Sea Grant
Woods Hole

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WHOI Sea Grant 1998-2000 Program Guide
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Program Guide

1998 – 2000

WOODS HOLE OCEANOGRAPHIC INSTITUTION

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Woods Hole Oceanographic Institution

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), a network 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.

Research

During the 1998-2000 funding cycle, the Woods Hole Oceanographic Institution (WHOI) Sea Grant Program will support 19 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, and Environmental Technology. Many of these projects address local and regional needs while others have national or even global implications.

In addition to research, WHOI Sea Grant supports a marine extension program and a communications, public outreach, and education program. During the 1998-2000 biennium, the program will support additional outreach efforts funded under peer-reviewed regional and national competitions. Major by-products of WHOI Sea Grant projects include publications, workshops and lectures. Since 1971, programmatic support has resulted in over 600 publications, including journal articles, theses, books, maps, fact sheets, pamphlets, and web-based products.

Research and outreach efforts involve the following research and academic institutions, as well as private industry: Woods Hole Oceanographic Institution, Marine Biological Laboratory, Boston University Marine Program, Brown University, University of Pennsylvania's Laboratory for Aquatic Animal Medicine and Pathology, University of Massachusetts at Dartmouth, North Carolina State University, Roskilde University (Denmark), Gothenburg University (Sweden), Rutgers University, Clemson University, University of Saskatchewan, University of Alaska, Purdue University, University of Florida at Gainesville, University of Mississippi, University of California at Davis, the INDIA Partnership (a 22-organization program funded by the European Union's Marine Science and Technology program), Canadian Wildlife Service, ICT Nisbet & Company, Shedd Aquarium, New England Aquarium, Cetacean Research Unit, and Saigene, Inc., as well as numerous state and local agencies.

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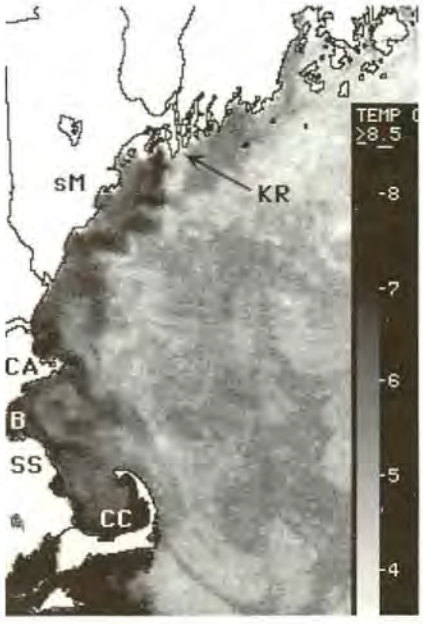
Estuarine and Coastal Processes

▶ 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 are investigating bloom dynamics before and after a sewage outfall pipe begins to re-route waste from Boston Harbor to a site nine miles offshore into Massachusetts Bay. During the first year of the multi-year project, investigators conducted three cruises in Massachusetts Bay and found *Alexandrium* to be present only in very low levels, similar to observations from the previous three years. Shellfish toxicity was detected in Casco Bay, Maine, in 1997, and intensive field efforts will be conducted there in 1998. In 1999 sampling efforts will again be focused on Massachusetts Bay, just months after the outfall will have begun discharging primary treated effluent into the bay. This research will undoubtedly assist in future management decisions relating to the controversial outfall project. (R/B-140)



▲ This satellite image shows sea surface temperature during an early spring runoff event, where freshwater from rivers flows into the ocean. The warmer (darker) coastal current that plays a dominant role in PSP dynamics within the region is seen originating near the mouth of the Kennebec River (KR), extending past Cape Ann (CA) and into Massachusetts Bay near Boston (B). PSP toxicity was detected only in southern Maine (sM) at this time. *Credit: NOAA Coastwatch image*

▶ Impacts of Accelerated Sea Level Rise in Storm-Induced Sedimentation on Southern New England Coastal Wetlands

Thompson Webb III and Jeffrey P. Donnelly, Brown University

To manage and restore coastal wetlands effectively, the processes that induce changes in the species distribution in salt marsh communities must be understood. Many global warming scenarios are predicting further increases in the rate of sea level rise as well as increases in the frequency of intense storms in the coming decades. Therefore, it is important to understand the effects of these factors on the structure and function of coastal wetland communities. This project will explore the regional consequences of accelerated sea level rise and the frequency of storm-induced sedimentation on the community structure of existing and prehistoric coastal wetlands. Field sampling and laboratory analysis will be used to test four hypotheses: (1) the coastal wetlands of Cape Cod, which are experiencing the greatest subsidence in the region, have been the first to be impacted by accelerations in the rate of sea level rise; (2) the response of both modern and ancient coastal wetlands to relative sea level rise rates greater than approximately 2.5 mm/year is a landward shift in community structure favoring stunted *Spartina alterniflora* and *Salicornia*-dominated communities; (3) the impacts of accelerated sea level rise have been diminished in portions of coastal wetlands subject to periodic storm-induced sedimentation; and (4) the timing of recent changes in wetland structure associated

▲ Field sampling, including Vibracore operations conducted in salt marshes, help investigators learn more about the impacts of sea level rise on coastal wetlands. Here, Brown University undergraduate students assist with a coring operation in Little Harbor Marsh, Wareham, MA. *Credit: Jeff Donnelly, Brown University*

▲ For over 100 years, this Chatham, MA, estuary featured a single inlet. A powerful 1987 storm produced the second inlet (foreground). Dr. Aubrey's Sea Grant project will develop a model to predict what will happen to systems like this in the future. This information is critical to estuarine ecosystem dynamics, such as plankton availability, shellfish habitat, wave exposure, tidal ranges and phases, and circulation-related pollution, among other factors. *Credit: Spencer Kennard, Kelsey-Kennard Photographers, Inc.*

with an acceleration in the rate of sea level rise is coincident with increased emission of "greenhouse" gases associated with the onset of the industrial revolution. (R/G-25)

▶ Multiple Tidal Inlet Stability

David G. Aubrey, Woods Hole Oceanographic Institution

A significant portion of the coastlines worldwide are comprised of estuaries or lagoonal systems, which often serve as habitat for diverse species and are increasingly used for human settlement. Many of these systems are connected to the open ocean by one or more inlets, through which most of the water circulation occurs due to buoyancy-driven, tidal, and wind-driven motions. A precise understanding of tidal inlet stability is fundamental for issues such as water quality, navigability, and beach and barrier stability. For long embayments, the existence and stability of multiple inlets can be important for a more efficient water exchange between the embayment and the ocean. The understanding of inlet interaction is important since changes in the physical characteristics of one inlet may affect the stability of adjacent inlets. This project will develop a model to identify the processes important for stability in multiple tidal inlet systems and will conduct a field experiment to test the model. (R/G-27)

▶ Assessing the Potential for Increased Paralytic Shellfish Poisoning in Massachusetts and Cape Cod Bays due to the Outfall Effluents

Donald M. Anderson and Andrew R. Solow, Woods Hole Oceanographic Institution

Harmful algal blooms (HABs) are a serious economic and public health threat throughout the world. Toxins from dinoflagellates can lead to Paralytic Shellfish Poisoning (PSP), known to cause shellfish quarantines, mortality of birds, larval and adult fish, and marine mammals, and illness or even death in humans. In the Northeastern U.S. and Canada, organisms responsible for PSP are two dinoflagellates in the genus *Alexandrium*. This project is designed to enhance ongoing research efforts examining the occurrence of toxic *Alexandrium* blooms in the Massachusetts and Cape Cod Bays. A new sewage outfall that will discharge primary treated effluent into Massachusetts Bay is set to go on-line late in 1998. Opponents to the project believe that there could be an increase of harmful or toxic algal species due to nutrients from the outfall effluent. Before this can be proven or disproven, the variability of *Alexandrium* population abundance within the bays must be established, along with thresholds that are indicative of significant change. Investigators will compile 25 years of state-gathered shellfish toxicity data for the bays and nearby locations. From the data, they will develop a statistical model of pre-outfall variability in shellfish toxicity. Once that is complete, investigators hope to propose "caution" and

▲ Closures of shellfish beds due to PSP in New England, and other HABs throughout the world, result in economic losses and public health problems.

"warning" levels that are indicative of significant change from historical means. And, once the outfall begins operation, the researchers will test the utility of these criteria using actual PSP data. (R/B-149)

▶ **Controls on Nitrogen Fluxes from Estuarine Sediments: The Importance of Salinity**

Anne E. Giblin and Charles S. Hopkinson, The Ecosystems Center, Marine Biological Laboratory, and Gary T. Banta, Roskilde University (Denmark)

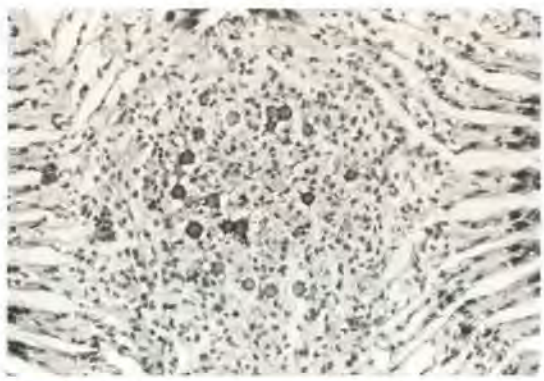
It is widely known and accepted that coastal ecosystems can be altered by nutrient inputs and that there is a direct relationship between human population in a watershed and the amount of nitrate-nitrogen that comes out of the watershed and into coastal waters. While many studies have looked at the relationship between nitrogen loading, nutrient recycling in the benthos, and the role of nitrogen in primary productivity, fewer have considered the effect of human-induced freshwater runoff (deforestation, agriculture, urbanization, river channeling, and damming, for example) on estuarine systems. Freshwater input strongly influences estuarine circulation, salinity distribution, primary production, plant and animal distributions, and nutrient dynamics. This project will focus on the interaction between freshwater flow and nutrient dynamics by: (a) determining the effect of salinity on nitrogen storage and release from sediments; (b) determining the effect of porewater (the water that is present in bottom sediment) salinity on rates of sediment nitrification and denitrification; and (c) modeling the implications of salinity control of benthic nutrient dynamics on temporal and spatial patterns of estuarine metabolism. Results from this study will be used to improve the understanding of the controls on estuarine primary and secondary productivity, and to refine an existing model of estuarine primary productivity. This model, which includes a hydrologic component, could be adapted for any estuary and could be used to assess the impact of water withdrawal (in drought conditions) or addition (floods or storms) to a watershed. It could also be used as a management tool for estuaries where there is some control over the freshwater inputs on a seasonal basis, to minimize eutrophication problems. (R/M-41)

Fisheries and Aquaculture

▶ **Laboratory-based Transmission of the QPX Parasite in Cultured Hard Clams and Studies on the Progression of the Disease**

Roxanna M. Smolowitz, University of Pennsylvania's Laboratory for Aquatic Animal Medicine and Pathology, and Dale F. Leavitt, Woods Hole Oceanographic Institution

The farming of hard clams (*Mercenaria mercenaria*, aka, quahog) is one of the fastest growing aquaculture industries in the eastern U.S., with a 1995 value of $25 million. In Massachusetts alone, cultured quahogs generated an annual income of over $4 million in 1995, a figure that has been projected to reach approximately $40 million in Massachusetts in just a few years. These projections, however, do not take into account a disease that was discovered in farmed quahogs in Massachusetts in 1995, and has now been reported in cultured clams in Virginia and both wild and cultured clams in New Jersey and Massachusetts. In two Massachusetts sites, Provincetown and Duxbury, reports of mortalities for cultured clams as high as 95% have dealt a severe blow to growers. Because the discovery of the disease was so recent, much remains unknown about the organism itself, the mechanism of infection, the clam's response to the disease organism, and the time frame for progression of the



▲ This photograph, magnified 100 times, shows the QPX parasite in the gill of an infected quahog, *Mercenaria mercenaria*.
Credit: Roxanna Smolowitz, University of Pennsylvania LAAMP

disease in relationship to certain physical or physiological conditions. This study will use three methods of disease transmission (injection, waterborne exposure, and diseased animal exposure) to investigate initial infection by the QPX organism and progression of the disease in healthy animals under controlled laboratory conditions. The goal is to develop a method or methods of disease transmission that can be used to study specific characteristics of infection and disease production including: effects of environment and age on initial infection of animals, pathogenesis of the disease in the clams, and development of resistant animals in the laboratory. (R/A-39)

▶ **Understanding the Potential of Offshore Mariculture: A Bioeconomic Approach**
Porter Hoagland, Di Jin, and Hauke L. Kite-Powell, Woods Hole Oceanographic Institution

Many factors influence the economic success of a business. Offshore or open-ocean aquaculture is no exception. While many technical, biological, and regulatory constraints to marine aquaculture are now being resolved through research and demonstration projects, few offshore marine aquaculture operations have been commercialized to date. This is likely due, in part, to an incomplete understanding among both entrepreneurs and financial backers of the economics of offshore aquaculture operations. This project will apply financial business planning and risk assessment techniques to develop a model of offshore aquaculture economics and use the model to investigate the economic viability of prospective offshore aquaculture operations in New England. The model will use a bioeconomic approach to incorporate emerging information on construction requirements and biological growth processes in marine settings, the effects of engineering and biological uncertainties, the costs of regulatory compliance, and variability in supply and demand in the relevant product markets. The model will incorporate risk-based methods, taking into account the risky nature of offshore aquaculture operations. (R/A-40)

▶ **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

With little known about the life history of the squid *Loligo pealei*, and an increase in fishing pressure on the species, local squid fishery managers are concerned about its future. Despite the fact that managers believe the fishery to be maximally exploited, recent developments have seen an increased winter offshore squid fishery that concentrates on pre-spawning adults, and a new export market for juvenile pre-recruits. This study, now in its second year, examines squid reproductive strategies and how they might affect gene distribution. In the first year, five weeks of field observations and five months of continuous laboratory experiments were conducted. Field studies led to the discovery of two new male tactics for copulation and verified multiple mating by females prior to egg laying. In the laboratory, investigators found that multiple male tactics are commonly used at each spawning event, two or more males sometimes mate with a female before laying eggs, and females mate with as many as four males in one day while laying eggs (one female had at least six mating partners over 33 days in the lab). Approximately 20,000 egg finger samples were gathered for use in paternity studies using molecular markers. In year two, investigators will continue laboratory work on paternity using two types of DNA fingerprints and will carry out additional field observations. (R/B-141)

▲ Squid, *Loligo pealei*
Credit: L. M. Golder, Marine Biological Laboratory

▶ 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 ballast water. Its predation on zooplankton and larval fish there caused severe damage to commercially important fish stocks for several years. 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 project will incorporate field and laboratory studies to examine the mechanisms by which ctenophores catch their prey. This information could help scientists predict what kinds of prey will be vulnerable. First year results disproved the notion that lobate ctenophores are relatively passive, non-discriminating predators. New findings from laboratory investigations of water flow around ctenophores, apparent sensory responses, and anatomy of feeding structures reveal a combination of anatomical and behavioral mechanisms that allow these ctenophores to be effective and selective in trapping several types of organisms. (R/B-143)

▲ Lobate ctenophore, *Mnemiopsis leidyi*
Credit: Laurence Madin, WHOI

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

Lauren S. Mullineaux, Woods Hole Oceanographic Institution

Commercial harvesting of soft-shell clam *Mya arenaria* contributes tens of millions of dollars annually to the New England economy. The recruitment of these clams is, however, 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, and, because it has a strong influence on soft-shell clam population dynamics and productivity, recruitment variations can make the fishery difficult to manage. This study focuses on spatial variation by investigating the interactions between burrowing behavior and hydrodynamic transport of clam larvae. First year field work and flume results suggest that the practice of netting in bivalve aquaculture can be effective in reducing suspension in two ways: first, it may reduce flow speeds over the sediment and thus decrease loss at fast current speeds, and second, when snails and other disturbances are excluded, resuspension is also reduced. In the second year of the study, field experiments will be designed to characterize the flow speeds at which clams may be suspended as they age and grow. Another caging experiment may be attempted to determine the relative losses due to transport and predation. Flume experiments will attempt to determine the lowest speed required to suspend buried clams and compare it with the critical erosion velocity of unburied clams. Investigators may simulate a hypoxia event to see if it affects burrowing enough to lower the flow speeds necessary to resuspend the clams. (R/B-142)

▲ Soft-shell clam, *Mya arenaria*
Credit: Dale Leavitt, WHOI

Environmental Technology

▶ Molecular Biomarkers of Chemical Sensitivity

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

A group of chemical contaminants known as PHAHs, or planar halogenated aromatic hydrocarbons, are persistent in the marine environment. Some of these contaminants accumulate in the blubber and other tissues of marine mammals. As a result, certain cetaceans and other marine mammals contain some of the highest levels of PHAHs reported in any wildlife groups. These contaminants may contribute to marine mammal mortality and morbidity. However, the magnitude of the risk that PHAHs pose to the health of marine mammals is controversial, in part because there is little direct information on the sensitivity of these animals to PHAHs. Because legal and ethical concerns preclude addressing these questions through direct testing of toxic chemicals on protected animals, alternate research approaches are required. In a previous Sea Grant study, these researchers studied PHAH sensitivity of beluga by cloning the gene for the beluga aryl hydrocarbon receptor (AhR) protein, which plays an important role in the mechanism of PHAH toxicity. This project will extend that work by examining the function of the AhR in intact cells, thus determining whether the results obtained with the associated AhR are reflected in real cellular events, including changes associated with toxicity. This project will lead to a better understanding of the risk to marine mammals exposed to PHAHs and may serve as a model for a new approach for assessing the risk of environmental contaminants to protected species. (R/B-151)

▲ Marine mammal strandings along Cape Cod shores remain largely unexplained. However, studying tissue samples from the animals that do not survive may provide important clues for researchers. *Credit: Cape Cod Times*

▶ Biochemical Toxicology in Cetaceans

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

This project, related to the project described above, will attempt to address recent scientific evidence that establishes links between chemicals released into the marine environment and damage to fish, birds, and mammals, including humans, by disrupting hormone action and interfering with reproductive and developmental processes—so-called "endocrine disruptors." These researchers have, over the years, conducted Sea Grant studies of biochemical toxicology in marine mammals using archived cetacean tissue samples from stranded animals and tissue biopsies. This project seeks to expand these efforts and to lay the foundation for a multi-institutional program focusing on molecular, histopathological, and gross-morphological features that may be linked to chemical effects in cetaceans. Such a concerted effort is essential for evaluating the susceptibility of cetaceans to different types of chemicals. Specifically, this project will obtain and archive cetacean tissue samples for analysis of enzyme and receptor systems relevant in chemical effects; establish a multi-investigator program to examine the properties of molecular, biochemical, and cellular systems that may participate in toxic mechanisms in cetaceans; describe histological features that may

be linked to or that could corroborate biochemical results indicating chemical effects in these animals; and determine the concentrations of environmental chemical residues, including PAH and PHAH that may occur in liver and other organs of cetaceans. (R/B-152)

▶ **Identifying Wastewater-Derived Nitrogen in Aquatic Ecosystems: Tests of a Stable Isotope Tracer Approach**

Ivan Valiela and James W. McClelland, Boston University Marine Program

Increasing nitrogen loading from watersheds is leading to eutrophication of coastal waters worldwide and is considered one of the most pervasive human-induced alteration of coastal ecosystems. To effectively manage and monitor these ecosystems, techniques for assessing nutrient-driven changes in coastal waterbodies must be developed. In previous Sea Grant studies, these investigators developed a stable isotopic approach for identifying wastewater-derived nitrogen in aquatic systems—an approach that has proven useful for tracking septic tank-derived nitrogen from the Waquoit Bay watershed of Cape Cod, Massachusetts, into its surrounding estuaries. In this project, investigators will put their approach to the test. They will determine if the approach can be applied to a broader range of estuaries in the Cape Cod region, in estuaries where nitrogen loads enter from sources other than septic tanks, and in freshwater and brackish water systems. This information—and this innovative approach—will be useful to environmental managers as it will provide them with a sensitive, economic tool for identifying and monitoring the impact of anthropogenic nitrogen inputs on aquatic food webs. (R/M-40)

▶ **Detection and Quantification of Live *Acanthamoebae* in Natural Marine Ecosystems Using Molecular Genetic Methods**

Rebecca J. Gast and David A. Caron, Woods Hole Oceanographic Institution

This project, set to begin in 1999, will look at the free-living amoebae *Acanthamoeba*. *Acanthamoebae* can opportunistically infect humans. They do not generally pose a risk to healthy individuals, other than a small number of annual cases of *Acanthamoeba* keratitis, a painful corneal infection typically caused by improper care of soft contact lenses. *Acanthamoebae* can be isolated from soil, salt and freshwater (including tap water), and some marine sediments. In the marine environment, most *Acanthamoebae* have been obtained near sewage and waste dumps. Their presence at sewage dumps suggests that they may be useful as indicators of sewage contamination. However, analyzing the natural distribution and abundance of amoebae in general has been problematic. This project will attempt to implement detection and quantification methods that will provide valuable information on the presence and distribution of *Acanthamoebae* and provide a new set of tools for analysis of natural species. The development of such methods will enable ecologists to examine the mechanisms that affect the growth and aging of ecologically important organisms. (R/B-147)

▲ This phase contrast photo shows *Acanthamoeba pearcei*. The cells at the center of the image show both life stages of the amoeba. The darker two (one elongated, one round) are live amoebae. The brighter, roundish cells are actually dormant cysts. *Credit: Rebecca Gast, WHOI*

The following four projects are part of a 7-project, multi-institutional 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)

▲ Common Tern, *Sterna hirundo*
Credit: Ian Nisbet

▶ Impact of Environmental Contaminants on an Aquatic Bird Population

Mark E. Hahn, Michael J. Moore, and Constance A. Hart, 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 Culture Bioassay

Mark E. Hahn, Woods Hole Oceanographic Institution

Marine organisms produce a variety of organic compounds (marine natural products), 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 ability of marine natural products to mimic the effects of dioxins and PCBs will be important to understanding the biochemical and physiological changes that have been observed in animals living in contaminated environments. In addition, some of these natural compounds may be useful as future research tools or as pharmaceutical agents. (R/B-124)

The following project is part of a National Strategic Initiatives (NSI) competition in Marine Biotechnology, made possible by a special National Sea Grant College Program award.

▶ Detection of Harmful Algal Species Using Molecular Probes: Field Trials

Donald M. Anderson, Woods Hole Oceanographic Institution

Over the past two decades the economic and public health impacts from harmful algal blooms (HABs) have increased dramatically throughout the world. One result of this expansion is that regulatory officials and the fishing industry are faced with a broad array of affected species, spanning all levels of the food chain, many of which can be contaminated by several different toxins. These changes have forced a major reevaluation of strategies to monitor seafood products for marine biotoxins. Present techniques to identify phytoplankton species and to count toxin rely on manual microscope techniques that are time consuming and require trained specialists. This project represents the last phase of ongoing efforts to develop molecular probes and assay systems for several key HAB species. By refining and field testing nucleic acid-based probe assays that can be used in the laboratory and the field by personnel with limited technical expertise, this project will contribute an accurate, fast, and reliable tool for private, state, and federal monitoring programs for HAB species. (R/B-146)

▲ Sampling for *Alexandrium* cysts in Buzzards Bay, Massachusetts, on the *R/V Asterias*.
Credit: Don Anderson, WHOI

Sea Grant Public Outreach, Education, and Extension Projects

The following project is part of a National Strategic Initiatives (NSI) competition in Outreach, made possible by a special National Sea Grant College Program award.

▶ Sea Grant's Marine Science Careers Web Site

Tracey I. Crago, Woods Hole Oceanographic Institution, and Steve Adams, University of New Hampshire

This project will expand on the highly successful 1996 publication *Marine Science Careers: A Sea Grant Guide to Ocean Opportunities*. That publication is now in use in all 50 states and is in its second printing. Feedback from readers—school guidance counselors, teachers, students, parents, science center, museum and aquaria personnel, and marine scientists, has been very positive. As such, the authors decided to bring the information available in *Marine Science Careers*—and a wealth of additional marine science career information—to another popular medium, the World Wide Web. The on-line version of the guide will continue the popular career profiles approach, offering visitors the opportunity to hear first-hand accounts of jobs in the marine sciences, including likes and dislikes, from the people who are working in the field. Also, a section on salary information will feature results of current compensation surveys for jobs in the public and private sector, including academia, private industry, and government positions. The site will also feature an "ask the scientist" section that will archive answers to previously asked questions, information about internship opportunities, summer and academic year opportunities for students, resources for teachers and guidance counselors planning career days, and on-line movies and slide shows that offer "day in the life of" opportunities for students to catch a glimpse of life aboard a research cruise or a behind the scenes look at animal trainers in marine aquaria. The site will also offer numerous links to other quality marine and science career web sites and resources. (E/R-19)

▲ Answers to questions about marine careers, and a chance for students to get advice from people working in the marine sciences, will be featured in Sea Grant's Marine Careers Web Site, coming in 1999. *Credit: Jeff Watts, WHOI*

▶ WHOI Sea Grant Communications, 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

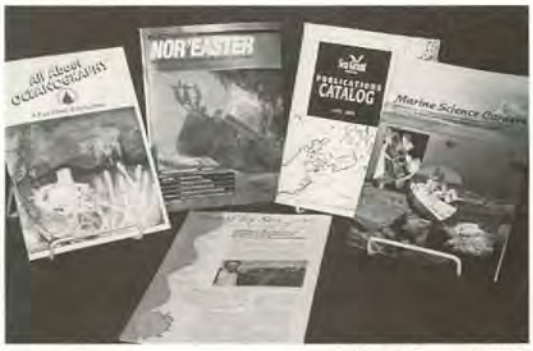
literacy, and bridge the gap between scientific research—especially marine and coastal research—and an informed and knowledgeable public.

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; check out our homepage at 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," an annual, hands-on, educational summer program for children ages 5-7, emphasizing exploration of the marine and coastal environment
- Dissemination of Sea Grant and other marine-related publications and videos, and the availability of the WHOI Sea Grant publications catalog
- 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; cosponsoring 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.

Tom Kleindinst, WHOI

Tom Kleindinst, WHOI

WHOI Sea Grant reaches out to audiences interested in coastal and marine issues by sponsoring guided walks, ecotours, lectures, and a summer program for children called "Sea Urchins." Sea Grant also produces publications to keep its audiences current on breaking research discoveries and techniques.

Tracey Crago, WHOI

▲ A prototype of the flashcards featuring seashore life from coastal New England. *Credit: Michael DiSpezio and Tessa Morgan*

▸ Development of Educational Flashcards and Interactive CD-ROM

Michael A. DiSpezio, Science Education Specialist

This educational project supports the development of a series of flashcards as an educational tool designed to inform and motivate a wide audience base about marine science issues. Within the classroom environment, the cards can be used by the teacher in engaging student interaction. Flashcards can also be used by students either individually or in groups. Two card types will be created: quiz cards and classroom/museum cards. Both will feature original watercolor artwork depicting seashore life from the New England coastal environment. The quiz card format will be designed as a game, with optional point values given for subject identification and bonus values for knowledge of subject characteristics in varying degrees of difficulty. The classroom/museum cards will feature large illustrations on one side, with text incorporating facts and concepts related to the subject on the other side. Overview cards and instructions about using this set for concept learning (e.g., taxonomy, habitat) will be included. And, as a higher technology option, the flashcard series will also be developed on CD-ROM. (E/R-20)

▸ WHOI Sea Grant Marine Extension Program

Dale F. Leavitt, Graham S. Giese, and Carolyn Ashbaugh, 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 Extension 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.
- 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: workshops on alternate shellfish and finfish species available for aquaculture with the region; roundtable discussions on growing bay scallops and surf clams; and a workshop for coastal managers, Coastal Landform Management in Massachusetts.

Two areas of particular interest in the region have served as the main focus areas of the WHOI Sea Grant Marine Extension 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. Aquaculture is expected to augment the dwindling supplies of wild commercial fish on the market and to assist in employment of displaced fishermen. The

WHOI Sea Grant Marine Extension 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 landforms: bluffs, beaches, dunes, barrier beaches, salt marshes, and tidal flats. Together, these landforms serve 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 landforms given the reality of present and future coastal development.

Stacy Shafer

Taking a systems approach, we work with individuals, communities, and resource managers at town, county, state and federal levels to (1) develop methods for quantification of changes in coastal landform sustainability, and (2) use this information for improved coastal landform management. 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.

Dale Leavitt, WHOI

Issues facing coastal communities in southeastern Massachusetts are similar to those facing coastal communities worldwide. Shoreline change, dwindling fish stocks, shellfish diseases, coastal pollution, and increasing coastal development are issues that necessitate the need for training opportunities and application of current research results for coastal managers. WHOI Sea Grant Marine Extension personnel, working with other federal, state and local groups, are creating those opportunities through workshops, on-site training and demonstration projects, classes, and advisory bulletins.

Dale Leavitt, WHOI

WOODS HOLE OCEANOGRAPHIC INSTITUTION SEA GRANT PROGRAM

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