cultured Massachusetts quahogs since at least 1992, but most likely even before then. The disease is known as QPX (quahog parasite unknown). Although the organism differs from the parasites infecting the oyster, the QPX parasite acts in a similar way to dermo and MSX and generally results in the death of the hard clam. QPX was first observed in New Brunswick, Canada in 1969. Since its discovery in Massachusetts, QPX has been found in Virginia (1996) and New Jersey (1997).

Tom Kleindinst, WHOI

Hematopoietic neoplasia is a leukemia-like disease that affects the soft-shell clam, Mya arenaria*. WHOI Sea Grant supported research on the transmission of the disease from diseased clams to healthy clams.*

In the cases of MSX, dermo, and QPX, it is unlikely that shellfish populations will naturally rid themselves of the diseases or that any attempts to eradicate them will succeed completely. Instead, it appears that shellfish managers will need to work around them. One way to do this is for managers to incorporate monitoring programs into their management plans. Aquaculturists, on the other hand, may be able to control the impact of such diseases by incorporating subtle changes into their shellfish husbandry practices.

Research into improved husbandry techniques and other methods for improving survival rates for diseased shellfish populations, has been supported in large part by the National Sea Grant College Program (NSGCP) and Sea Grant research taking place in individual states. Since 1990, the NSGCP has sponsored a national initiative focused on oyster disease research, and more recently, an initiative to address oyster disease concerns in the Gulf Coast states. As a result, significant break-throughs have been made in our understanding of oyster diseases and how to control or manage around them.

Because QPX is a relatively new problem facing shellfish growers and harvesters, the research response, thus far, has taken place at a fairly local level. On Cape Cod, for example, QPX was identified by WHOI Sea Grant Extension personnel working in conjunction with a research veterinarian and quahog farmers from Provincetown. In response to the high mortality rates in Provincetown's cultured quahog population, the WHOI Sea Grant Program responded immediately, contributing emergency response funds that permitted Woods Hole marine biologists and pathologists to identify the disease organism. Only after that was accomplished could resource managers and farmers attempt to minimize the impact of the disease on their quahogs.

Since that time, WHOI Sea Grant and other agencies, including the Commonwealth of Massachusetts, have continued to fund research directed at understanding and controlling QPX. To date, the disease has been brought into the laboratory and can be grown in culture in the laboratory and outside of the quahog, a vitally important first-step in studying any new disease organism. In addition, efforts are underway to develop and test strains of quahogs that will be resistant to the QPX parasite. This was done successfully with oysters that are resistant to MSX.

As is the case in agriculture or human health management, disease research is a never-ending process. As disease organisms change and evolve, scientific research programs must adapt so that methods to counteract the devastating impact of disease may be developed.

SEA GRANT RESEARCH AIDS LOBSTER INDUSTRY

On average, 15.3 million pounds of lobsters are landed in Massachusetts each year, representing an economic value of approximately $64.5 million.[1] While these numbers have remained fairly steady over the last decade, the National Marine Fisheries Service has classified the lobster fishery as "overexploited." They are being harvested as fast as they reach legal size, many without the opportunity of reproducing. What might this mean for the fishery down the road? Fewer lobsters, say biologists.

It is a fact that less than one-tenth of 1 percent of hatched lobster eggs will survive to legal size, which takes, on average, seven years in Northeast U.S. waters. Of the lobsters that make it to legal size, an estimated 90 percent are caught the same year that they become "legal"—in many cases before they ever reproduce. At this rate, only 10 percent of the inshore lobster stock is available for replenishing the species. Illegal harvesting practices have the potential of reducing this number even further.

The illegal practice of "dipping" berried female lobsters involves dipping them into a solution of chlorine bleach and seawater to remove the eggs, and virtually all evidence that there were eggs. The stronger the concentration of bleach, the faster the egg-binding cement breaks down; however, a solution that is too strong will kill the lobster. "Dipping" allows the lobsters to be sold as "clean," or non-egg-bearing.

With WHOI Sea Grant and other support, two researchers, Dr. Robert Bullis, an aquatic veterinarian at the Marine Biological Laboratory, and Mike Syslo, director of the Massachusetts State Lobster Hatchery, developed a stain test to determine if a female lobster was scrubbed. It works like this:

A swimmeret clipped from a suspect lobster is placed into a test vial containing a potassium-iodide solution. If the solution turns yellow, the lobster has tested positive for chlorine. The test is quick, easy to administer, portable, and inexpensive, and has met favorably with fishery managers and law enforcement.

Recently, Massachusetts enacted a law that increases the fines for illegally harvested lobsters, including "dipped" female lobsters. With the stiffer fines and new detection test, lobsters may finally have a way to get even with dishonest fishermen.

[1]Source: National Marine Fisheries Service and Massachusetts Division of Marine Fisheries

The key to conservation and intelligent use of marine resources is to have a fundamental understanding of the function and interactions of marine organisms and systems. Sea Grant funding has allowed us to pursue some basic questions concerning comparative biochemistry of marine organisms; this research is helping us understand how these organisms interact with chemicals they encounter in their environment.

Mark Hahn, *Associate Scientist, Biology Department, Woods Hole Oceanographic Institution*

Mike Syslo, Massachusetts Lobster Hatchery

This photograph shows a "berried" female lobster. A typical 1-pound female lobster can carry between 8,000 and 12,000 eggs, while a mature lobster can carry up to 80,000 eggs. Prior to being extruded and carried externally for nine to 11 months, female lobsters carry their eggs internally for nine months. Eggs are about the size of the head of a pin.

Funding from the WHOI Sea Grant Program was essential to my thesis work. This funding supported the development and application of a stable isotopic approach for tracking land-derived nitrogen into estuarine food webs. Results from Waquoit Bay, Massachusetts, show that stable nitrogen isotope ratios in estuarine biota record increasing contributions of anthropogenic nitrogen to estuaries. Anthropogenic N is detectable in estuarine biota at relatively low N loads. Hence, this approach shows promise as a means for detecting incipient eutrophication. Future Sea Grant funding will be used to define the general applicability of a stable isotopic approach for detecting incipient eutrophication in aquatic systems.

James McClelland
Boston University Marine Program, Marine Biological Laboratory

C. Estuarine and Coastal Processes

Estuarine and coastal processes, whether physical, chemical or biological, are especially complex due in large part to the susceptibility of estuarine and coastal waters to forcing by adjacent marine, terrestrial and meteorological systems. At the same time it is those waters that lie in the immediate vicinity of the coast—coastal ponds, estuaries, and embayments—that are most impacted by society's commercial, recreational, and residential activities. In recent years, the rate of development in southeastern Massachusetts coastal communities, especially on Cape Cod and the Islands, was among the highest rate of increase within the Commonwealth of Massachusetts. For example, the population of Barnstable County (Cape Cod) increased by 26 percent from the period 1980 to 1990, compared with a statewide increase of only 5 percent during the same decade. Other threats to coastal communities include sea-level rise, conflicts between private ownership of the coast and public access, and recreational demands of the increasing coastal population (boating, fishing, shellfishing, beaches).

Research supported within this theme is often multidisciplinary and directly interfaces with the management community that must make regulatory decisions on the proper stewardship of coastal ecosystems. Some examples of current efforts include:

Studies of circulation patterns in Massachusetts Bay with applications to the impacts of the proposed outfall from the City of Boston;

- Nutrient management in coastal ponds on Cape Cod and Nantucket;
- Sediment transport processes with application to understanding coastal erosion and sustainability of coastal landforms;
- Comparative assessment of flushing rates in estuaries;
- Ecosystem level measurements of denitrification in estuaries;
- A stable isotopic approach for early detection of wastewater nitrogen in estuarine food webs.

Our coastal hazards outreach effort is directed at integrating a scientific understanding of the processes that maintain coastal landforms with the management concerns arising from the effects of these processes on coastal towns. That was the subject of the Sea Grant

Vincent De Witt, *Cape Cod Times*

A WHOI Sea Grant-funded study of Cape Cod coastal residents, led by researchers at WHOI's Marine Policy Center, used a survey to determine the relationship between level of knowledge and perceived flood risk. Investigators found that effective communication about flood risk among scientists, policy makers, and the public was an influential factor in respondents' willingness to pay (WTP) for flood insurance.

"Many important policy decisions are made in order to prevent potential future catastrophe, such as that caused by severe storms or hurricanes," commented Yoshiaki Kaoru, the study's lead investigator. "Risk perceived by the public can significantly influence policy decisions."

workshop "Coastal Landform Management in Massachusetts" that took place in October, 1997.

The two-day "Coastal Landform Sustainability in Massachusetts" workshop consisted of four invited presentations addressing issues of:

(1) shoreline change: a coastal landform management dilemma;

(2) managing inner shores;

(3) managing altered shores; and

(4) monitoring changes in sustainability.

Each presentation was followed with a breakout session where all participants in the workshop were presented with a management scenario that required their input to effect a solution or recommendation for remediation. Each session ended with group presentations of majority and minority opinions that were brought back from each breakout group to the full workshop for discussion. The format of the workshop allowed all of the participants to assume the various roles of landowner, coastal resource manager, commercial or recreational user, and public rights advocate and to attempt to negotiate an action that imposed a minimal impact on the sustainability of the coastal landform. The proceedings of the workshop are currently being edited for publication.

As a follow-up to the workshop, Dr. Giese, in partnership with the Cape Cod Commission, will develop a schedule with four participating pilot project communities to present the project and offer training sessions to each town's Conservation Commissions and Planning Boards. They will arrange meetings with each of the participating towns to explain the process for quantifying the impacts of local decision making on coastal landforms and to review the checklists developed for tallying positive and negative impacts. After several months, the progress of each town will be evaluated. A meeting of representatives from each participating town will take place periodically to examine and compare results, revise procedures as necessary, and to plan for the next phase of the project. It is expected that the second phase of this project will include a conference or workshop for community and state representatives to discuss expansion of the project into other areas of coastal Massachusetts.

Pamela Truesdale

This mangled pedestrian bridge, located on the Shining Sea Bikeway along Falmouth's shoreline, illustrates the dramatic impact of August 1991's Hurricane Bob.

On behalf of the Friends of Sengekontacket Barrier Beach Task Force, thank you for being a guest teacher in David Faber's class on May 11th. As you could see, the eight grade students participating in the beach profiling project on State Beach have a lot of enthusiasm and motivation to understand beach processes. Your ability to establish rapport with this age group and help them refine their measuring techniques created a very exciting learning environment. To be able to present the data they had collected to an expert validated their beach profiling efforts.

Christina Miller, *Chair*
Friends of Sengekontacket,
Martha's Vineyard

Stacy Shafer

The objectives of our program in coastal landform sustainability are to:

- Quantify, on a town-by-town basis, the gains and losses of Cape Cod coastal landform sustainability resulting from decisions of local resource management agencies;
- Identify the state and local policies and/or administrative procedures (or lack thereof) that have resulted in these gains and losses; and
- Review progress and recommend improvements in maintaining coastal landform sustainability at regularly scheduled regional meetings.

Other outreach efforts include written documents and oral presentations concerning the nature of coastal processes and means by which individuals and society can minimize the hazardous consequences of those processes. An example is our contribution to the Coastal Floodplain Task Force, organized by the Massachusetts Office of Coastal Zone Management. The product of this work, "Scientific Recommendations for Performance Standards for Land Subject to Coastal Storm Flowage," was submitted to the Commissioner of the Department of Environmental Protection in July, 1995.

D. Outreach, Education and Human Resources

At WHOI Sea Grant, outreach and education activities figure prominently in the management of the program. These activities are carried out by the Extension and Communications programs within WHOI Sea Grant's management structure. Together, they serve as the primary conduit for dissemination of Sea Grant supported research results. Outreach strategy decisions are based on our identification of the research and information needs of our constituencies, along with careful planning and input from our advisory groups, Institution directorate, and guidance from the National Sea Grant Office. Many different outreach vehicles are employed to address our diverse audiences and users.

In addition to his position as Extension Leader and Sea Grant's aquaculture specialist, Dale Leavitt, in the fall of 1997, assumed the position of technical director of SEMAC within the Cape Cod Cooperative Extension Service. This shared responsibility enhances WHOI Sea Grant's cooperation with the regional and state government. Along with Graham Giese, the Extension coastal processes specialist, they coordinate the technology and information transfer activities undertaken by WHOI Sea Grant. Both are members of the program's management team.

Tracey Crago, as leader of the WHOI Sea Grant communications effort, is also a member of the program management team and a member of WHOI's administrative staff,

which affords principal investigator status and responsibilities including oversight of budgets and staff management. Sheri DeRosa, communications and program assistant, provides general program administrative support, coordination of proposal review process, oversight of office volunteers, database management, and publication distribution.

Within Massachusetts, outreach staff members work with their counterparts at MIT Sea Grant to design a cohesive and organized approach to serving the needs of the state. At the regional level, the WHOI Sea Grant outreach staff members work closely with colleagues from the five other northeast Sea Grant programs to establish regional approaches to developing messages and projects that fit in with the themes of the respective programs. To maintain involvement at the national level, the staff is encouraged to participate in national committees, working groups, task forces, and strategic planning meetings.

Currently, Leavitt and Giese are members of the New England Regional Extension group and Leavitt serves on the National Sea Grant Extension Assembly's Program Committee. Crago serves as the northeast region's elected representative to the National Sea Grant Communications Steering Committee and is active in a number of working groups as well as the national communications strategic planning process. Crago also represents the WHOI program as its educational point of contact and is involved in the development and implementation of the Sea Grant Marine Educators' strategic planning process. DeRosa is a member of the Exhibits and Events subcommittee of the national communications steering committee.

The goal of the WHOI Outreach, Education and Human Resources component is active and effective dissemination of Sea Grant information, research, and technology. By reaching out to audiences in an attempt to answer questions, increase environmental awareness, improve science literacy, and bridge the gap between marine research and an informed and knowledgeable public, the Sea Grant outreach effort is making significant contributions to citizens and organizations within the Commonwealth as well as the Northeast region and the nation.

The WHOI Outreach program also strives to increase the visibility of WHOI Sea Grant and the Sea Grant regional and national networks. Recognizing that within these networks exist countless resources, we believe that promoting and publicizing these resources to our user groups is essential. The increased networking capability afforded by Internet, e-mail, and efforts of network extension, communications, education groups, the National Sea Grant office, and Sea Grant's National Media Relations Office enhances our capacity to showcase Sea Grant locally, regionally, and nationally.

Specific objectives of the Outreach, Education and Human Resources program during the next five years, in keeping with the aforementioned goals, are listed below. These goals are meant to complement the outreach efforts already mentioned within the Fisheries and Aquaculture, Environmental Technologies, and Estuarine and Coastal Processes sections of this document.

Thank you for all the information you gave me regarding pollution. You will be happy to know that I got third place in my science fair. The judges said my project was excellent. Once again, thanks for all your help.

Justin Demers, *Elementary School Student*

I just received your new joint MIT/WHOI newsletter,* Two if by Sea.** ***It really got my attention and I immediately read it from cover to cover. I think this new newsletter is the best Sea Grant public information publication I have ever seen. It is absolutely great.

Dean Horn, *former Director MIT Sea Grant College Program*

Thanks for the nice letter regarding the "Oceans Alive" talk. I actually enjoyed giving the lecture and appreciate your kind words. This kind of public series is really needed to reach the local community, and I realize what a lot of work it is to carry off—thanks to Sea Grant.

Brad Butman, *Former Chief Branch of Atlantic Marine Geology, U.S. Geological Survey*

Just wanted to say thank you once again for an enjoyable morning on Saturday. I appreciate all the effort that goes into planning an event that comes off so smoothly, and gives the appearance of being no trouble at all! I think everyone had a really terrific time. The Coastweeks program is a wonderful concept and you should feel proud of your part in making it such a success.

Cyndy Chandler, *Information Systems Associate, Marine Chemistry & Geochemistry Department, Woods Hole Oceanographic Institution*

(1) To disseminate the results of Sea Grant-supported research to audiences through a variety of vehicles, including: newsletter and magazine articles, development of educational classroom activities for formal and informal educators, ecotours, workshops, scientific publications, Sea Grant-sponsored list-servers for our constituents, Marine Extension Bulletins, "Focal Points" fact sheets (printed and Web-based), and news releases, to name a few.

(2) To satisfy our current audiences by continuing—and improving as necessary—our successful outreach efforts, including our annual "Oceans Alive" public lecture series, annual Coastweeks events, publications such as *Nor'easter* magazine and *Two if by Sea* (the joint WHOI/MIT Sea Grant newsletter), the *Directory of Cape and Islands Coastal Outreach Organizations* (updated annually and also available online), our Web site, the "Sea Urchins" summer marine science program for children ages 5-7, the widely distributed WHOI Teacher Packet, and our Sea Grant exhibit at the WHOI Visitor Center.

(3) To reach out to new audiences by hosting, sponsoring, or producing new events or programs that showcase applications of marine science and technology. For example, we would like to expand our interactions with industry, some of which began in 1994 with the Marine Biotechnology initiative sponsored by the NSGO and during the researching of *Marine Science Careers: A Sea Grant Guide to Ocean Opportunities*. Year of the Ocean (1998), development of the national Sea Grant marine careers web site, workshops, and the "Oceans Alive" lecture series, are vehicles we will use to facilitate these interactions.

Tracey Crago, WHOI Sea Grant

(4) To make our program a more utilized source of non-biased, accurate, and relevant marine scientific information for Massachusetts policy makers, regulators, and legislators. In doing so, WHOI Sea Grant will be able to make significant contributions to the state that will last for generations. We plan to team up with organizations that have proven success in dealing with these audiences, including local chapters of the League of Women Voters.

(5) To increase our support of teacher and student education at the K-12, undergraduate, and graduate level by: sponsoring a marine communications intern, annual support of a summer teacher fellow at WHOI, providing research support for graduate students, sponsoring programs that enable educators to earn continuing education credits, and continuing to

SEA GRANT MARINE CAREERS WEB SITE

The marine sciences are an attractive and popular career choice for many students. While students often picture themselves working with marine mammals, the reality is that very few marine scientists specialize in this area. Today's marine scientists pursue a great variety of wide-ranging careers, developing and utilizing the latest technology to address problems or issues that face our marine resources.

Many of these diverse career options are highlighted in *Marine Science Careers: A Sea Grant Guide to Ocean Opportunities,* first published in January 1996. This comprehensive, 40-page guide to careers in marine biology, oceanography, ocean engineering, and related fields takes readers right to the source, featuring question-and-answer profiles of 38 marine scientists and other professionals.

Thus far, two press runs of *Marine Science Careers* have resulted in over 25,000 copies in circulation. Each of the 29 Sea Grant programs participated in one or both of the press runs, as did a number of other marine-related organizations. Funds from a private foundation made it possible to send a free copy of the guide to each of the 4,926 high schools in the 21 non-coastal states. The foundation was so pleased with the effort that they sent an additional $15,000 contribution to WHOI Sea Grant, unsolicited, in 1997.

A portion of these funds will be used to support a national Sea Grant web site devoted to marine science careers, a successful proposal in National Sea Grant College Program's 1997 Outreach National Strategic Investments. The web site will feature an introduction and overview of the site, descriptions of the various disciplines of marine science, profiles of 'role models' in each discipline, a Q&A section, a resources section describing opportunities (such as internships, fellowships, etc.), additional information (books, videos, web sites), and organizations to contact, information about Sea Grant, and salary information for a wide range of jobs in the public, private, and government sectors. Interactive, "add-on" features such as career day planning information, on-line slide shows featuring a 'day-in-the-life-of-a-marine biologist' and related themes, and on-line movies portraying life on a research vessel or field studies will be later additions to the site.

work with the Sea Grant Educators, Massachusetts Marine Educators, the National Marine Educators Association, and the National Science Teachers Association.

(6) To build upon our program's leadership role as a provider of marine science careers information, by expanding on the success of *Marine Science Careers: A Sea Grant Guide to Ocean Opportunities* and developing a national Sea Grant marine careers web site.

(7) To build upon our current level of involvement in the regional and national Sea Grant networks by membership on subcommittees, working groups, and strategic planning processes.

One of the keys to successful completion of our objectives, and achieving high quality products and services, will be our ability to market and evaluate our progress and our audiences' response to our efforts. Much of what we hope to accomplish in the next five years will involve the training of our staff in marketing and evaluation techniques to increase our ability to market our publications and products.

This guide will be of major assistance. I like its comprehensiveness. Not only does it give job information and where to learn more, but it also give students real life feedback from workers in the field. I wouldn't change a thing. It is too rare that we guidance counselors are given concise, relevant information on specific careers to give our students. Thanks.

Marine Science Careers *evaluation postcard from Milwaukee, Wisconsin*

WHOI Sea Grant was the primary funding source for my thesis research on the use of organic aggregates by shellfish. The entire experience was educational: writing the proposal, discovering the connections between basic and applied research, presenting the work and even writing completion reports. In addition to providing me with the financial resources to successfully complete by dissertation, receiving a Sea Grant award was tremendously important for my confidence as a graduate student. I could not have done it without Sea Grant support.

Merryl Alber, *Assistant Professor, Department of Marine Sciences, University of Georgia*

Implementation of the Program

The proposal solicitation process is initiated in early spring one year before the two-year program cycle begins. This involves a large-scale mailing of a general announcement and call for pre-proposals to all colleges and universities, all non-profit marine research institutions, and other non-profit groups in the Commonwealth of Massachusetts. The announcement of pre-proposal solicitation is also posted on the WHOI Sea Grant home page (http://www.whoi.edu/seagrant) and listed in the Massachusetts Coastal Zone Management monthly calendars and state newsletter. We coordinate the scheduling of pre-proposal and proposal solicitation with the MIT Sea Grant Program. Two general information meetings on the application process are held at WHOI and at MIT before the pre-proposals are due. At those meetings WHOI Sea Grant and MIT Sea Grant staff review all aspects of the pre-proposal and proposal review process and discuss budget-related and cost sharing requirements.

Pre-proposals are reviewed by a committee of specialists that judge the appropriateness of individual pre-proposals for Sea Grant support, identify potential opportunities for matching funds, opportunities for students, outreach aspects of individual projects, and potential linkages between different projects and principal investigators. Full proposals are requested from generally less than half of the pre-proposals submitted. Each full proposal is sent to 4-5 external reviewers for evaluation. Peer reviewers are contacted prior to sending the proposal to ensure that each reviewer can provide a timely and objective review. Each peer reviewer is also asked to confirm in writing that no conflict of interest with the principal investigator exists. While the proposals are undergoing peer review, WHOI Sea Grant staff also review the projects for completeness, cost sharing, and budget related forms. A review packet is sent to individual investigators including anonymous mail reviews. Principal investigators are asked to provide responses to reviewers' comments and suggestions, but are not allowed to alter the proposal. A Proposal Review Panel determines the final selection of proposals.

Nationalization of the Implementation Plan

Through our interactions within the Northeast region and the National Sea Grant network, we are already incorporating many of our results on the regional and national scale. This will continue through interactions at regional and national topical workshops and through participation of program staff in Sea Grant Week.

WOODS HOLE OCEANOGRAPHIC INSTITUTION SEA GRANT PROGRAM

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