OVERVIEW

Estuarine and Coastal Processes

Over the past three decades, Woods Hole Sea Grant has invested in research, extension, and outreach in the programmatic theme area Estuarine and Coastal Processes. **This investment has resulted in better understanding of the physical, chemical, geological, and biological processes of coastal habitats.** This information has been applied to critical management decisions in the coastal zone including water quality issues, shoreline erosion and storm damage, and food web dynamics.

Why Estuarine and Coastal Processes?

Coastal ponds, estuaries, embayments, open coasts, and coastal resources are highly impacted by society's commercial, recreational, and residential activities. The economic stability of our coastal communities and the health of our coastal population depend on an understanding of the complex interactions of physical, chemical, geological, and biological processes in the near shore and estuarine environment. Furthermore, an understanding of this complex interaction between these natural processes is susceptible to forcing by adjacent marine, terrestrial, and meteorological systems, as well as human activity.

Tom Kleindinst, WHOI

An understanding of these systems is critical if we are to take action—or even know which actions to take—to sustain our vital coastal resources for future generations, particularly in light of explosive population growth in coastal communities. In southeastern Massachusetts, development in coastal communities was among the highest rate of increase within the Commonwealth of Massachusetts. The population of Barnstable County (Cape Cod), Dukes County (Martha's Vineyard), and Nantucket County increased by 19.1 percent, 28.8 percent and 58.4 percent, respectively, from the period 1990 to 2000, compared with a statewide increase of 5.5 percent for the same period.

Woods Hole Sea Grant Involvement

In Estuarine and Coastal Processes, Woods Hole Sea Grant has identified two priority areas that best fit within the academic and research environment within the region: **processes contributing to and the consequences of shoreline change**, and **water quality issues in coastal watersheds**. These areas are very important in the Commonwealth of Massachusetts and especially in southeastern Massachusetts, where

shoreline habitats represent one of the most important economic and aesthetic resources of Cape Cod and the Islands; yet, these same habitats are challenged by increased population growth in these coastal communities. *Thematic elements include*:

- Identification and characterization of the sources of nutrients to coastal watersheds;
- Development of innovative approaches for characterizing groundwater flow to coastal watersheds;
- Elucidation of processes related to nutrient enrichment and consequences of excess nutrients in coastal watersheds;
- Examination of processes related to contaminant fate and distribution in coastal embayments;
- Analysis of historical shoreline maps to determine the rate of shoreline change of the coastal habitats in Massachusetts; and
- Workshops for coastal managers dealing with protection of shoreline habitats and coastal watersheds.

INVESTMENT

Woods Hole Sea Grant's Investment, 2000–2006

Research Project Title	P.I.(s)	Years Funded
Mitigation of Fish-Killing Algal Blooms Using Clay (R/B-157)	Don Anderson and Mario Sengco, Woods Hole Oceanographic Institution (WHOI)	2000–2001
Controls on Nitrogen Fluxes from Estuarine Sediments: The Importance of Salinity (R/M-141)	Anne Giblin and Chuck Hopkinson, Jr., Marine Biological Laboratory	2000–2002
Demographic Analysis of the Northern Atlantic Right Whale (R/M-45)	Hal Caswell, WHOI	2000–2002
Post-Outfall Studies of Toxic Alexandrium *Populations in Massachusetts Bay* (R/B-158)	Don Anderson, Woods Hole Oceanographic Institution	2000–2002
The Recycling of Anthropogenic Metals in Massachusetts Bay Sediments: Assessing the Impact of the New Outfall (R/B-160)	Bill Martin, Roger François, and Raja Ganeshram, WHOI	2000–2002
Development of a Carbon Isotopic Method for Quantifying Groundwater Inputs to Estuaries (R/M-47)	Dan McCorkle, WHOI	2001–2003
Assessments of Economic Impacts and Evaluations of Rational Management Alternatives (R/M-48)	Porter Hoagland, Di Jin, and Hauke Kite-Powell, WHOI	2001–2003
Groundwater Discharge of Nutrients into Coastal Ponds as Traced by Radium Isotopes (R/M-46)	Matt Charette and Ken Buesseler, WHOI	2001–2002
Application of Radium Isotpic Approach for Water Mass Age: Implications for Estuarine Phytoplankton Blooms (R/M-49)	Matt Charette (WHOI); Ivan Valiela and Gabrielle Tomasky, Boston University	2002–2004
Effects of Varying Freshwater Discharge on Nitrogen Dynamics in the Oligohaline Regions of Estuaries (R/M-50)	Anne Giblin and Chuck Hopkinson, Jr., Marine Biological Laboratory	2002–2004
The Recycling of Anthropogenic Metals in Massachusetts Bay Sediments: Assessing the Impact of the New Outfall—Phase II (R/B-164)	Bill Martin and Roger François, WHOI	2002–2004
Near-Source Atmospheric Deposition as a Potential Nitrogen Source to Coastal Lagoons (R/P-70)	Eric Davidson, Woods Hole Research Center; Robert Howarth and Roxanne Marino, Cornell University	2004–2006
Development of an Autonomous Multi-Scale Digital Imaging System for Identification and Mapping of Aquatic Species (R/P-64)	Cabell Davis, WHOI	2004–2006
The Wild Harbor Oil Spill: Ecological Effects 30 Years Later? (R/P-67)	Ivan Valiela, Boston University Marine Program	2004–2006
Isotopic Tracers of Groundwater Discharge into Casco Bay, ME (R/P-65)	Dan McCorkle; WHOI, Ed Laine, Bowdoin College	2004-2006
Post-Depositional Remobilization of Trace Metals in the Sediments of Massachusetts Bay and Boston Harbor: Implications for the Fate of Anthropogenic Metals in the Coastal Environment (R/G-28)	Bill Martin and Roger François, WHOI; Mike Bothner and John Crusius, U.S. Geological Survey	2004–2006

In addition to the formal projects identified above, program development funds ("New Initiatives") have also been used to initiate new projects, provide opportunities for students to attend conferences to present their work, respond to emergency funding requests, jump-start a research program or test a new technique, and support workshops relevant to the research conducted under this theme.

Research Support, 2000–2006

Sea Grant Funds:	**$1,773,555**
Matching Funds:	**$1,005,507**
TOTAL:	**$2,779,062**

Student Support, 2000–2006

Graduate Student Support:	**14 Students**	**86 Months' Student Support**
Undergraduate Student Support:	**2 Students**	**6 Months' Student Support**

PROFILE – Mario Sengco

Ashaio Li

Clay mixed with seawater, is sprayed into the water column, where the clay particles bind with harmful algae organisms and then sink to the bottom.

Mario Sengco knows a lot about clay. As a marine biologist, that may seem extraneous to his work with harmful algal blooms (HABs), but it turns out that clay is the key ingredient in a recipe that the Koreans, Japanese, and Chinese have been using for over a decade to manage and control red tide.

Sengco, a former WHOI post-doc, came to the MIT/WHOI Joint Program in Applied Ocean Science and Engineering to work with Don Anderson, one of the world's leading HABs experts. He had just begun his graduate work when Anderson learned about the use of clay as a HABs mitigation tool from Asian colleagues. Sengco was intrigued by the concept.

Native clays, identified for their success at removing cells from each of four toxic algae tested, were used in the study.

In laboratory experiments designed to mimic field conditions, results showed that the clay removes 80-90 percent of the toxins in 2-hour treatments. "While this knocks the remaining population down to lower levels," explained Sengco, "we wonder, from a practical perspective, is 80-90 percent removal enough?"

In additional laboratory studies supported by Woods Hole Sea Grant, researchers saw no permanent adverse effect on juvenile salmon treated with clay for relatively long periods with high doses. Sengco said the use of clay to mitigate HABs is used routinely in Asia—primarily for aquaculture operations—which supply approximately 30 percent of the region's fish. In the U.S., the concept has yet to catch on, due in large part to environmental concerns such as water quality.

Research Dividends, 2000–2006

Research Highlights

- Woods Hole Sea Grant-supported scientists mapped coastal wetlands vegetation and employed stratigraphic analysis to examine different layers of sediments to illustrate the rapid changes in sea level rise that have occurred during the past century. These changes suggest a 10–20-year lag in the response of the oceans to atmospheric temperature forcing.
- Demographic population models for the right whale demonstrated that adult survival is the key to management of this endangered species. Preventing the death of as few as two females per year from entanglement or ship strikes could stabilize the now-declining population in Massachusetts waters.
- Isotopic tracers have been used to map the early effects of nutrient enrichment and the effect of groundwater flow on the nutrient and freshwater budgets of coastal ponds. Using the stable isotope signature of nitrogen as a tracer, scientists have examined the effects of wastewater nitrogen on coastal food webs and the relative contribution of wastewater nitrogen to the nitrogen budget of coastal watersheds. This information allows coastal managers to assess the impacts of nutrient enrichment on coastal embayments.

Timing is Everything: The Importance of Salinity to Estuaries

by Tracey Crago

Chuck Hopkinson, Jr.

Woods Hole Sea Grant researchers Anne Giblin and Chuck Hopkinson, Jr., of the Marine Biological Laboratory (MBL), have been studying the marshes of Massachusetts' north shore to look at the effects of freshwater discharge on the nitrogen dynamics of estuarine systems.

"Salinity changes in the overlying water can have a profound effect on both the timing and magnitude of benthic nitrogen release," says Giblin. Could the region's numerous intertidal marshes—considered a net sink for nitrogen due to denitrification and burial—also act as a source of nitrogen in the summer, when salinity is higher? It turns out that they can.

Increased salinity, researchers found, causes adsorbed ammonium to be released from the sediment—most notably during inundation at high tides. Through diffusion and convection, it becomes available in the water column where it could stimulate a phytoplankton bloom.

Their findings, says Giblin, speak to the importance of hydrological manipulation within estuarine systems. For example, a model of the nitrogen cycle could be used to assess the impact of water withdrawal or addition on the watershed and to look at storm and drought events.

What's more, says Giblin, the hydrologic conditions of an estuary could play a role in enhancing or retarding eutrophication. "This model could be a powerful management tool for estuaries like the Parker River, where there is some control over the freshwater inputs on a seasonal basis, to help better manage estuaries to minimize eutrophication problems."

- Studies supported by Woods Hole Sea Grant conducted before and after the new ocean outfall from the City of Boston was put in place have been critical in determining the effects of improvements in wastewater treatment and disposal to Massachusetts Bay. In collaboration with the Massachusetts Water Resources Authority, scientists have evaluated the fate of nutrients, trace elements, and other contaminants—and the consequences related to such discharges—as the location of the outfall shifted from near shore to nine miles offshore. The results of these pre- and post-outfall studies have been used to guide the design of the outfall monitoring program.

How One Thing (Nitrogen) Leads to Another (Shellfish Growth)

by Tracey Crago

Ruth Carmichael

Worldwide, changing land usage and increasing populations threaten coastal resources by increasing nitrogen inputs from atmospheric deposition, fertilizers, and wastewater. On Cape Cod, wastewater is the primary contributor of nitrogen to local estuaries, transported via groundwater.

This nitrogen leads to increases in algae in the water column and an accumulation of organic matter in the sediments, decreasing oxygen in near-bottom waters. Studies by Ivan Valiela, professor at Boston University Marine Program (BUMP), have demonstrated effects of excess nitrogen, including changes in benthic species and finfish communities. But what happens, wondered BUMP graduate student Ruth Carmichael, to the shellfish?

Carmichael selected eight Cape Cod estuaries that offered a range of N loads in which to look at the effects of N loading on shellfish food supply and habitat as well as shellfish growth and survival. Her results indicated an increase in the amount and quality of food available to shellfish as N loads increased. She also observed that the primary effects of N loading appear to be that the clams are reaching maximum size faster. But Carmichael wondered if there were secondary effects of nutrient enrichment that might ultimately limit the potential for growth, despite increased food supply.

Salinity turned out to be a factor: in the two estuaries where clams showed depressed growth, salinity measurements were frequently less than 20 parts per thousand. Such conditions may mean that animals pump food from the water column less rapidly and thus feed less efficiently, says Carmichael.

In another experiment, Carmichael found that, even though there was more overall food available, N loading may change the relative abundance of different food particles. “N-enriched estuaries,” says Carmichael, “have relatively fewer food components assimilated—and perhaps preferred or selected—by shellfish.”

Carmichael is careful to point out that her work should not be taken out of context. “Nitrogen is an important estuarine resource,” she says. “It stimulates primary and secondary production; it’s a natural part of the system. Finding a balance between the conflicting effects of increased nitrogen loading to coastal embayments is an important management consideration.”

Research Publications, 2000–2006

International Invasive Sea Squirt Conference: Program and Brief Abstracts
Whitlach, B. (ed.)
59 pp., 2005 WHOI-W-05-001

Assessment of a $\delta^{15}N$ Isotopic Method to Indicate Anthropogenic Eutrophication in Aquatic Ecosystems
Cole, M.L., I. Valiela, K.D. Kroeger, G.L. Tomasky, J. Cebrian, C. Wigand, R.A. McKinney, S.P. Grady, and M.H. Carvalho da Silva
J. Environ. Qual., Vol. 33, pp. 124-132, 2004
WHOI-R-04-001

Nitrogen Loading to Pleasant Bay, Cape Cod: Application of Models and Stable Isotopes to Detect Incipient Nutrient Enrichment of Estuaries
Carmichael, R.H., B. Annett, and I. Valiela
Elsevier, *Marine Pollution Bulletin*, Vol. 48, pp., 137-143, 2004 WHOI-R-04-002

Salt Marshes: Biological Controls of Food Webs in a Diminishing Environment
Valiela, I., D. Rutecki, and S. Fox
Journal of Experimental Marine Biology and Ecology, Vol. 300, pp. 131-159, 2004
WHOI-R-04-003

Elm, an Estuarine Nitrogen Loading Model: Formulation and Verification of Predicted Concentrations of Dissolved Inorganic Nitrogen
Valiela, I., S. Mazzilli, J.L. Bowen, K.D. Kroeger, M.L. Cole, G. Tomasky, and T. Isaji
Water, Air, and Soil Pollution, Vol. 157, pp. 365-391, 2004 WHOI-R-04-004

Estuarine Respiration: An Overview of Benthic, Pelagic, and Whole System Respiration
Hopkinson, Jr., C.S. and E.M. Smith
In: P. del Giorgio and P.J. leB. Williams. *Respiration of Aquatic Ecosystems of the World*, Academic Press, NY (328 pp)., pp. 122-146, 2004
WHOI-R-04-005

Gut-Associated Microbial Symbionts of the Marsh Fiddler Crab, *Uca Pugnax*
Gulmann, L.K
Doctoral Dissertation, MIT/WHOI Joint Program in Oceanography/Applied Ocean Science and Engineering, 159 pp., 2004 WHOI-X-04-001

New Interpretation of Glacial History of Cape Cod May Have Important Implications for Groundwater Contaminant Transport
Mulligan, A. and E. Uchupi
EOS, Transactions, American Geophysical Union, Vol. 84, No. 19, 3 pp., 2003 WHOI-R-03-001

Sampling Marine Pore Waters for Mn, Fe, U, Re and Mo: Modifications on Diffusional Equilibration Thin Film Gel Probes
Morford, J., L. Kalnejais, W. Martin, R. Francois, and I.-M. Karle
Journal of Experimental Marine Biology and Ecology, Vol. 285-286, pp. 85-103, 2003
WHOI-R-03-002

Sediment DIN Fluxes and Preferential Recycling of Benthic Microalgal Nitrogen in a Shallow Macrotidal Estuary
Tobias, C., A. Giblin, J. McClelland, J. Tucker, and B. Peterson
Marine Ecology Progress Series, Vol. 257, pp. 25-36, 2003 WHOI-R-03-005

Detection of Eutrophication in Aquatic Ecosystems: Nitrogen Stable Isotopes in Macrophytes and Groundwater
Cole, M.L.
Doctoral Dissertation, Boston University Graduate School of Arts and Sciences, 153 pp., 2003
WHOI-X-03-001

A Radiocarbon Method and Multi-Tracer Approach to Quantifying Groundwater Discharge to Coastal Waters
Gramling, C.M.
Doctoral Dissertation, MIT/WHOI Joint Program in Oceanography/Applied Ocean Science and Engineering, 347 pp., 2003 WHOI-X-03-002

Sea Grant
Woods Hole

Research Publications, 2000–2006

Ammonium Dynamics in Tidal Salt Marshes: An Experimental Study of Ammonium Adsorption, Tidal Flushing and Ammonia Volatilization
Koop-Jakobsen, K.
Master's Thesis, Roskilde University (Denmark), Department of Life Sciences and Chemistry, 3 pp. (abstract only), 2003 WHOI-X-03-004

Response of Growth and Density of a Population of *Geukensia demissa* to Land-Derived Nitrogen Loading, in Waquoit Bay, Massachusetts
Evgenidou, A. and I. Valiela
Estuarine, Coastal and Shelf Science, Vol. 55, pp. 125-138, 2002 WHOI-R-02-006

Tidal Flushing of Ammonium from Intertidal Salt Marsh Sediments: The Relative Importance of Adsorbed Ammonium
Koop-Jakobsen, K. and A. Giblin
Biol. Bull., Vol. 203, pp. 258-259, 2002 WHOI-R-02-008

Nitrogen Sources to Watersheds and Estuaries: Roles of Land Cover Mosaics and Losses within Watersheds
Valiela, I. and J.L. Bowen
Environmental Pollution, Vol. 118, pp. 239-248, 2002 WHOI-R-02-009

Mark-Recapture Statistics and Demographic Analysis
Fujiwara, M.
Doctoral Dissertation, MIT/WHOI Joint Program in Oceanography/Applied Ocean Science and Engineering, 138 pp., 2002 WHOI-X-02-001

Rapid Shoreward Encroachment of Salt Marsh Cordgrass in Response to Accelerated Sea-level Rise
Donnelly, J.P. and M.D. Bertness
PNAS, Vol. 98, No. 25, pp. 14218-14223, 2001 WHOI-R-01-003

Changes in the Metal Content of Surficial Sediments of Boston Harbor Since the Cessation of Sludge Discharge
Zago, C., A.E. Giblin, and A. Bergamasco
Marine Environmental Research, Vol. 51, pp. 389-415, 2001 WHOI-R-01-004

Demography of the Endangered North Atlantic Right Whale
Fujiwara, M. and H. Caswell
Nature, Vol. 414, pp. 537-541, 2001 WHOI-R-01-005

Hydrodynamic Controls on Multiple Tidal Inlet Persistence
Salles, P.
Doctoral Dissertation, MIT/WHOI Joint Program in Oceanography/Applied Ocean Science and Engineering, 272 pp., 2001 WHOI-Y-01-001

Accumulation of Red Tide Toxins in Larger Size Fractions of Zooplankton Assemblages from Massachusetts Bay, USA
Turner, J.T., G.J. Doucette, C.L. Powell, D.M. Kulis, B.A. Keafer, and D.M. Anderson
Marine Ecology Progress Series, 13 pp., 2000 WHOI-R-00-013

Estimated Annual Economic Impacts from Harmful Algal Blooms (HABs) in the United States
Anderson, D.M., P. Hoagland, Y. Kaoru, and A.W. White
WHOI Technical Report (WHOI-2000-11), 101 pp., 2000 WHOI-T-00-002

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Extension and Outreach Publications, 2000–2006

Gulf of Maine Marine Habitat Primer
Gulf of Maine Council on the Marine Environment
56 pp., 2005 WHOI-B-05-001

Cape Cod Landforms and Coastal Processes
O'Connell, J.F. (ed.)
Poster, 1 pp., 2004 WHOI-G-04-004

Beach and Dune Profiling: Training in the Use of the Emery and O'Emory Rod Methods
O'Connell, J.F.
DVD, approximately 48 minutes, 2004
WHOI-G-04-005

New Shoreline Change Data Reveal Massachusetts is Eroding
O'Connell, J.F.
Marine Extension Bulletin, 4 pp., 2003
WHOI-G-03-001

NEAS Key to Benthic Marine Algae of the Northeastern Coast of North America from Long Island Sound to the Strait of Belle Isle
Sears, J.R. (ed.)
161 pp., 2002 WHOI-H-02-001

New Shoreline Change Data and Analysis for the Massachusetts Shore with Emphasis on Cape Cod and the Islands: Mid-1800s to 1994
O'Connell, J.F., E.R. Thieler,and C. Schupp
Environment Cape Cod, Vol. 5, No. 1, pp. 1-14, 2002 WHOI-R-02-007

Stabilizing Dunes and Coastal Banks using Vegetation and Bioengineering: Proceedings of a Workshop held at the Woods Hole Oceanographic Institution, Woods Hole, MA
O'Connell, J.F. (ed.)
WHOI Technical Report. No. WHOI-2002-12, 119 pp., 2002 WHOI-W-02-001

Northeast Beaches: A Balancing Act
Urban Harbors Institute, UMASS
Conference Abstracts, 50 pp., 2002
WHOI-W-02-002

Beach and Dune Profiles: An Educational Tool for Observing and Comparing Dynamic Coastal Environments
O'Connell, J.F.
Marine Extension Bulletin, 6 pp., 2001
WHOI-G-01-001

Sustaining Coastal Landforms
O'Connell, J.F.
Focal Point, 3 pp., 2001 WHOI-G-01-002

Evaluation of Coastal Erosion Hazards: Results from a National Study and a Massachusetts Perspective
O'Connell, J.F.
Focal Point, 3 pp., 2001 WHOI-G-01-003

Mapping and Analyzing Historical Shoreline Changes in Massachus etts In: Proceedings of CoastGIS '01: Managing the Interfaces Conference, Halifax, Nova Scotia, Canada, June 18-20, 2001
Schupp, C.A., E.R. Thieler, and J.F. O'Connell
9 pp., 2001 WHOI-R-01-001

The Massachusetts Shoreline Change Project: 1800s to 1994
Thieler, E.R., J.F. O'Connell, and C.A. Schupp
Technical Report, 39 pp., 2001 WHOI-T-01-001

Can Humans & Coastal Landforms Co-exist?: Proceedings of a Workshop held at the Woods Hole Oceanographic Institution, Woods Hole, MA. January 24, 2001
O'Connell, J.F. (ed.)
WHOI Technical Report. No. WHOI-2001-14, 118 pp., 2001 WHOI-W-01-001

Shoreline Change and the Importance of Coastal Erosion
O'Connell, J.F.
Focal Point, 3 pp., 2000 WHOI-G-00-001

Theme Booklet: Estuarine and Coastal Processes
Woods Hole Sea Grant
4 pp., 2000 WHOI-G-00-005

Coastal Landform System Sustainability Project: An Analysis of Activities Permitted on Coastal Landforms on Cape Cod, Massachusetts in 1999
O'Connell, J.F.
58 pp., 2000 WHOI-T-00-001

IMPACTS

Estuarine and Coastal Processes Extension

Coastal development and multiple uses of the shore have dramatically increased in recent decades. Historically, local decision makers have approved shoreline construction and other activities with limited understanding of the interaction of human activities and coastal processes. Statewide, decision makers have not—until recently—had access to user-friendly shoreline change data. Along much of the Massachusetts coastline, this has resulted in the reduction of natural sediment supply to beaches, dunes, and barrier beaches, and accelerated erosion and degradation of these important resources.

Extension Support 2000–2006

Sea Grant Funds:	**$570,560**
Matching Funds:	**$183,540**
TOTAL:	**$754,100**

In the area of Estuarine and Coastal Processes, Woods Hole Sea Grant's priority areas for Extension are: **preserving and restoring the beneficial functions of coastal landforms; analyzing the effectiveness of coastal erosion control alternatives; producing and analyzing shoreline change data; and engaging citizens in gathering scientific data to gain a more in-depth understanding of coastal processes.**

Woods Hole Sea Grant's extension program is guided by the Marine Outreach Guidance Group (MOGG), an advisory committee comprised of members of Sea Grant's user community. The extension program is fully integrated with the Cape Cod Cooperative Extension Service and the University of Massachusetts Extension Program. With two full-time specialists—one in the area of Coastal Processes, the other in Fisheries and Aquaculture—and additional support from staff members from the Woods Hole Sea Grant Program and the County Extension Program, the Sea Grant Extension Program is well connected to its user groups and the communities it serves. In the area of Coastal Processes, staff members work with a diverse group of individuals, unified by their interest in preserving the Massachusetts shoreline. In addition, the program has a strong field research and technical assistance component focused on local, applied questions.

Woods Hole Sea Grant's Investments and Dividends, 2000–2006

Extension projects supported in 2000–06 have involved numerous partners and targeted wide-ranging issues and problems. These projects have yielded new techniques and tools, driven by the expressed needs of Sea Grant's identified user communities. A few highlights include:

Extension Goal

To maintain and restore the beneficial functions of coastal landforms, while balancing impacts of living along the shore.

Issue 1

Revetments are sometimes prescribed as a way to protect structures on eroding coastal banks. However, sediment eroding from these coastal banks provides the primary source of sand for the existence and beneficial functions of beaches, dunes and barrier beaches in Massachusetts.

Actions:

Woods Hole Sea Grant...

- Worked with the conservation commission in the Cape Cod town of Wellfleet to come up with ways to mitigate the adverse impacts of a proposed revetment in that community.
- Designed an innovative solution to offset the adverse impacts of a private homeowner's proposed revetment by calculating the volume of sediment eroding from the coastal bank and suggesting that this amount of sand be placed, periodically, over the proposed revetment, allowing it to enter the littoral system during a storm where it eventually provides material for fronting and adjacent beaches, dunes, and barrier beaches.
- Provided unbiased, technical information and served as a mediator between a private landowner (represented by a private consultant) and a town, resulting in a compromise that allows for the protection of private property while maintaining the important beneficial functions of coastal resources.

Eric Mitchell

Protecting waterfront development requires creative approaches that are based on site-specific conditions.

Eric Mitchell

Non-structural measures are preferable because they are less disruptive of the coastal system's natural function.

Dividends:

- The solution (to cover revetments with beach-compatible sand) represents a state of the art mitigation approach, retaining the beneficial function of a coastal bank that otherwise could be lost. This approach has already been applied in other coastal communities (Wellfleet and Eastham on Cape Cod), and is now being considered, case-by-case, in additional communities as Woods Hole Sea Grant is asked to review proposals that involve armoring (Plymouth).

- Woods Hole Sea Grant's ongoing technical assistance and workshops on coastal processes targeting coastal community conservation commissioners, consultants, and coastal homeowners have resulted in a better understanding of the role of coastal landforms. As a result of this understanding and education, these audiences have been, increasingly, willing to consider, and in many cases agree to, added expenses and/or orders of conditions for solutions that represent a more sustainable, long-term approach to coastal processes management.

Woods Hole Sea Grant Workshops	Year
Can Humans & Coastal Landforms Co-Exist?	2001
Coastal Construction Workshop *Co-sponsors:* FEMA, DEM Flood Hazard Management Program, and the N.E. Floodplain Managers Association	2001
Stabilizing Dunes and Coastal Banks Using Vegetation and Bioengineering	2002
Northeast Beaches: A Balancing Act *Co-sponsors:* WHOI Coastal Ocean Institute, USGS, WBNERR, MCZM, NE Shore & Beach Preservation Association, Urban Harbors Institute, and Mass. Audubon Society	2002
Coastal Engineering Manual (CEM) Workshop *Co-sponsors:* Boston & American Society of Civil Engineers, Army Corps of Engineers	2003

Issue 2

Erosion control alternatives vary from low-tech to high-tech, with price tags ranging from expensive to prohibitive for waterfront homeowners. Understanding erosion control options—and the suitability and effectiveness of these alternatives for specific situations—is critical for local decision-makers whose decisions ultimately impact the long-term sustainability of coastal landforms.

Actions:

Woods Hole Sea Grant...

- Conducts reviews of various coastal erosion control projects to create awareness of options and to document their effectiveness and suitability in various conditions.
- Compares, documents, and presents findings related to the performance of many coastal erosion control alternatives through workshops, field trips, and discussions with towns, landowners, and private consultants.
- Provides a forum for information exchange and an opportunity to share on-the-ground experiences on the effectiveness and suitability of alternatives at specific locations based on local conditions.
- Generates workshop proceedings, technical reports, and web-based information regarding erosion control alternatives that is widely distributed and easily accessible.

Dividends:

- Providing information on erosion control alternatives has resulted in improved decision-making, better informed coastal decision-makers, and improved policies at the local level. The Cape Cod communities of Wellfleet, Eastham, Orleans, Brewster, and Falmouth, as well as the Cape Cod Commission, a regional planning agency, have adopted the policy of requiring or considering non-structural erosion control as a first measure, and also require mitigation for armoring coastal banks.
- Analyzing erosion control alternatives and providing unbiased, technical analyses to promote and preserve the beneficial functions of coastal resources can result in savings to homeowners and towns by:
  - ❖ Providing storm and flood protection. Property damage from flooding now totals over $1 billion each year in the U.S. In Massachusetts alone, there has been over $197 million paid in flood insurance claims since 1978, and an estimated $108 million worth of damage to public property. In 2001, late winter floods caused nearly $8 million in flood and storm damage along the coastline. (Source: Northeast States Emergency Consortium (NESEC) and *Natural Hazards Mitigation Planning: A Community Guide* (MA), 2003)
  - ❖ Preserving one of the most valuable Cape Cod tourist attractions: the beach. Nearly one-fifth of all domestic visitors to Massachusetts go to Cape Cod and/or the islands of Martha's Vineyard and Nantucket. Of those, 48 percent go to the beach. Of Massachusetts' residents, 46 percent visit the coast each year. (Source: The Massachusetts Ocean Management Task Force Technical Report, *Trends in the Demographics of Human Population and the Massachusetts Marine Economy*, 2004)

Jim O'Connell, Sea Grant/CCCE

The primary source of sand that allows for the existence of beaches, dunes, and barrier beaches comes from eroding coastal banks.

Jim O'Connell, Sea Grant/CCCE

Preventing a sand source from eroding, as shown here, will cause accelerated erosion of the shoreline.

Technical Assistance Key Role of Sea Grant Extension Agents

by Kate Madin

When Stacey Justus, hazard mitigation planning specialist with the Cape Cod Commission, needs a specialist to help evaluate proposals, she calls on Jim O'Connell, a former Commission staff member and now coastal processes specialist with Woods Hole Sea Grant and Cape Cod Cooperative Extension. The Commission is a regional planning agency put in place to implement land use policy, review and regulate Developments of Regional Impact, and recommend designation of Districts of Critical Planning Concern. Justus has worked with O'Connell on two recent projects:

The town of Eastham brought a proposal before the Commission that required regulatory review for an ocean beach project. O'Connell's expertise in coastline change was essential during the two-year review process, according to Justus. His contributions included application review, explanations of erosion rate documentation, and comments on potential impacts based on those rates. "There would have been no other way for us to get that type of expertise into our review if he weren't there in the positions of County and Sea Grant Extension."

The second project was a pre-disaster mitigation planning project that the Commission undertook for all of Barnstable County. Funded by FEMA, the Commission was asked to generate a pre-disaster hazard mitigation plan for natural disasters, and to help each town create local plans. O'Connell participated extensively, identifying hazards and regional issues of concern and going with Justus to meet with town officials. He acted as regional advisor and technical consultant on local issues at a town level, helped write the county plan, and drafted the section on shoreline change. Even further, he completed and contributed his own data, and shoreline change rate maps, in order to help the Commission and town officials identify how change rates affected each town.

"We wouldn't have been able to do this without Jim," says Justus. "It's one thing to know and present the science, but to have a person who can go out to the community and help them make sense of the science is another thing entirely. That kind of practical experience—and personality—is really needed."

Extension Goal

To involve and educate local citizens in the process of monitoring shoreline change.

Issue 1

While many citizens are aware of the dynamic nature of coastal landforms—through personal observations, media reports, and anecdotes—quantifying their observations is critical and will lead to better stewardship of coastal resources.

Actions:

Woods Hole Sea Grant...

- Woods Hole Sea Grant, in partnership with Cape Cod Cooperative Extension, began a training program for volunteers to conduct beach and dune profiling at several beaches in southeastern Massachusetts. The program now comprises approximately 80 volunteers—including citizens, town officials, private consultants, and students—capturing profiles on 11 beaches in 7 communities.

- The data being generated are used for a variety of scientific, technical, and educational purposes, including:
  - ❖ tracking the fluctuation of various beach reference features (i.e., mean high water contour, dune vegetation line, zero foot contour) to help determine uncertainty ranges of long-term shoreline change data,
  - ❖ tracking the performance of small beach nourishment projects, and
  - ❖ measuring accumulation of sand at sand/snow fences.
- A training DVD (*Beach and Dune Profiling: Training in the Use of the Emory and O'Emory Rod Methods*, 2005) and related Sea Grant Marine Extension Bulletins have been generated and distributed to citizen groups, local officials and schools.

Dividends:

- Sea Grant/Cape Cod Cooperative Extension's beach and dune profiling program captures on-the-ground beach and dune change data at all times during the year (winter/summer), and following storms. These data show actual quantified changes, leading to a more literate and better-informed citizenry. In one example, beach profiling participants from the Quivet Neck Homeowner's Association in East Dennis noted a lack of sand accumulation on their private and public beaches, resulting, in part, from a nearby jetty. They also noted that sand dredged from the adjacent chan-

Jim O'Connell, Sea Grant/CCCE

Even in winter, volunteers from the Cape Cod town of Dennis measure sand at beach access ways.

Beach and Dune Profiling Meets the Press
Training in the Use of the Emory & O'Emory Rod Methods DVD
Woods Hole Sea Grant Extension Bulletin: *Beach and Dune Profiles*: *An Educational Tool for Observing and Comparing Dynamic Coastal Environments*
"Documenting short-term variability of beach reference features using a volunteer beach and dune profiling program in Massachusetts," Coastal Zone '05 *(Proceedings on the 14th Symposium on Coastal and Ocean Management)*
"The art and science of mapping and interpreting shoreline change data: the Massachusetts experience," Coastal Zone '03, (*Proceedings on the 12th Symposium on Coastal and Ocean Management)*
"Beach and dune profile monitoring: A Massachusetts citizen monitoring effort to document short-term changes to beaches and dunes," (poster), 8th Annual Cape Cod Natural History Conference, 2003
Articles, Interviews for several local, regional media: **Newspapers** including *Patriot Ledger, Cape Cod Times, The Boston Globe, Cape Codder, Cape Cod Chronicle*, and *Nantucket Inquirer and Mirror*. **Radio:** WCAI-FM and WNAN-FM (local NPR stations) **Magazines, Newsletters:** *The Volunteer Monitor, Environment Cape Cod, Martha's Vineyard Magazine* **Television:** Chronicle (news magazine; WCVB-TV, Boston Channel 5, 2004 and 2005)

nel had been disposed of in the near shore, rather than on the eroding beach they were profiling. The group suggested that placement of the dredged sand be a point of consideration in the beach and dune profiling report. These citizens have become active stewards for the protection of their coastal resources.

- Standardized data collection procedures have yielded data that has been used to make comparisons, monitor short-term trends, and document storm-induced changes. Results from this work have been featured in numerous publications and presentations, for lay audiences, technical staff, and coastal decision makers.
- At Chatham's Cockle Cove, data collected on the residence time of sand from a beach nourishment project have supported the project's economic viability and contributed to a greater understanding of such projects.
- In the Cape Cod town of Dennis, volunteers measured sand accumulation at beach access ways to help the town's beach and recreation departments justify the practice—and related expenses—of purchasing and installing sand/snow fences and re-configuring the accumulated sand onto the nearby public beach.

Volunteers Measure Nantucket's Shoreline Change

by Kate Madin

Jim O'Connell, Sea Grant/CCCE

Extension agent Jim O'Connell travels to Nantucket every three months to assist with the beach and dune profiles,

As director of the University of Massachusetts Boston's Nantucket Field Station, Dr. Sarah Oktay oversees research, training, and educational outreach programs on topics including erosion, biology, biodiversity, climate, pollution, and water quality.

Erosion is a hot topic on Nantucket, where erosion rates rank highest among Massachusetts' communities: the island's south shore loses an average of 12 feet per year. Oktay frequently consults with Jim O'Connell, coastal processes specialist for Sea Grant and Cape Cod Cooperative Extension, relying on his expertise in shoreline change issues. O'Connell, says Oktay, is "an incredible help and a great resource for erosion on the island."

Working together, they set up a citizen beach and dune profiling project on Nantucket—a program that has become popular with participants and visitors alike. The program has now accumulated nearly two years' of data, which Oktay used to create a poster illustrating the changes to Nantucket's shoreline. She says the poster has been useful for public officials and legislators "to show them that people can do and understand science."

When Oktay speaks to newspaper reporters, she often refers their questions about coastal change to O'Connell, who "is always willing to make a huge effort to get there and help them." She receives 10-15 requests a week for information about coastal erosion, including requests from other researchers, many of whom she also refers to O'Connell. "I wish I could clone him," says Oktay. "I wish I had 20 other scientists just like Jim, who is so personable and available. I consider Jim a poster child for the best way for scientists to interact with the public."

Sea Grant
Woods Hole

Extension Goal

To quantify and reduce the risks associated with living along the shore.

Issue 1

Shoreline change data are used to assist homeowners and local and state officials involved in locating shoreline construction and relocation projects. Prior to 2002, the last plotted shoreline for Massachusetts was from 1978, data rendered questionable because it was plotted following a major storm along the eastern shore.

Action:

Woods Hole Sea Grant...

- In collaboration with the U.S. Geological Survey, Cape Cod Cooperative Extension, and Massachusetts Coastal Zone Management, completed the updating and documentation of shoreline change and susceptibility to loss from erosion on a statewide basis.
- Used digital orthophotos to generate and plot a new (1994) shoreline that was added to an existing historic shoreline change database. Statistics of shoreline change were generated on a lot-by-lot basis along 850 miles of ocean-facing shore.

Dividends:

- Towns in Massachusetts are updating their local pre-disaster mitigation plans, including updated shoreline change data.
- Large format shoreline change maps (orthophotos) and accompanying shoreline change data were issued to all 78 Massachusetts coastal communities.
- Communities can use the data to help make informed decisions about permitting construction in coastal areas. For example, the Cape Cod Commission's Regional Policy Plan requires that new construction be placed in a location back from the shore or eroding coastal bank, equal to 30 times the long-term average rate of erosion. The Commission requires that this policy be adopted into the local comprehensive plans of all 15 Cape communities. Rates used in this policy resulted from data generated by this project.
- Shoreline change data has been incorporated as a part of the Massachusetts Hazard Mitigation Plan, Barnstable County All Hazards Pre-disaster Mitigation Plan, as well as all local Pre-disaster Mitigation Plans.
- Shorefront property owners now have access to a user-friendly resource that provides lot-specific information on shoreline dynamics; ultimately, this resource can be used by homeowners and municipal officials for making more informed decisions about construction on shorefront property, potentially minimizing economic losses.

Sea Grant
Woods Hole

Issue 2

Damage to property and natural resources in coastal high hazard areas is exacerbated by poor land-use and construction practices, which in turn impact the economic, aesthetic, and public safety values in these areas. These impacts are cumulative. Strengthening local standards to protect the beneficial functions of coastal resources in the 100-year coastal floodplain, and mitigating for present flood-related impacts, enhances community public safety, and economic and aesthetic values.

Jim O'Connell, Sea Grant/CCCE

Elevating waterfront structures on open pilings, while protecting the structures from storm waves, will not prevent erosion-related damages.

Action:

Woods Hole Sea Grant...

- Participated on a working group that generated technical standards for activities proposed in coastal floodplains. Where adopted and applied, these standards leadto construction practices that preserve the benefits of coastal floodplains in their natural state: storm damage prevention, flood control, wildlife habitat, and pollution prevention.
- Participated in Barnstable County's All Hazards Pre-disaster Mitigation Planning effort, coordinated across all 15 Cape Cod communities by the Cape Cod Commission.

Dividends:

- In 2002, the regional planning agency for Barnstable County, the Cape Cod Commission, revised and updated their regulatory standards for reviewing activities in "land subject to coastal storm flowage" (the 100-year coastal floodplain) in concert with the working group recommendations. All 15 Cape Cod communities are required to prepare 'local comprehensive plans' incorporating standards in the Commission's Regional Policy Plan; to date, all Cape communities have adopted the recommended standards for land subject to costal storm flowage in their plans.
- Community-specific standards based on shoreline change, relative sea level rise, and coastal landform function have been articulated in each local comprehensive plan. Additionally, potential projects have been identified that, if implemented, will reduce the potential for future flood and erosion-related damage. Currently, 12 of the 15 Cape communities have completed—and received FEMA approval for—their hazards pre-disaster mitigation plans and are eligible for federal pre-disaster mitigation funds to construct projects that will reduce the potential for future flood-related damages.