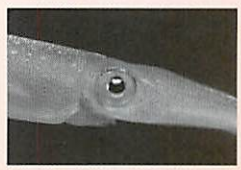
Sea Grant
Woods Hole

2002-2004

Program Guide



Woods Hole Oceanographic Institution

The Woods Hole Oceanographic Institution (WHOI) Sea Grant Program supports research, education, and extension projects that encourage environmental stewardship, long-term economic development, and responsible use of the nation's coastal and ocean resources. It is part of the National Sea Grant College Program of the National Oceanic and Atmospheric Administration (NOAA), a network of 30 individual programs located in each of the coastal and Great Lakes states, to foster cooperation among government, academia, industry, scientists, and the private sector.

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 current status as an Institutional Sea Grant Program. The Woods Hole 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 Woods Hole Sea Grant Program.

Research

During the 2002–2004 funding cycle, the Woods Hole Sea Grant Program will support 15 concurrent research projects and several smaller "new initiative" efforts aimed at taking the first steps into promising new areas. Together, these projects fit into the following theme areas: Environmental Technology, Estuarine and Coastal Processes, and Fisheries and Aquaculture. Many of these projects address local and regional needs, while others have national or even global implications.

In addition to research, Woods Hole Sea Grant supports a marine extension program and a communications, public outreach, and education program. During the 2002–2004 biennium, the program will support additional research efforts funded under peer-reviewed regional and national competitions. Major by-products of the Woods Hole Sea Grant projects include publications, workshops, and presentations. Since 1971, programmatic support has resulted in over 761 publications, including journal articles, theses, books, maps, fact sheets, pamphlets, newsletters, and web-based products.

Research and outreach efforts involve the following academic institutions, as well as private industry: Woods Hole Oceanographic Institution, Marine Biological Laboratory, Boston University Marine Program, Harvard University, University of Massachusetts at Amherst, Roskilde University (Denmark), Northeast Massachusetts Aquaculture Center, Southeast Massachusetts Aquaculture Center, and Martha's Vineyard Shellfish Group, as well as numerous federal, state, and local agencies and partners, and private individuals.

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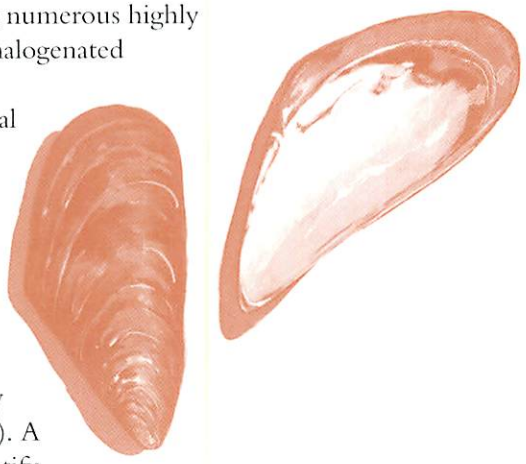
Cover photos: top, Roger Hanlon, Marine Biological Laboratory; middle, Tom Kleindinst, WHOI; lower, Tracey Crago, Woods Hole Sea Grant

Environmental Technology

Ligand Screen for Orphan Receptors in Marine Animals

Mark E. Hahn and Sibel I. Karchner, Woods Hole Oceanographic Institution

The oceans are a sink for many types of chemical pollutants, including numerous highly toxic compounds such as polynuclear aromatic hydrocarbons (PAH), halogenated aromatic hydrocarbons (HAH), and planar HAH (PHAH). These chemicals are found at high concentrations in sediments at many coastal sites, and can accumulate to extremely high levels in marine animals inhabiting those sites. The toxicity of many such pollutants occurs wholly or in part through interference with receptor-dependent signaling pathways. While much is known about such receptors in vertebrate animals, knowledge of toxicologically relevant receptors in invertebrates is extremely limited. Investigators will establish an assay that can be used to characterize the ligand (or chemical)-binding specificity of receptors in invertebrates and early vertebrates. The assay will be established initially using the aryl hydrocarbon receptor (AHR). A screening assay for receptor ligands would serve two functions: to identify toxicologically important ligands among known environmental contaminants, and to identify novel receptor-active compounds, including those of natural origin, in sediments and other environmental matrices. Identifying compounds that act as receptor ligands is important for understanding the impact of organic contaminants on marine invertebrates. Accurate ecological risk assessment for contaminated marine sites depends on the selection of appropriate "sentinel" species that are most at risk. While data from toxicity testing in selected species can provide some guidance for the choice of target species, the most accurate risk assessments will require a fundamental understanding of molecular mechanisms in various taxa, allowing prediction of the most sensitive species at contaminated sites. This project will contribute to such an understanding. (R/P-66)



Contaminants and Aquatic Animals: A Biomarker to Assess Species Differences in Susceptibility to Dioxin-like Chemicals

Mark E. Hahn, Woods Hole Oceanographic Institution

Planar halogenated aromatic hydrocarbons (PHAHs) are widespread contaminants of the marine environment. This group of chemicals, which includes chlorinated dioxins, certain chlorinated biphenyls, and certain other halogenated compounds, is highly toxic to most vertebrate animals. Certain marine mammals contain some of the highest levels of PHAHs reported in any wildlife species, but the magnitude of that risk is controversial because there is little information on the sensitivity of these animals to PHAH. Despite numerous studies about PHAH accumulation in marine mammals and circumstantial evidence for adverse effects of contaminants, a cause-and-effect relationship between PHAH contamination and reproductive abnormalities or other effects in most marine mammals remains

Eric Montie, MIT/WHOI Joint Program

▲ Grey seals *(Halichoerus grypus)* photographed between North and South Monomoy Island, Chatham, MA.

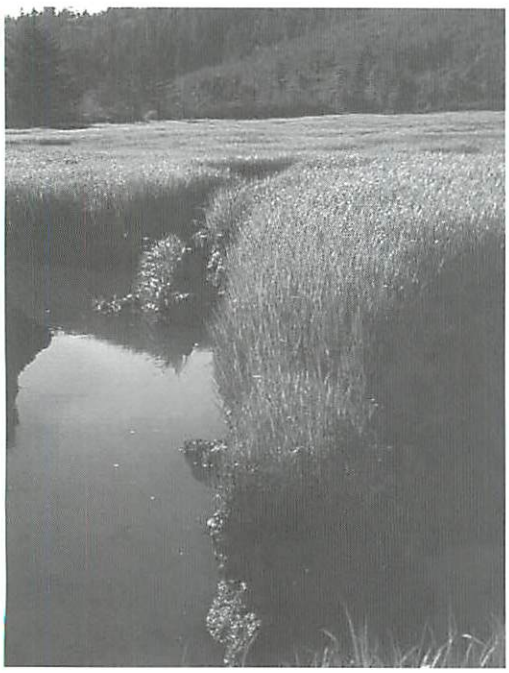
speculative. PHAHs are thought to produce toxicity through changes in the expression of genes involved in the control of cell growth and differentiation. These changes are initiated by the binding to the aryl hydrocarbon receptor (AHR), a ligand-dependent transcription factor. Researchers will investigate the mechanistic basis for PHAH toxicity in three species of marine mammals that either are known to accumulate high levels of PHAHs or are highly sensitive to the toxic effects of these compounds: harbor seals, mink, and polar bears. To do this, they will clone and characterize the AHR, an intracellular protein that is responsible for dioxin effects. These will test the hypothesis that the characteristics or expression of the AHR can be used as a biomarker of susceptibility to dioxin toxicity in marine mammals. This research builds on the investigator's previous Sea Grant work on the comparative biochemistry and molecular biology of the AHR in marine species including beluga whales by expanding this work to other groups of marine mammals for which effects of contaminants are better known. The work in marine mammals will complement another study to examine the AHR in several species of birds and past work in fish to allow a broader comparative perspective concerning the characteristics of the AHR and its role in determining PHAH sensitivity. (R/P-67)

Estuarine and Coastal Processes

Development of a Carbon Isotopic Method for Quantifying Groundwater Inputs to Estuaries

Daniel C. McCorkle, Woods Hole Oceanographic Institution

The contribution of groundwater to the coastal ocean and to estuaries is not well understood, primarily due to the difficulties associated with identifying and distinguishing between groundwater inputs and other freshwater inputs, such as surface river flow and surface runoff. In the first year of this project, investigators developed a carbon isotope-based method for estimating groundwater inputs to estuaries and applied the method to field sites in coastal North and South Carolina. Current sampling methods for estimating submarine groundwater discharge along the coast include seep meters and piezometers and geochemical tracers such as radium, radon and ^{14}C. This project, now in its second year, will attempt to use dissolved inorganic carbon (DIC) isotopes to distinguish between two freshwater sources—groundwater and tidal inputs—to the North Inlet in SC. Investigators have also sampled the surface waters and groundwaters in the region to document the range of carbon isotopic compositions; this will provide essential context for upcoming studies. Results to date have shown that in the NC/SC study region, the DIC in groundwater from confined aquifers is characterized by low radiocarbon content (low $\Delta^{14}C$ values), while the DIC in both surface seawater and surface freshwater (rivers, streams, and water table or surficial aquifer) has high $\Delta^{14}C$ values. Isotopic analyses of groundwater in the same areas and of the known DIC sources to these tidal creeks (seawater, stream water, and CO^2 from salt marsh decomposition processes),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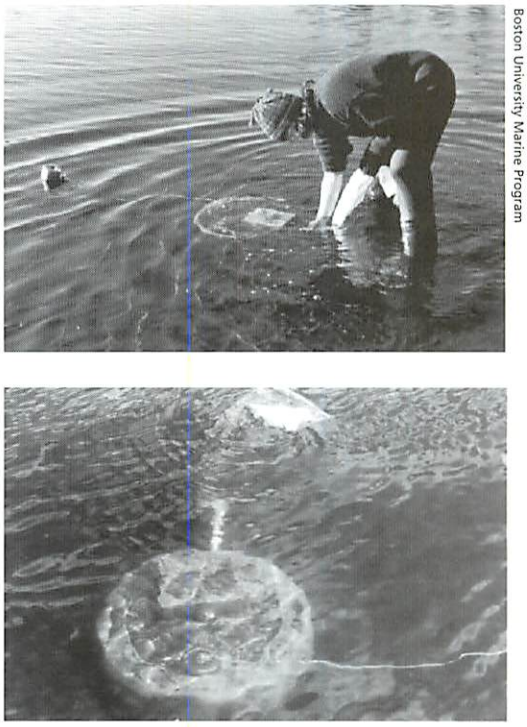
show that confined aquifers are the only significant low $\Delta^{14}C$ source to these estuaries. Using carbon isotopic tracers to identify and quantify groundwater inputs to coastal and estuarine systems will help to show the influence such inputs have on water quality and the transport of nutrients from land-based sources. This project, combined with R/M-46 *(described below)*, could provide important tools with which to estimate groundwater fluxes—and the associated fluxes of nutrients and contaminants—in a variety of settings. (R/M-47)

Application of Radium Isotopic Approach for Water Mass Age: Implications for Estuarine Phytoplankton Blooms

Matthew A. Charette, Woods Hole Oceanographic Institution, Gabrielle Tomasky and Ivan Valiela, Boston University Marine Program

Building on previous Sea Grant-supported projects that looked at biological and chemical processes in Waquoit Bay (Cape Cod, Massachusetts), this project will use radium isotopes as tracers of water residence times (T_r) in estuaries to understand the relationship between residence times and phytoplankton bloom dynamics. The key question guiding this research is "How is it possible to have phytoplankton blooms in shallow estuaries if water residence times are of similar duration to planktonic cell division rates?" Water residence times are important to the ecological, chemical, and biological processes of shallow water estuaries. In Waquoit Bay, the residence time has been reported to be relatively short (less than two days) and it has been shown that phytoplankton respond to local nutrient conditions. These results imply either calculation of whole system water residence time is in error, or that different water parcels within the estuary differ sufficiently in age to allow blooms to develop. To address this, researchers will use radium isotopes to determine (1) whether the whole estuary T_r truly represents water age, and (2) if T_r for specific parcels of water have sufficiently different water ages. To obtain evidence of the plankton response to both differences in T_r and nitrogen (N) loads, investigators will assess the composition and structure of phytoplankton in the water parcels of the Waquoit Bay estuarine system. Investigators hypothesize that in estuaries with high N loads but short residence times, phytoplankton populations will shift toward taxa with short generation times, thus allowing them to take advantage of the nutrient enrichment. This shift in phytoplankton community structure could be the mechanism allowing the significant differences in biomass and production previously measured in the Waquoit system. Where N loads are low, the hypothesis is that the phytoplankton community merely reflects the composition, biomass, and production of the itinerant assemblage that enters and leaves the estuary via tidal exchange. Understanding more about how land-derived nutrient inputs and water renewal rates interact within a system has useful implications for coastal zone managers who need information about the relationship between nutrient concentrations and biological changes. (R/M-46)



Boston University Marine Program

▲ Data from seepage meters are used to quantify groundwater radium flux to the estuary and are used in the water mass age caluclation.


Andrea Shriver, Boston University Marine Program

▲ Juvenile soft-shell clams and quahogs are planted in modified aquaculture cages then deployed in estuaries with different nitrogen loads. Investigators monitor the animals for growth and survival in response to eutrophication.

Effects of Anthropogenic Nitrogen Loads on Commercially Important Bivalves

Ivan Valiela and Ruth H. Carmichael, Boston University Marine Program

In many coastal regions, land-derived nitrogen loads have increased as a result of increased wastewater associated with residential sprawl. This often leads to eutrophication and can alter the features of the receiving estuarine ecosystems. Commercially important bivalves that grow in shallow coastal habitats are susceptible to the effects of nitrogen enrichment, including changes in food quantity and quality and habitat degradation. In some areas, abundance of commercially important bivalves appears to have decreased in recent years as anthropogenic nutrient enrichment has increased. In this project, investigators will quantitatively define how land-derived nitrogen loads alter food supply and benthic habitats used by shellfish and how populations of shellfish are affected by these changes. By looking at eight Cape Cod, Massachusetts estuaries with varying nitrogen loads investigators will determine the potential food supply for bivalves (specifically, quahogs, *Mercenaria mercenaria*; soft-shell clams, *Mya arenaria*, and bay scallops, *Argopecten irradians*), measure changes in sediment properties due to eutrophication-related processes, measure the growth and survival of shellfish, directly link changes in shellfish growth and survival to amounts and sources of anthropogenic nitrogen load, and characterize food processing by bivalves to determine how eutrophication-related changes in food quantity and quality may affect their growth and survival. By providing a quantitative understanding of the relationships between nitrogen loading rates to estuaries and bivalve growth and survival, project results will be useful to coastal managers and policy-makers as they manage areas of promising habitat for commercial and recreational shellfishing and practices such as harvesting, seeding, or relaying shellfish. (R/M-51-PD)

Effects of Varying Freshwater Discharge on Nitrogen Dynamics in the Oligohaline Regions of Estuaries

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

This field and laboratory-based project will examine how changes in salinity alter nitrogen processing and release from sediments. Previous work by the investigators looked at how salinity affected nitrogen dynamics in subtidal sediments in the oligohaline, or low salinity, zone of estuaries. They found that, while subtidal benthic nitrogen fluxes are important in controlling productivity in the overlying water, the surrounding fresh and brackish water tidal marshes may be equally important. Because of evapotranspiration and less frequent flooding, marshes tend to experience greater changes in salinity compared to subtidal sediments. Investigators hypothesize that although marshes may be considered a net sink for nitrogen due to denitrification and burial, they may act as a source of nitrogen in summer. In spring, large amounts of nitrogen entering a system during spring runoff may be stored in sediments and marsh plants. In summer,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when river discharge is low, elevated sediment salinities may cause the marsh to release part of its stored nitrogen back to the estuary, thereby contributing to the mid-summer algal bloom observed in the oligohaline zone in many estuaries. Marshes occupy greater than 10 times the area relative to the subtidal sediments sampled in previous work. This project will continue the sampling of subtidal sediments while also moving into the intertidal marsh to assess the effects of fluctuating salinity on the whole estuarine ecosystem and to accurately model the system's nitrogen dynamics. (R/M-50)

The Recycling of Anthropogenic Metals in Massachusetts Bay Sediments: Assessing the Impact of the New Outfall (Phase II)

William R. Martin and Roger Francois, Woods Hole Oceanographic Institution

This project begins its second phase by examining the behavior of a suite of trace metals in surface sediments in Massachusetts Bay. Sewage discharge can be an important source of metals to the coastal environment. In 2000, sewage discharge into Boston Harbor was rerouted to a site 14 km offshore in Massachusetts Bay. The effect of the change is to decrease organic matter and nutrient loading in Boston Harbor and increase it in the vicinity of the new sewage outfall. These changes affect the input of organic matter and metals in sediments at both locations. Once released, metals are persistent, since they neither decay nor decompose. Thus, their residence time in coastal waters is determined largely by their association with particulate phases and by particle transport processes. In the initial phase of this study, begun in 2000, investigators looked at trace metal behavior at a site of fine-grained sediment accumulation near the new outfall site just as the site became operational. This study phase will look at the effect of the recent increase in sewage output on metal accumulation in local sediments. Investigators will examine the processes that determine whether anthropogenic metals that rain to the seafloor with organic matter and iron and manganese oxides are either returned to the water column via remineralization reactions or sequestered in the sediment column. This project will benefit from related studies, by the investigators and others, of sewage inputs at another site—Inner Harbor in Hull Bay, Massachusetts, where sewage inputs have recently decreased. This will allow investigators to study the potential release of metals from sediments accumulated earlier (Hull) as well as those arriving at the sediments now (Massachusetts Bay). The sites also offer contrasting chemical characteristics that may play a role in metal cycling. A key characteristic of coastal sediments is strong seasonal variability in remineralization reactions as well as solid phase and solution phase transport by bioturbation, driven by variability in organic matter inputs and water temperature. To distinguish long-term trends due to changes in human activities from natural, seasonal variability, investigators will measure benthic fluxes and porewater profiles over the duration of the project. (R/B-164)

Dann S. Blackwood, USGS

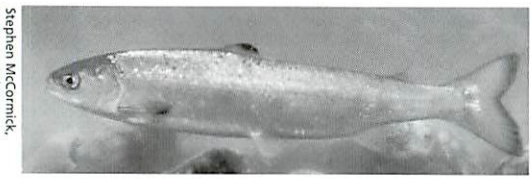
▲ Investigators recover push cores collected by divers at the Hull Bay field site.

Fisheries and Aquaculture

Developmental Effects of Contaminants on Salinity Preference and Seawater Survival for Atlantic Salmon: Integrating Physiology and Behavior

Stephen D. McCormick, Darren T. Lerner, and Emily Monosson, University of Massachusetts, Amherst

Over the last 20 years populations of Atlantic salmon *(Salmo salar)* in northern New England have decreased ten-fold, resulting in their recent listing as an endangered species in Maine. Although the reason for the decline is unknown, contaminants are a leading candidate. The parr–smolt transformation is a critical and highly sensitive life history stage of Atlantic salmon that coincides with downstream migration and seawater entry. Nonylphenol (NP) and PCBs are common contaminants found in the effluent from sewage treatment plants, industrial sites, and storage facilities. In addition to possible impacts on wild Atlantic salmon, contaminants are also an important issue for the salmon aquaculture industry. This project will investigate the possible effects of low-level contamination, particularly the effects of known endocrine disruptors on key developmental stages in salmon, such as the parr–smolt transformation.



Stephen McCormick, U Mass, Amherst

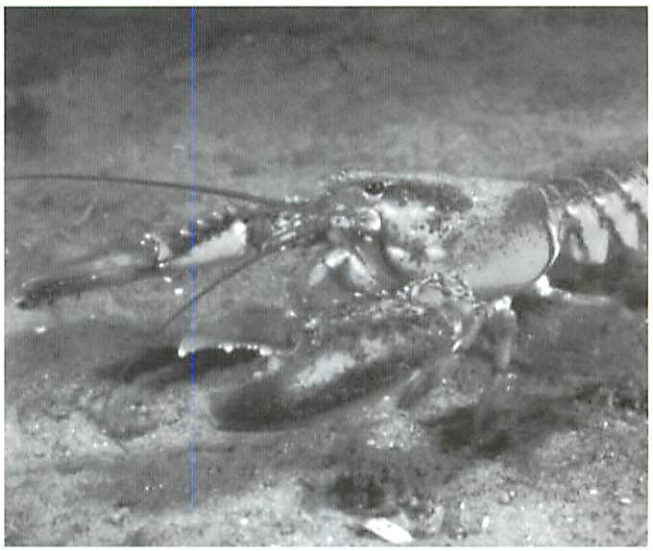
Specifically, investigators will determine the capacity of contaminants to act as endocrine disruptors of the parr–smolt transformation by adversely affecting salinity preference and tolerance of smolts following exposure at different developmental stages; determine how contaminant exposure affects smolt capacity to cope with stressful events (swimming fatigue, dam passage, capture or handling); and investigate the mechanisms by which contaminant exposure affects seawater survival. The results of this study should be broadly applicable to other aquatic vertebrates and may indicate a need for improvement and modification to sewage treatment plants, commercial waste protocols, pesticide applications, and remediation efforts. (R/B-165)

Larval Spread and Population Mixing Between Onshore and Offshore Lobster Populations

Stephen R. Palumbi, Stanford University and C. Sarah Cohen and Colleen M.Cavanaugh, Harvard University

The American lobster *(Homarus americanus)* produces more fisheries income than any other species in the Mid-Atlantic and New England states. In recent years, record landings have been reported. Overall, 80 percent of the landings are caught inshore, within three miles of the coast. As fishing effort has increased, an offshore fishery has developed in both nearshore federal waters and in distant deepwater areas. The fishery is considered 'growth overfished,' meaning that a high percentage of lobsters are taken just after reaching minimum legal size, leaving few animals to reproduce. So how can the fishery sustain record landings year after year? One possibility, say lobster researchers, is the presence of 'refuge populations' in deeper offshore waters that may produce eggs and larvae that replenish inshore populations. If such populations exist, it remains unclear how significantly local populations of lobsters are replenished by the import of larvae. To better understand lobster larval population mixing and adult migration, investigators will conduct a series of genetic analyses for different life-history stages of lobsters south of Cape Cod, Massachusetts, in both inshore and offshore populations. Working with lobster fishers and managers, the researchers will collect lobster larvae across inshore areas starting in New Bedford, Massachusetts. New Bedford Harbor, closed to lobster fishing since 1979 due to contaminated sediments associated with the EPA Superfund site, is a

known lobster marine reserve. The large and reproductive source populations there produce 'larval clouds' from which larvae can be genetically marked and their dispersion mapped. Findings may help determine the usefulness of lobster reserves as a management tool. Researchers will investigate whether stage I larvae are well mixed in inshore areas or if there is genetic patchiness. Evidence of patchiness would indicate that local management of the population may be called for. The same question will be investigated for stage IV larvae. At this stage, genetic patchiness would indicate that the larval supply is not constant on a regional scale and that lobster recruits do not come from a single larval pool as assumed in most fisheries models. Lastly, investigators will determine whether adult lobsters sampled from inshore versus offshore areas differ in gene frequencies. While sample size limitations preclude a definitive answer to this question, genetic differences, if apparent, could be used to predict the degree of onshore–offshore larval mixing by using maximum likelihood mixed-stock techniques. (R/O-34)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Tidal Exchange Among Soft-shell Clam Populations Using Natural Tags

Lauren S. Mullineaux and Simon R. Thorrold, Woods Hole Oceanographic Institution

Though most adult coastal benthic invertebrates, such as clams, are sedentary, they are mobile during a planktonic larval phase. Adult clams harvested in one area may not have originated in that area. Researchers, shellfishers and fishery managers could benefit from knowledge of the source of the larvae, how they disperse from one habitat to another, and how this dispersal affects regional recruitment. Most models of population dynamics assume that recruitment into the population is related directly to the reproductive capacity of the local population. In species with dispersive larvae, this can lead to substantial errors in modeling population growth and stability over generations. A more useful approach—using site-specific geochemical signatures (natural tags)—has proven effective in other migratory species, including birds, fish, butterflies, and some marine invertebrates. This project builds on a Sea Grant laboratory-based study (*Mullineaux and Hart,* R/O-32) and will adapt techniques developed for fish otoliths and apply them to study the larval dispersal of soft-shell clam *(Mya arenaria)* populations in the coastal regions of Massachusetts. Soft-shell clams are locally common, economically important, cover a wide geographic range, and tolerate a broad range of environmental conditions. Investigators will conduct field studies to: characterize geographic variation in the geochemistry of *Mya arenaria* shell material (shells will be measured from six locations to determine the unique combination of elemental composition and environmental conditions of each habitat); characterize interannual variation in the geochemistry of the shell material (elemental composition of post-larval shell material in newly-recruited individuals will be measured in two separate years at each site to determine if temporal variation in shell elemental composition is significant); and measure the geochemistry of the initial larval shell in newly recruited individuals for comparison to location-specific elemental signatures (to distinguish between recruits from local sources versus remote sources). (R/O-35)

Resolving Population Structure with Molecular Genetics to Enhance Management of the Highly Exploited Squid Fishery

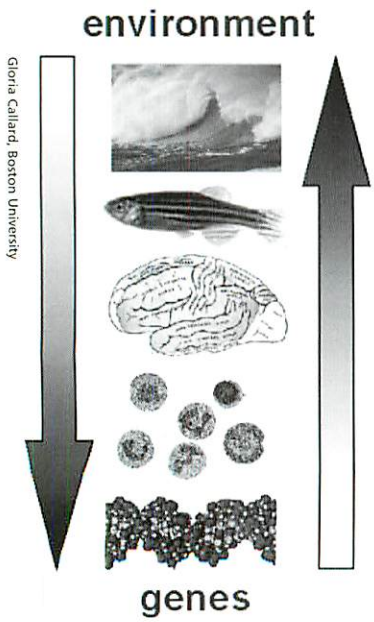
Roger T. Hanlon and Kendra M.Buresch, Marine Biological Laboratory, and Jon K.T. Brodziak and Steve Cadrin, National Marine Fisheries Service Northeast Fisheries Science Center

The long-finned squid, *Loligo pealeii*, is a commercially valuable and heavily exploited resource in the northeast U.S. Boats fish squids in inshore summer grounds along Cape Cod, Long Island, and Rhode Island, and, increasingly, in offshore winter grounds. According to the National Marine Fisheries Service (NMFS), current *Loligo* catch levels have exceeded maximum sustainable yield.

Roger Hanlon, Marine Biological Laboratory

Investigators in this project will build upon previous Sea Grant-supported work on the *Loligo* mating system and preliminary work on genetic diversity to determine if the population structure is a single genetic stock or if *Loligo* represents more than one distinct population throughout its fished range (Nova Scotia to North Carolina). These data will be useful in assessing the current stock management plan, which assumes a single unit stock for the entire fishery. Employing molecular genetic techniques—DNA fingerprinting using microsatellites as genetic markers—a research team of fisheries biologists, fishermen, and molecular biologists will determine the *Loligo* stock structure within the fished population along the Atlantic coast. Researchers will compare samples from nine inshore spawning sites to determine geographic population structure along the Atlantic coast. They will also compare population samples from three offshore locations to determine if genetic differentiation exists among the offshore sites. Finally, they will compare inshore population samples with offshore population samples to determine if inshore and offshore squid represent more than one single unit stock. If the genetic data indicate evidence of multiple populations, then the current squid exploitation model must be altered to ensure genetic variation within *Loligo* populations. If the evidence does not show multiple stocks, then impacts of the growing offshore fishery should be addressed. (R/B-166)

The following project is part of a National Strategic Investments (NSI) competition in Marine Environmental Biotechnology, funded through the National Sea Grant College Program.



Gloria Callard, Boston University

Estrogen- and Aryl hydrocarbon-receptor Mediated Reproductive Effects and Adaptations in the Marine Environment

Gloria V. Callard, Boston University

By comparing killifish (*Fundulus heteroclitus)* populations from polluted New Bedford Harbor (NBH), Massachusetts with a nearby, unpolluted estuarine environment (Scorton Creek (SC) in Sandwich, Massachusetts), this study seeks to understand the ongoing, long-term effects of pollutants on reproduction and development in marine fish. Using sensitive, tissue-specific, mechanism-based markers of endocrine disrupting chemical action and effect, together with standard methods of reproductive endocrinology, this study will extend the researcher's findings in laboratory fish (zebrafish, goldfish) to wild fish populations. Killifish are non-migratory, estuarine fish that are considered to be reliable indicators of environmental quality. The NBH killifish population is an extremely valuable resource for understanding long-term, multi-generational effects of pollutants on a wild fish population in a natural environment. The history of pollution in NBH indicates that the killifish population there has survived exposure to high levels of PCBs, metals, and other contaminants for over 50 years, or 15–20 generations: unequivocal

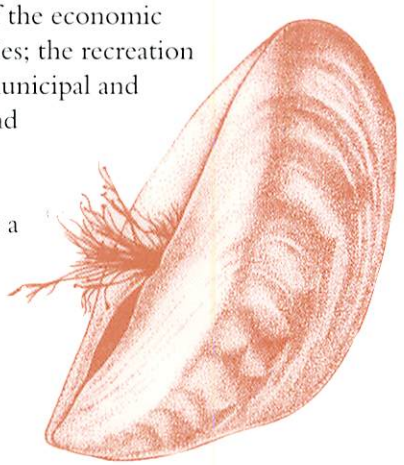
evidence that they survive, reproduce, develop—even thrive—in that environment. For all that is known about the NBH killifish population, relatively little is known about endocrine disruption and reproductive adaptation in killifish at NBH or at other polluted sites. This study will attempt to gather direct scientific evidence for a mechanism-based cause-and-effect relationship between pollutants and endocrine disruption in nature, and to begin to understand how a population might adapt and evolve mechanisms for sustaining reproduction under conditions of human induced adversity. Using a molecular endocrinological approach, this study seeks to increase the degree of certainty in formulating sound regulatory and policy decisions relating to endocrine disruption in a natural marine environment and can serve as a model for additional studies of aquatic and terrestrial species. (R/P-68)

The following project is part of a National Strategic Investments (NSI) competition in Aquatic Nuisance Species, funded through the National Sea Grant College Program.

Aquatic Nuisance Species: Assessments of Economic Impacts and Evaluations of Rational Management Alternatives

Porter Hoagland III, Hauke L. Kite-Powell, and Di Jin, Woods Hole Oceanographic Institution

Although thousands of non-native aquatic nuisance species (ANS) are known to exist in U.S. aquatic systems, the U.S. Congress has estimated the economic "disruption" to communities from the introduction and spread of just one—the zebra mussel, *Dreissena polymorpha*—at $5 billion. To date, only a few analysts have attempted to publish estimates of the economic impacts of ANS introductions into freshwater and marine ecosystems and these estimates may differ by as much as two orders of magnitude. As such, it has been difficult for policymakers, natural resource managers, industry officials, scientists, and the public to make well-reasoned decisions about how to mitigate ANS introductions. This project seeks to develop an economic framework for making rational decisions about the introduction and spread of non-indigenous ANS on regional and national scales in the U.S. Investigators will focus their assessments of the economic impacts of such introductions on sport, commercial, and tribal fisheries; the recreation and tourism industries; the shipping and navigation industries; and municipal and industrial water uses. Investigators will develop estimates of output and employment impacts and changes in value-added, measured in both dollars and jobs. These estimates can be used to improve our understanding of the scale and distribution of economic effects across a wide range of activities in the economy. Investigators will document methods for data collection and analysis, model building, data table updating, and relevant documentation for the future application of the model for assessing policy responses to ANS events. (R/M-48)

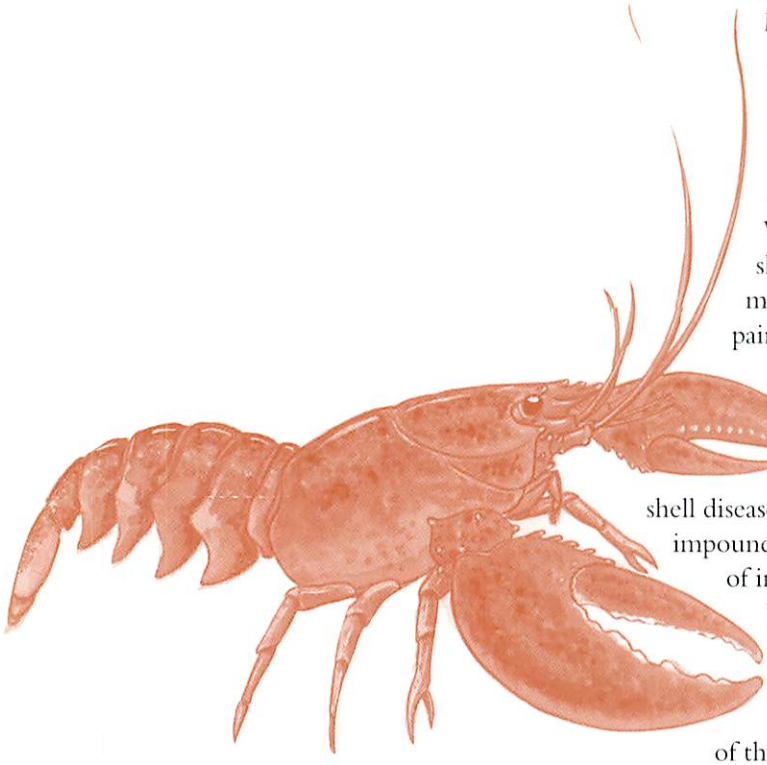


Michigan Sea Grant

The following project is part of the Sea Grant Industry Fellowship Program, funded through the National Sea Grant College Program.

A Scanning Electron Microscopy Study of Epidemic Shell Disease of the American Lobster, *Homarus americanus*

Roxanna Smolowitz, Marine Biological Laboratory, and Andrea Hsu, Boston University Marine Program



In recent years, shell disease in lobsters *(Homarus americanus)* has been found in high levels from eastern Long Island Sound to Buzzards Bay, Massachusetts, and most recently in Cape Cod Bay, Massachusetts. As the region's most lucrative fishery, the health of the lobster population is of great concern. While it is widely believed that shell disease etiology is bacterial, no studies thus far have presented results. Preliminary scanning electron microscopy (SEM) imaging of diseased lobsters from Vineyard Sound, Massachusetts, presented viable proof that shell disease etiology is bacterial, with specific bacterial mechanisms involved to initiate lesion formation. This study pairs a pathologist and aquatic veterinarian with a graduate student to use SEM to examine lesions of epizootic and impoundment lobsters from sites along the New England coast to verify preliminary findings and examine the migration and transmission qualities of the causative shell disease bacteria. To do this, normal lobster and lobsters with impoundment or epizootic shell disease will be acquired with the help of industrial partners and taken to the laboratory for analyses. While previous studies of lobster shell disease have focused primarily on impounded lobsters, this project will focus on epidemic shell disease in wild lobsters to understand the causes and implications and to learn more about the biology of the animal and the economics of the fishery. (R/B-167)

Sea Grant Public Outreach, Education, and Extension Projects

WHOI Sea Grant Communications, Public Outreach, and Education

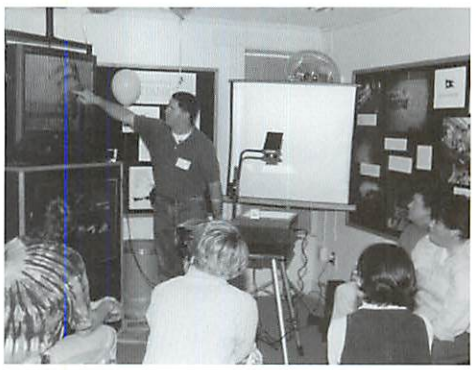
Tracey I. Crago, Sheri D. DeRosa, and Katherine A.C. Madin, Woods Hole Oceanographic Institution

Disseminating Sea Grant research results requires the effective translation and transfer of those findings to those in need of the information. The Woods Hole Sea Grant communications program reaches out to its audiences in an attempt to answer questions, increase environmental awareness, improve ocean science literacy, and bridge the gap between marine scientific research and an informed and knowledgeable public.

Tom Kleindinst, WHOI

Audiences with whom we interact on a frequent basis include educators, students, scientists, members of coastal outreach organizations and local regulatory agencies, coastal decision-makers, 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 marine business owners, among others. Some of the ways WHOI Sea Grant reaches its audiences include:

- Woods Hole Sea Grant's sponsorship of the annual public lecture series, "Oceans Alive"
- Web-based accessibility to Woods Hole Sea Grant information and resources and pointers to other useful information at www.whoi.edu/seagrant
- Access to current marine science careers information at **www.marinecareers.net**. This site, a collaboration with New Hampshire Sea Grant, has been featured in numerous national publications and websites about science careers and attracts over 230,000 hits per month
- Co-sponsorship of professional development workshops ("Topics in Oceanography") for middle- and high school science teachers in the spring and fall, and distribution of a WHOI teacher packet



WHOI

- Participation in the Massachusetts Coastal Training Program (MA CTP), a partnership of the Waquoit Bay National Estuarine Research Reserve, Massachusetts Coastal Zone Management, and WHOI Sea Grant, to foster sound science-based coastal decision-making at the state and local level
- 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 theavailability of an online Woods Hole Sea Grant publications catalog
- Co-sponsorship of the joint WHOI/MIT Sea Grant newsletter, *Two if by Sea*; publication of numerous fact sheets, *Focal Points* fact sheets and *Marine Extension Bulletins*, brochures, and contributions to various marine educational newsletters and magazines
- Sponsorship of a low-power radio broadcast, *SoundWaves*, targeting Woods Hole–Martha's Vineyard ferry passengers as they wait for their ferry. The 31-minute, continuous loop broadcast features information about the Woods Hole scientific community, local history, and facts and figures about the ferry.
- Involvement in several annual educational events, including local science and technology fairs, career days at area high schools, conferences, and symposia.

WHOI Sea Grant Marine Extension Program

Dale F. Leavitt and James F. O'Connell, Woods Hole Oceanographic Institution and Cape Cod Cooperative Extension

Transferring the results of research and providing general marine-related information are important components of the Woods Hole Sea Grant Program. The following examples demonstrate how Woods Hole 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:

- Establishment of two series of fact sheets, one designed for coastal decision-makers and the general public *(Focal Points)*; the other designed for technical users *(Marine Extension Bulletins)*.
- *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.
- Establishment of two shellfish-related electronic mail groups to facilitate communications among the shellfish growers and among the local shellfish regulatory agencies within southeastern Massachusetts.
- Workshops, courses, tours, and site visits 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 or participated in the following: shellfish culture techniques (course), fish farming within a cranberry bog (workshop), restocking programs (pilot projects), new aquaculture technology (demonstration projects), eelgrass restoration (workshop & demonstration projects), QPX research, dune and beach profiling techniques (field trips), bioengineering and coastal plants for shoreline stabilization (workshop), Northeast beaches (conference), hazard mitigation strategies (workshop), and others.
- Woods Hole 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.

Tracey Crago, Woods Hole Sea Grant

Two areas of particular interest in the region have served as the main focus areas of the Woods Hole Sea Grant Marine Extension Program:

Fishing and Aquaculture—Our fisheries and aquaculture outreach focuses on building partnerships and resource networks within the region to cover topics that the industry deems important. Working with the aquaculture industry and municipal shellfish management agencies in Massachusetts, the program has co-hosted workshops, courses, and tours of facilities to showcase the latest research and technology. Recent pilot projects aimed at assisting towns and private growers are focusing on increasing harvestable stocks of a variety of commercial shellfish species; restoring stocks that are suffering from declines, due to a variety of reasons; and improving fisheries habitat to provide appropriate conditions for shellfish to flourish.

Dale Leavitt, Woods Hole Sea Grant

▲ Bay scallop restoration efforts on Cape Cod require collaboration between Woods Hole Sea Grant Extension, Barnstable County, and town resource managers. This collaboration ensures that the latest technical information is applied to solve local problems.

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 function naturally to serve as the region's coastal hazards defense system, in addition to important recreational, wildlife habitat, aesthetic and economic values. However, these landforms have been and continue to be altered to accommodate coastal development. Our objective, therefore, is to assist the region in understanding, and thus sustaining, the beneficial functions of these landforms while accommodating human activities. Taking a hands-on approach, we work with individuals, groups, and government officials to gather baseline data to (1) document long- and short-term, as well as storm-induced changes to coastal landforms, (2) assess the effects and effectiveness or erosion control alternatives, and (3) use this information for improved resource and coastal development management. Our methods include one-on-one discussions, field visits and training, and workshops.

Jim O'Connell, Woods Hole Sea Grant

Jim O'Connell, Woods Hole Sea Grant

▲ Sea Grant's work with coastal residents and local officials to maintain beach and dune conditions contributes to more effective shoreline management in Massachusetts.

Sea Grant
Woods Hole

Woods Hole Oceanographic Institution Sea Grant Program

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