Sea Grant
Woods Hole

PROGRAM GUIDE

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WHOI Sea Grant 1996-1998 Program Guide
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WOODS HOLE OCEANOGRAPHIC INSTITUTION

1996-1998

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The Woods Hole Oceanographic Institution (WHOI) Sea Grant Program supports research, education, and advisory projects to promote the wise use and understanding of ocean and coastal resources for the public benefit. It is part of the National Sea Grant College Program of the National Oceanic and Atmospheric Administration (NOAA). The Sea Grant network consists of 29 individual programs located in each of the coastal and Great Lakes states to foster cooperation among government, academia, and industry.

Sea Grant's affiliation with WHOI began in 1971 with support for a number of individual research projects. In 1973, WHOI was designated a Coherent Sea Grant Program and, in 1985, was elevated to its present status as an Institutional Program. The WHOI Sea Grant Program has made great strides to channel the expertise of world-renowned ocean scientists toward meeting the research and information needs of users of the marine environment. Public and private institutions throughout the Commonwealth of Massachusetts and the northeast region participate in the WHOI Sea Grant Program.

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RESEARCH

During the 1996-1998 funding cycle, the WHOI Sea Grant Program will support 18 concurrent research projects and several smaller "new initiative" efforts aimed at taking the first steps into promising new areas. These projects fit into the following theme areas: Estuarine and Coastal Processes, Fisheries and Aquaculture, Marine Biotechnology, and Marine Policy. Many of these projects address local and regional needs while others have national or even global implications.

A major by-product of this research is outreach, in the form of publications, workshops and lectures. Since 1971, WHOI Sea Grant research has resulted in nearly 600 publications, including journal articles, theses, books, maps, fact sheets, and pamphlets.

Research and outreach efforts involve the following research and academic institutions, as well as private industry: WHOI, Marine Biological Laboratory, Boston University Marine Program, University of Massachusetts at Dartmouth, University of Massachusetts at Amherst, North Carolina State University, State University of New York at Stony Brook, Roskilde University (Denmark), New England Aquarium, Nantucket Research and Education Foundation, SmithKline Beecham Pharmaceuticals, and Hydros, Inc.

Estuarine and Coastal Processes

▸ Tidal Flat Deposition: Processes and Rheology

David G. Aubrey, Woods Hole Oceanographic Institution

Pollutants often accumulate in fine sediments along coastal and estuarine zones and along the open coast. Because the fate and transport of some pollutants follow that of fine sediments, it is important to understand the processes behind sediment movement. Unfortunately, fine sediment deposits are often difficult to sample. To address this problem, researchers have combined hydrodynamics with sediment characteristic information to develop a theoretical methodology for examination of fine sediment deposits in tidal flat areas. In continuation of a 1994-1996 Sea Grant-supported study, researchers will design a prototype instrument capable of making quick measurements of sediment characteristics in the field. Such data can then be used in models to improve our understanding of the fate of important coastal ecosystems. (R/G-21)

▸ Quantifying Flushing Rates of Estuaries

W. Rockwell Geyer and James R. Ledwell, Woods Hole Oceanographic Institution

The severity of anthropogenically-induced problems (those caused by humans)—such as nutrient loading (eutrophication) or contamination of shellfish beds by toxic dinoflagellates—depends largely on the flushing rate of the system. In this comparative study, researchers will measure flushing rates of three, hydrodynamically different, estuaries. Following Rhodamine dye releases in three Massachusetts estuaries—the Parker River, Childs River and Waquoit Bay—investigators can monitor residence times and three-dimensional spreading of the dye through measurements of forcing variables (winds, tides, and freshwater inflow) as well as currents and water properties. This project seeks to improve the empirical and theoretical understanding of flushing mechanisms in estuaries. (R/O-30)

▶ Ecosystem Level Measurements of Denitrification in Estuaries

Anne E. Giblin and Charles S. Hopkinson Jr., Ecosystems Center, Marine Biological Laboratory

Nutrients generated from sewage, agricultural, or urban runoff commonly travel through watersheds, from rivers to coastal systems, resulting in nutrient overloading conditions such as algal blooms, oxygen depletions and, ultimately, fish kills. Currently, there is no reliable method to quantitatively measure an ecosystem response to nutrient overloading from human population and land use changes. Through collaboration with researchers from a National Science Foundation-funded project, investigators will determine the importance of nitrogen conversions (for example, denitrification) in three major estuarine zones of the Parker River/Plum Island Sound estuary in Massachusetts. Through utilization of a "whole system" nitrogen addition tracer experiment, scientists will measure benthic breakdown of the labeled nitrogen and the loss of nitrogen as N_2 gas—a form unavailable to plants, including those which contribute to algal blooms. By studying three habitats in the highly productive, yet commonly eutrophied low salinity zone, researchers hope to develop and expand models of water quality which will be useful for coastal community land use and nutrient discharge planning. (R/M-37)

▶ A Stable Isotopic Approach for Early Detection of Wastewater Nitrogen in Estuarine Food Webs

Ivan Valiela, Boston University Marine Program

Another Sea Grant-funded nutrient loading study investigates the use of nitrogen stable isotopes for detecting and monitoring wastewater-induced eutrophication.

▲ These aerial photographs show Waquoit Bay and its surrounding waterways as they appeared in 1938 (left) and in 1981 (right). Urbanization in the surrounding watershed increased dramatically over the intervening 41 years. By comparing natural and development-related changes that have taken place around Waquoit Bay and its adjacent estuaries, Dr. Valiela and Boston University graduate student James McClelland are gaining an understanding of the close coupling between land-use in coastal watersheds and nitrogen dynamics in nearshore waters.

Nitrogen (N) inputs to estuaries from coastal watersheds are contributed by three major sources: wastewater, atmospheric deposition, and fertilizers. N stable isotope ratios in groundwater-borne wastewater are elevated relative to the other N sources, so that wastewater acts as a N-15 enriched tracer introduced to estuaries. Changes at the molecular level with increased wastewater loading should be detectable before changes at the population and community level. To test the sensitivity of stable isotopes for detecting wastewater N in estuaries, investigators will measure N stable isotope signatures in groundwater and biota from seven estuaries entering into Waquoit Bay, Massachusetts, that receive low to high N loads. Isotopic changes across estuaries with increased wastewater loading will be compared with changes at the population and community level (monitored by the Waquoit Bay Land Margin Ecosystem Research program) that are traditionally used to assess eutrophication. Tracking wastewater N isotopically through estuarine food webs may provide a means for identifying wastewater-induced eutrophication at an earlier stage than is presently possible. Early detection of eutrophication from wastewater is critical for making effective land use management decisions in coastal regions. (R/M-38)

▶ Dynamics of the Toxic Dinoflagellate *Alexandrium* in the Gulf of Maine: Source Populations and Downstream Impacts

Donald M. Anderson, Woods Hole Oceanographic Institution and Jefferson T. Turner, University of Massachusetts at Dartmouth

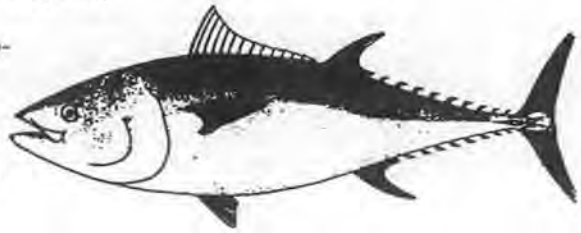
Toxic algal blooms or "red tides" can cause serious health and economic problems, including Paralytic Shellfish Poisoning (PSP), which occurs when shellfish, zooplankton, and other marine animals accumulate toxins while feeding on dinoflagellates of the genus *Alexandrium*. For humans, impacts of *Alexandrium* blooms range from the quarantine of shellfish beds to sickness or even death if the contaminated shellfish are eaten. For marine ecosystems, the impacts can be equally devastating, with mortalities or incapacitation occurring at multiple levels of the food web as toxins are passed from consumer to consumer. With evidence that toxic *Alexandrium* cells may be transported into Massachusetts coastal waters from the southwestern Gulf of Maine, researchers will investigate bloom dynamics before and after a new sewage outfall pipe begins to re-route waste from Boston Harbor to a site nine miles offshore into Massachusetts Bay (scheduled for April 1998). This research will undoubtedly assist in future management decisions relating to this controversial project. (R/B-140)

Fisheries and Aquaculture

▶ School Structure and Individual Feeding Behavior of Bluefin Tuna, *Thunnus thynnus*

Francis Juanes, University of Massachusetts at Amherst

Bluefin tuna are an important commercial and recreational fish species from Labrador to Brazil. Unfortunately, tuna behavior is difficult to study in the field, and traditional stock assessment techniques are inaccurate. To help remedy these problems, researchers, in collaboration with the New England Aquarium, will study tuna schooling and feeding behavior by analyzing video of captive bluefin. Exploring bluefin behavior will aid in developing new stock assessment techniques, such as aerial photographic assessment. Investigators hope that this study will ultimately help with long-term management of this important but poorly understood species. (R/B-138)



▶ Development of Phenotypic Markers for Identification of Seeded Scallops

Alan M. Kuzirian and Hemant M. Chikarmane, Marine Biological Laboratory

The bay scallop *Argopecten irradians* is an important commercial shellfish in Massachusetts, particularly on the islands of Nantucket and Martha's Vineyard. Recent years of overfishing have resulted in low populations. As such, it has become imperative to implement alternative harvesting methods such as aquaculture. Before large-scale enhancement projects begin, it is important to determine whether planted scallops contribute to the population or whether they are being consumed or "farmed" before they are able to reproduce. To find out, researchers in collaboration with the Nantucket Research and Education Foundation (NREF) will develop visible and DNA-based phenotypic markers for scallop identification. The markers will provide information for direct estimates of seeded scallop survival in their natural habitat. Through this project, investigators hope to demonstrate both the success of hatchery-bred scallops set in the wild as well as the viability of focused aquaculture programs in fisheries enhancement. (R/A-34)

The following four projects are part of a multi-institutional initiative titled "Regional Fisheries Issues" made possible by a special National Sea Grant College Program award.

▸ Reproductive Strategies and their Contribution to Genetic Diversity and Life Cycle Flexibility in the Commercially Important Squid, *Loligo pealei*

Roger T. Hanlon, Marine Biological Laboratory

In the northeastern U.S., fisheries resources—especially in the Georges Bank ecosystem—have been altered drastically by human fishing pressure. The northeast squid fishery for *Loligo pealei* has increased in value to approximately $32 million (23,000 metric tons), partly due to increased fishing effort that is in some degree related to reduced groundfish resources. Unfortunately, our knowledge of the life history of this squid is poor and fishery managers believe the fishery is maximally exploited. Two recent developments in the fishery are of great concern to the local squid fishery managers: (1) the rapidly developing winter offshore fishery that concentrates on pre-spawning adults and now produces 90% of the total landings, and (2) a new export market that has developed for juvenile pre-recruits. This Sea Grant-supported study will permit us to acquire baseline information on reproductive strategies that affect gene distribution before this heavily fished resource suffers the same fate as groundfishes. Field observations and sampling plus laboratory behavioral experiments will be assayed by DNA fingerprinting to determine details of the mating system. The results will give us better predictive information about the effect of targeted fishing on reproductively active squids. (R/B-141)

▲ The reproductive tactics in female squids *(Loligo pealei)* include a specific body pattern called "Lateral blush" that is used in visual signalling with males during courtship on spawning grounds.

▸ Predatory Impact of Lobate Ctenophores on Commercially Important Fishes and their Prey

Laurence P. Madin, Woods Hole Oceanographic Institution

Ctenophores are voracious macroplanktonic carnivores that use their tentacles or filmy oral lobes to catch their food. Because they grow and reproduce rapidly, populations of ctenophores can dramatically alter the structure of marine communities by predation on smaller zooplankton. For example, the lobate ctenophore *Mnemiopsis leidyi* was accidentally introduced into the Black Sea in 1982 from ship's ballast water. Its predation on zooplankton and larval fish there has caused severe damage to commercially important fish stocks and led to the complete loss of regional anchovy fisheries in the Black Sea and neighboring Sea of Azov. On our shores, *Mnemiopsis* exerts a strong influence on copepod populations in estuaries and coastal waters. Its close relative *Bolinopsis infundibulum* may significantly impact prey populations that support cod and haddock fisheries on Georges Bank. This Sea Grant-supported study will use field and laboratory studies to examine the mechanisms these ctenophores use to catch their prey; this information may enable us to predict what kinds of prey will be vulnerable. This study benefits from ongoing research investigations by the researcher and his colleagues in the NSF and NOAA-sponsored Global Oceans Ecosystems Dynamics (GLOBEC) program, which is investigating the deterioration of northeastern U.S. cod and haddock stocks on Georges Bank. This comparative study of both *Mnemiopsis* and *Bolinopsis* will provide a better understanding of how introduced predators can impact existing species and monopolize new habitats. The results will help in the development of management strategies for these predators in the Black Sea, recently-invaded Mediterranean Sea, and potentially endangered Georges Bank ecosystems. (R/B-134)

▸ Behavioral and Hydrodynamic Components of Postlarval Bivalve Transport within Coastal Embayments

Lauren S. Mullineaux, Woods Hole Oceanographic Institution

This Sea Grant-supported study, a combination of manipulative field investigations and laboratory flume experiments, will yield valuable information about soft shell clam *(Mya arenaria)* recruitment and its influence on population dynamics and distributions. Commercial harvesting of these clams contributes tens of millions of dollars annually to the New England economy. The recruitment of soft shell clams is, how-

ever, notoriously variable both in time and space: while some years see virtually no clams settling in a particular bay, other years see clams settling at very high densities. Recruitment within a bay can be highly localized. Because recruitment has a strong influence on soft shell clam population dynamics and productivity, variations can make the fishery difficult to manage. The present study focuses on spatial variation by investigating the interactions between burrowing behavior and hydrodynamic transport of clam larvae. The results will facilitate our ability to predict the locations of sustained recruitment, thereby providing valuable information for those utilizing the soft-shell clam fishery and fishery managers. Another component of the study will provide specific information on the mechanisms by which covering the sediment with mesh netting affects the transport and recruitment of soft shell clam postlarvae—information of direct relevance to the aquaculture industry and fisheries management. (R/B-142)

▶ Statistical Modelling of Environmental Effects on Recruitment in Georges Bank Haddock

Andrew R. Solow, Woods Hole Oceanographic Institution

Achieving sustainability in commercial fisheries is perhaps the most difficult problem facing the managers of marine resources. Sustainability is achieved when recruitment balances removal. The "recruitment" to a fishery refers to the addition of fish to the exploitable stocks each year. It also determines the prospects for recovery in a depleted fishery in which fishing mortality has been reduced. Understanding the sources of variability in recruitment is therefore critical for managing a fishery. This Sea Grant study will detect and model physical environmental effects on recruitment to the Georges Bank haddock *(Melanogrammus aeglefinus)* stock. For both scientific reasons and reasons connected to fisheries management, there is great interest in understanding—and ultimately modeling—the way in which the physical environment influences recruitment. While earlier attempts to model the physical environmental effects into the stock-assessment relationship have been made, this approach represents an improvement because it explicitly accounts for the stock-size effect on recruitment. Focusing on the Georges Bank haddock is ideal for three main reasons: (1) they are economically important and currently depleted; (2) they are, apparently, highly sensitive to variations in the physical environment; and (3) there is relatively long time series data available. In addition, the methodology developed during the course of this project will be more widely applicable to stocks other than haddock. (R/O-31)

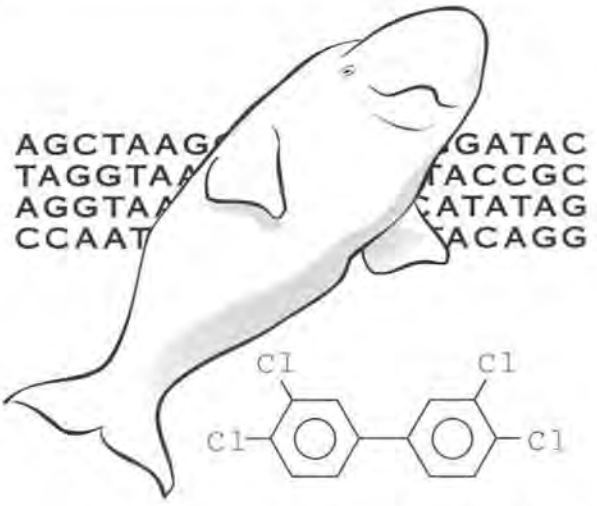
Marine Biotechnology

▶ Molecular Biomarkers of Chemical Sensitivity in Protected Species: A New Approach to Environmental Risk Assessment

Mark E. Hahn and Brenda A. Jensen, Woods Hole Oceanographic Institution

Planar halogenated aromatic hydrocarbons (PHAH), including PCBs and dioxins, are ubiquitous and persistent contaminants of the global environment. Certain species of seals and whales have some of the highest levels of these pollutants documented in any animal group due, in part, to their position at the top of the food chain, and because PHAH tend to accumulate in the blubber of these animals. These compounds have been suggested as contributing to marine mammal mortality and morbidity, but the magnitude of the risk that PHAH pose to the health of marine mammals is controversial. The sensitivity of these animals to PHAH is not easily measured, since legal and ethical concerns preclude the direct testing of toxic chemicals on protected animals such as marine mammals. In this Sea Grant-supported project researchers will determine the dioxin and PCB sensitivity of whales (including the beluga, *Delphinapterus leucas*) by characterizing a protein that is critical to PHAH effects. Through DNA cloning and in vitro analysis of the aryl hydrocarbon receptor protein, investigators hope to better understand the sensitivity of beluga and other whales to

these pollutants. This state-of-the-art technique, commonly used to study human sensitivity to toxics, will aid the evaluation of the beluga's risk to PHAH and will serve as a model for a new method for assessing protected animals' risk to environmental contaminants. (R/B-137)



▲ Halogenerated aromatic hydrocarbons (HAHs) are common industrial contaminants of the marine environment. HAHs are long believed to affect marine mammal populations, particularly the fish eaters like the beluga, but the mechanism is unknown. Determining the molecular properties of the aryl hydrocarbon receptor should reveal part of the answer.

▶ Development of Species-Specific Immunofluorescent Markers for Bivalve Larvae with an Application to Fisheries Management

Cheryl Ann Butman and Elizabeth D. Garland, Woods Hole Oceanographic Institution

Waters surrounding Nantucket Island, MA are known sinks for late-stage larvae of commercially-important bivalves such as *Argopecten irradians* (bay scallop), *Mya arenaria* (soft shell clam), and *Spisula solidissima* (surf clam). The planktonic larval stage is an important part of the life history of a benthic invertebrate as it is only during this stage that the organisms disperse, and thus exchange genes among populations, colonize new habitats or replenish old ones. However, limitations in sampling and identification of these planktonic organisms often hamper research and management practices. In this study, larvae will be sampled using a newly designed, automated sampling tool—the MASZP (moored, automated, serial zooplankton pump). Employing a cutting-edge molecular technique, the collected larvae will then be marked with fluorescent antibody tags to facilitate detection, identification, and enumeration in the samples. Identifying and enumerating previously indistinguishable planktonic larvae at early stages of their life cycle will be invaluable in studies of factors controlling population distributions, and of fisheries and aquaculture management. (R/B-139)

The following four projects are part of a 7-project, multi-institutional enhancement initiative supported by the National Sea Grant College Program titled "Chemical/Biological Interactions: Receptor-Mediated Effects on Reproduction and Development in Aquatic Species."

▶ Fish Cytochrome P450 Genes Involved in Chemical Effects

John J. Stegeman, Woods Hole Oceanographic Institution

In this study, researchers will establish a molecular basis for explaining and monitoring effects of anthropogenic or natural chemicals on endocrine and developmental processes in fish. Through studying the salt marsh minnow, *Fundulus heteroclitus*, investigators will clone and sequence genes for cytochrome P450 that may metabolize and activate or inactivate chemical compounds. These studies will provide a molecular foundation for understanding the mechanisms and monitoring the effects of diverse chemical pollutants. The results will have implications for and applications in ecology, toxicology and pharmacology of fish, and could provide new approaches for screening effluents and new chemicals for biological reactivity. (R/P-60)

▶ Molecular Biological Approaches for Non-Destructive Assessment of Chemical Effects on Marine Mammals

John J. Stegeman and Michael J. Moore, Woods Hole Oceanographic Institution

Pollutants in the marine environment, such as polynuclear aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), dioxins, and furans, are believed to have adverse affects on marine populations, including marine mammals. Exposure to such pollutants may effect the physiology of marine mammals, including reproduction, immune defense, endocrine system functions, and, possibly, neural systems that control social and migratory behavior. Using molecular biological techniques, researchers in this study will focus on the pilot whale—studying biopsy samples of free-ranging populations as well as archived samples taken from stranded whales—to evaluate the exposure of marine mammals to harmful chemical compounds. By quantifying expression of the cytochrome CYP1A gene (a sensitive biomarker of hydrocarbon effects) in the livers and other organs of the pilot whale, investigators

will be able to characterize metabolic activity. The methods established in this study will provide a non-destructive means to study compounds that may pose a threat to fragile marine mammal populations. (R/P-61)

▶ **Impact of Environmental Contaminants on an Aquatic Bird Population**
Mark E. Hahn and Michael J. Moore, Woods Hole Oceanographic Institution and Ian Nisbet, I.C.T. Nisbet and Co.

Many questions surround the extent to which dioxin-like compounds and chlorinated pesticides disrupt endocrine functions—such as reproductive and developmental processes—in humans and aquatic animals, including birds. This project seeks to examine abnormalities, including gonadal feminization, in common tern embryos from two coastal Massachusetts sites with different levels of environmental contamination. Using chemical, biochemical, and immunohistochemical methods as well as cell-culture bioassays, researchers will measure exposure of the birds to a variety of environmental pollutants. Through a combination of field and laboratory-based studies, investigators hope to assess possible relationships between health effects and specific contaminants, including dioxin-like compounds and environmental estrogens. (R/P-58)

▶ **Identification of Bioactive Marine Natural Products Using a Fish Cell Culture Bioassay**
Mark E. Hahn, Woods Hole Oceanographic Institution

Marine organisms produce a variety of organic compounds, some of which display useful biological activities. Many of these products are structurally related to dioxins, PCBs and other anthropogenic compounds that act through specific receptor-mediated mechanisms. Investigators in this study will use a newly-devised cell culture bioassay system to determine marine natural products that stimulate or inhibit the same biochemical systems that respond to dioxins. Exploring the mimicking effects of natural marine compounds will be important in understanding the biochemical and physiological changes that have been observed in animals living in contaminated environments. In addition, identification of these compounds may be useful as future research tools or as pharmaceutical agents. (R/B-124)

Marine Policy

▶ **An Optimal Risk Sharing Strategy for Marine Oil Transport**
Di Jin and Hauke L. Kite-Powell, Woods Hole Oceanographic Institution

Risk management of oil transportation is a major concern facing both the marine transportation industry as well as those interested in the protection of coastal resources. Since the passing of the Oil Pollution Act of 1990 (OPA 90), oil carriers face unlimited liability in U.S. waters. During the first phase of this project, researchers developed an analytical model based on economic theory, and principles of environmental law, damage assessment and marine insurance to determine the optimal level of liability limits in marine transportation. In phase II, this project will expand the model to incorporate institutional and technological details for policy analyses and to develop empirical estimates and policy suggestions for public debates on oil imports and environmental protection. With certain portions of OPA 90 up for revision, this research will undoubtedly benefit federal and state agencies, as well as industry and nongovernmental organizations as they deal with marine transportation and environmental policy issues. (R/S-28)

▶ Public Outreach and Education

Tracey I. Crago and Sheri D. DeRosa, Woods Hole Oceanographic Institution

The primary goal of the WHOI Sea Grant Program's communications, public outreach, and education effort is effective and active dissemination of Sea Grant information and research. Achieving this goal involves effectively translating and transferring the results of Sea Grant-supported research to individuals, agencies, and other user groups in need of information about the coastal and marine environment. The WHOI Sea Grant communications program reaches out to its audiences in an attempt to answer questions, increase environmental awareness, improve science literacy, and bridge the gap between scientific research—especially marine and coastal research—and an informed and knowledgeable public.

◀ WHOI Sea Grant sponsors "Sea Urchins, an annual hands-on, educational summer program for children ages 5-7, emphasizing exploration of the marine and coastal environment. *Photo: Tom Kleindinst, WHOI.*

Audiences we interact with on a frequent basis include educators, students, scientists, members of coastal outreach organizations and local regulatory agencies, visitors to the Woods Hole Oceanographic Institution, members of the general public interested in marine and coastal issues, commercial and recreational fishermen and boaters, and local business owners, among others. Some of the ways WHOI Sea Grant reaches its audiences include:

- WHOI Sea Grant's annual public lecture series, "Oceans Alive";
- On-line accessibility to WHOI Sea Grant information and resources—via the Internet—and pointers to other useful information; our homepage address is http://www.whoi.edu/seagrant/;
- Publication and distribution of *Marine Science Careers: A Sea Grant Guide to Ocean Opportunities;*
- Distribution of a WHOI "teacher packet" including materials and resources available to educators;
- Sponsorship of "Sea Urchins";
- Dissemination of Sea Grant and other marine-related publications and videos, and the availability of the new WHOI Sea Grant Publications Catalog 1971-1995;
- Organizing and participating in events throughout the year, including annual beach cleanups and guided coastal walks during "Coastweeks," and storm drain painting projects to inform citizens of the dangers associated with dumping waste down storm drains;
- Contributing feature articles in *Nor'easter* magazine, a regional Sea Grant publication; co-sponsoring a joint WHOI/MIT Sea Grant newsletter, *Two if by Sea*; publishing numerous fact sheets, advisory briefs, and brochures, as well as contributions in various marine educational newsletters and magazines;
- WHOI Sea Grant's involvement in several annual educational events, including local science and technology fairs, conferences, and symposia. (A/S-14)

▲ Sea Grant organizes several special events throughout the year, including "Coastweeks" activities aimed at introducing participants to new ways of interacting with the coastal environment, and storm drain painting projects. *Top photo: Brenda Crago, WHOI/Sea Grant. Left photo: Tom Kleindinst, WHOI.*

▸ Marine Advisory Program

Dale F. Leavitt and Graham S. Giese, Woods Hole Oceanographic Institution

Transferring the results of research and providing general marine-related information are important components of the WHOI Sea Grant Program. The following examples demonstrate how WHOI Sea Grant's Marine Advisory Program facilitates communication among users and managers of marine resources, including members of the fishing community, local officials, environmental regulatory agencies, and the public:

- *Directory of Cape and Islands Coastal Outreach Organizations* is a compilation of local private and public organizations that regularly deal with issues pertaining to coastal and marine management. The *Directory* is a handy reference tool that serves to encourage collaboration among these groups; it is updated annually and can now be found on the WHOI Sea Grant home page.
- Members of the coastal outreach community in southeastern Massachusetts can now join an electronic mail group maintained by Sea Grant to enhance the networking and information sharing.
- Workshops and courses provide an opportunity for local users and producers of marine resource information to share their knowledge and concerns, thereby producing a more efficient and effective resource management system. During the past year, Sea Grant has co-sponsored the following: first annual Quahog Farmer's Forum; an intensive, week-long course titled "Aquaculture for Regulators"; and a nine-month Hard Clam Farmer's Training Program.

▲ WHOI's Marine Advisory Program took the lead in a soft shell clam recruitment project in Cape Cod's Barnstable Harbor. Results indicate that flat manipulation–plowing the flats and covering large areas with anti-predator netting–enhanced settlement of the commercially important bivalve. *Photo: Dale Leavitt, WHOI/Sea Grant.*

Two areas of particular interest in the region have served as the main focus areas of the WHOI Sea Grant Marine Advisory Program:

Fishing and Aquaculture—two interrelated areas where our outreach efforts have been required. Amendment 7 to the Groundfish Management Plan is now officially in place and more commercial fish species are being included under federal/state oversight. To augment the dwindling supplies of wild commercial fish on the market and to assist in employment of displaced fishermen, aquaculture is considered a viable alternative. The WHOI Sea Grant Marine Advisory Program provides assistance by conducting literature searches, offering training programs, assisting in management and regulatory decisions, and helping to transfer the newest technology being developed within the scientific research program. One vehicle WHOI Sea Grant uses to accomplish the outreach objectives is through the annual Quahog Farmer's Forum directed at all individuals associated with the quahog aquaculture industry in the region.

Coastal Processes—Our coastal processes outreach focuses on the management of the region's coastal land forms: bluffs, beaches, dunes, barrier beaches, salt marshes and tidal flats. Together, these land forms act as the region's coastal hazards defense system—a system that is self-sustaining under natural conditions, but one that has been and is presently being modified to accommodate coastal development. Our objective, therefore, is to assist the region in sustaining its coastal land forms given the reality of present and future coastal development.

Taking a systems approach, we work with individuals, communities, and resource managers at town, county, state, and federal levels to (1) develop programs that restore coastal land form sustainability, and (2) find solutions to practical problems that minimize sustainability loss. Our methods include one-on-one discussions, field visits and demonstrations, classroom presentations, and public meetings and workshops. We encourage direct inquiries to our coastal hazards specialist by telephone, mail, or electronic mail. (M/O-2)

Sea Grant Program, Woods Hole Oceanographic Institution

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Front cover photos: Terri Corbett, WHOI.

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Look inside for details about WHOI Sea Grant's 1996–1998 Projects & Programs!