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Woods Hole Sea Grant: Estuarine and Coastal Processes

Snapshot

WHOI Sea Grant's investment in estuarine and coastal processes 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.

Related Files

» PDF: Estuarine and Coastal Processes

Background

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

Objectives

WHOI Sea Grant's theme in Estuarine and Coastal Processes is consistent with the needs for better information on coastal habitats and societal pressures on the coastal zone. Within the framework of the NOAA Sea Grant Strategic Plan, 1995-2005, these efforts are focused on three major portfolios: Economic Leadership, Coastal Ecosystem Health and Public Safety, and Education and Human Resources. Within these portfolios there are major strategic initiatives in advanced technology for commercial products, seafood production, coastal economic development, coastal ecosystem processes, public safety, technology transfer, and public outreach.
To fulfill our objectives and mandate within the strategic plan, WHOI Sea Grant's theme in Estuarine and Coastal Processes has focused on:

- Improvement of our understanding of the processes that control water quality and sediment quality in coastal habitats;
- Characterization of sediment transport processes, especially in understanding the balance between erosion and deposition in coastal habitats;
- Implementation of better management policies for protection of shoreline habitats.

Sea Grant Involvement

Since 1990 the WHOI Sea Grant Program has played a major role in supporting multidisciplinary studies directed at understanding the potential effects of an offshore ocean outfall from the City of Boston, Massachusetts. In 1985 the Massachusetts Water Resources Authority (MWRA) was created to modernize water and sewer services in the metropolitan Boston area and to spearhead the cleanup of the harbor. Part of the cleanup plan is to discharge effluent through a 9.5-mile, 24-foot diameter outfall tunnel that will discharge effluents to Massachusetts Bay. When the offshore outfall was initially proposed, many questions were raised by local communities on the potential impacts of effluent discharge in the relatively pristine waters of outer Massachusetts Bay and Cape Cod Bay. To address these concerns, WHOI Sea Grant supported several investigations, beginning in 1992 and continuing until the present, directed at better understanding the potential effects that discharges from the new outfall may have on Massachusetts and Cape Cod Bays. These include studies of water circulation, nutrient enrichment, food web dynamics, and harmful algal blooms. WHOI Sea Grant will continue to support investigations on fundamental processes in the offshore habitats of Massachusetts and Cape Cod Bays when the outfall becomes operational in order to identify the natural variability in ecosystem parameters and help explain the trigger points of post-outfall effects.

Other studies of coastal processes supported by the WHOI Sea Grant Program have led to the development of new tools for assessing water quality conditions, new models that help explain the dynamics of barrier beaches and coastal lagoons, and a better understanding of historical patterns in sea level rise. Our coastal hazards outreach effort is directed at integrating a scientific understanding of the processes that maintain coastal landforms with the management concerns arising from the effects of these processes on coastal towns.

Producing Significant Results

Research Support

Controls on Nitrogen Fluxes from Estuarine Sediments: The Importance of Salinity, Anne E. Giblin and Charles S. Hopkinson, Marine Biological Laboratory Ecosystems Center (R/M-41)

Demographic Analysis of the Northern Right Whale, Hal Caswell, WHOI Biology Department (R/M-45)

Groundwater Discharge of Nutrients into Coastal Ponds as Traced by Radium Isotopes, Matthew A. Charette and Ken O. Buesseler, WHOI Marine Chemistry and Geochemistry Department (R/M-46)

Development of a Carbon Isotopic Method for Quantifying Groundwater Inputs to Estuaries, Daniel C. McCorkle, WHOI Geology and

Geophysics Department (R/M-47)

Post-Outfall Studies of Toxic Alexandrium Populations in Massachusetts Bay, Donald M. Anderson and Bruce A. Keafer, WHOI Biology Department (R/B-158)

The Recycling of Anthropogenic Metals in Massachusetts Bay Sediments: Assessing the Impact of the New Outfall, Roger Francois, Raja Ganeshram, and William R. Martin, WHOI Marine Chemistry and Geochemistry Department (R/B-160)

Dynamics of the Toxic Dinoflagellate Alexandrium in the Gulf of Maine: Source Populations and Downstream Impacts, Donald M. Anderson, WHOI Biology Department, and Jefferson T. Turner, University of Massachusetts-Dartmouth Biology Department (R/B-140)

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, Department of Geological Sciences (R/G-25)

Multiple Tidal Inlet Stability, David G. Aubrey, WHOI Geology and Geophysics Department (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, WHOI Biology Department, and Andrew R. Solow, WHOI Marine Policy Center (R/B-149)

Quantifying Flushing Rates of Estuaries, Wayne R. Geyer and James R. Ledwell, WHOI Applied Ocean Physics and Engineering Department (R/O-30)

Ecosystem Level Measurements of Denitrification in Estuaries, Anne E. Giblin and Charles S. Hopkinson, Marine Biological Laboratory Ecosystems Center (R/M-37)

A Stable Isotopic Approach for Early Detection of Wastewater Nitrogen in Estuarine Food Webs, Ivan Valiela, Boston University Marine Program (R/M-38)

Tidal Flat Deposition: Processes and Rheology, David G. Aubrey, WHOI Geology and Geophysics Department (R/G-21)

Ecologically Based Environmental Management, Brian L. Howes and Dale D. Goehringer, WHOI Biology Department (R/M-30)

Boundary Mixing in Massachusetts Bay, Wayne R. Geyer and James R. Ledwell, WHOI Applied Ocean Physics and Engineering Department (R/O-24)

Benthic Processing of Sewage Additions: Controls of Denitrification in High Energy Environments, Anne E. Giblin and Charles S. Hopkinson, Marine Biological Laboratory Ecosystems Center (R/P-56)

Toxic Red Tides in Massachusetts and Cape Cod Bays, Donald M. Anderson, WHOI Biology Department (R/B-112)

Economic Impacts of Harmful Algal Blooms, Yoshi Kaoru, WHOI Marine Policy Center, and Donald M. Anderson, WHOI Biology Department (R/S-24)

Benthic Processing of Sewage Additions: Role in Anoxia and Nitrogen Cycling, Anne E. Giblin and Charles S. Hopkinson, Marine Biological Laboratory Ecosystems Center (R/P-47)

Vertical Mixing Processes in Massachusetts Bay, Wayne R. Geyer and James R. Ledwell, WHOI Applied Ocean Physics and Engineering Department, and Graham S. Giese, WHOI Geology and Geophysics Department (R/O-17)

The Role of Colloids in Metal Transport in Coastal Waters, S. Bradley Moran, WHOI Chemistry Department (R/P-46)

Citizen's Monitoring Effort for Falmouth's Coastal Ponds, Brian Howes and Dale D. Goehringer, WHOI Biology Department (R/M-26)

Ecologically-Based Environmental Management, Brian Howes and Dale D. Goehringer, WHOI Biology Department (R/M-30)

Nitrogen Budget for a Eutrophic Salt Pond: Relative Importance of Benthic Regeneration and Groundwater Inputs, Brian L. Howes and John M. Teal, WHOI Biology Department (R/P-34)

Formation and Maintenance of Shore-Oblique Sand Ridges: Hydrodynamics and Sediment Transport, John H. Trowbridge, WHOI Applied Ocean Physics and Engineering Department, and David G. Aubrey, WHOI Geology and Geophysics Department (R/O-12)

Coastal Upwelling in Cape Cod Bay, Wayne R. Geyer, WHOI Applied Ocean Physics and Engineering Department, and Graham S. Giese, WHOI Geology and Geophysics Department (R/O-14)

Instrumental High Resolution, Long-Term Measurement of Primary Production and Oxygen Concentration in Eutrophic Coastal Ponds, Craig D. Taylor and Brian L. Howes, WHOI Biology Department (R/P-38)

Public Risk Perception and Coastal Flood Insurance, Yoshi Kaoru, WHOI Marine Policy Center, and Graham S. Giese, WHOI Geology and Geophysics Department (R/S-25)

An Optimal Risk Sharing Strategy for Marine Oil Transport, Di Jin and Hauke Kite-Powell, WHOI Marine Policy Center (R/S-28)

Estimating the Value of Marine Mining for Strategic Minerals Supply, James M. Broadus, WHOI Marine Policy Center (R/S-20)

Extension Support
WHOI Sea Grant Focal Points, fact sheets for legislators and coastal decision-makers:

- Cape Cod Coastal Erosion: A Case Study
- Shoreline Change and the Importance of Coastal Erosion
- Beach and Dune Profiles: An Educational Tool for Observing and Comparing Dynamic Coastal Environments
- The Massachusetts Bay Outfall

WHOI Sea Grant Marine Extension Bulletins, technical fact sheets for regional industry, agencies, and professional organizations:

- Perigean Spring Tides (Predicting Potential Disasters: How Tidal Information May Save you from a Coastal Crisis)

The following workshops:

- Coastal Landform Management in Massachusetts (1997)

The following programs or special events:

- Cape Cod Sustainable Landform Project -- quantification, on a town-by-town basis, the gains and losses of Cape Cod coastal landform sustainability resulting from decisions of local resource management agencies with recommendations on the administrative policies and procedure that have resulted in these gains and losses. (1996-present)
- "Coastal Landform Management in Massachusetts" Workshop (October 1997) and Proceedings
- "All-Cape Coastal Science Seminar Series" (1991-1994)
- Pond Watchers citizens water quality monitoring program (1987-1994)
- Coastal Studies Program for High School Students (1992-1994)

Contributions to the Scientific Community

Research projects supported between 1990-2000 have yield numerous advances and discoveries within the scientific community. A few highlights include:

- Sea Grant and municipal funding initiated a citizen's water quality monitoring program that sampled several coastal embayments in Falmouth, Massachusetts, to establish a baseline for nutrient inputs for each embayment. The monitoring program continues to gather information and provide the town with important information about the health of these embayments and the impact on these embayments by natural and human inputs to these systems. A key decision relating to sewering one of the villages hinged upon the data and analysis by scientists and community water quality volunteers.
- Several projects related to the ocean outfall for Boston, that will eventually discharge sewage into Massachusetts Bay, have yielded important baseline data about the Massachusetts Bay and Cape Cod Bay systems. For example, Sea Grant supported studies have gathered data on the ability of the benthic community to process sewage-derived nutrients, vertical and horizontal mixing processes in Massachusetts and Cape Cod Bays, and relationships between increased nutrients and incidence of harmful algal blooms (HABs).
- Investigators have used stable isotopes to study wastewater nitrogen in estuarine food webs and found that waste water derived nitrogen is assimilated into various trophic levels.
- Studies of New England salt marshes using radiocarbon dating of marsh peat and examination of historical records of marsh vegetation imply a region-wide change in sea level is likely the cause of recent patterns in flooding regime and corresponding increases in sea level rise. This transgressive trend is unprecedented in the recent geologic past. Additionally, investigators concluded that an increase in sea level should be anticipated in coming decades.
- An in-depth analysis of status and projections for the northern right whale, a critically endangered species, is forthcoming.

Investment in Education

Graduate Student Support: 15 students; 54.5 months
Undergraduate Student Support: 2 students; 9.5 months

What it Cost

Research Support (1990-2000):

Sea Grant Funds: $2,663,235
Matching Funds: $1,909,350
Total: $4,572,585

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Mail: Woods Hole Oceanographic Institution, 266 Woods Hole Road, Woods Hole, MA 02543, USA.
E-Contact: info@whoi.edu; press relations: media@whoi.edu, tel. (508) 457-2000
Problems or questions about the site, please contact webdev@whoi.edu