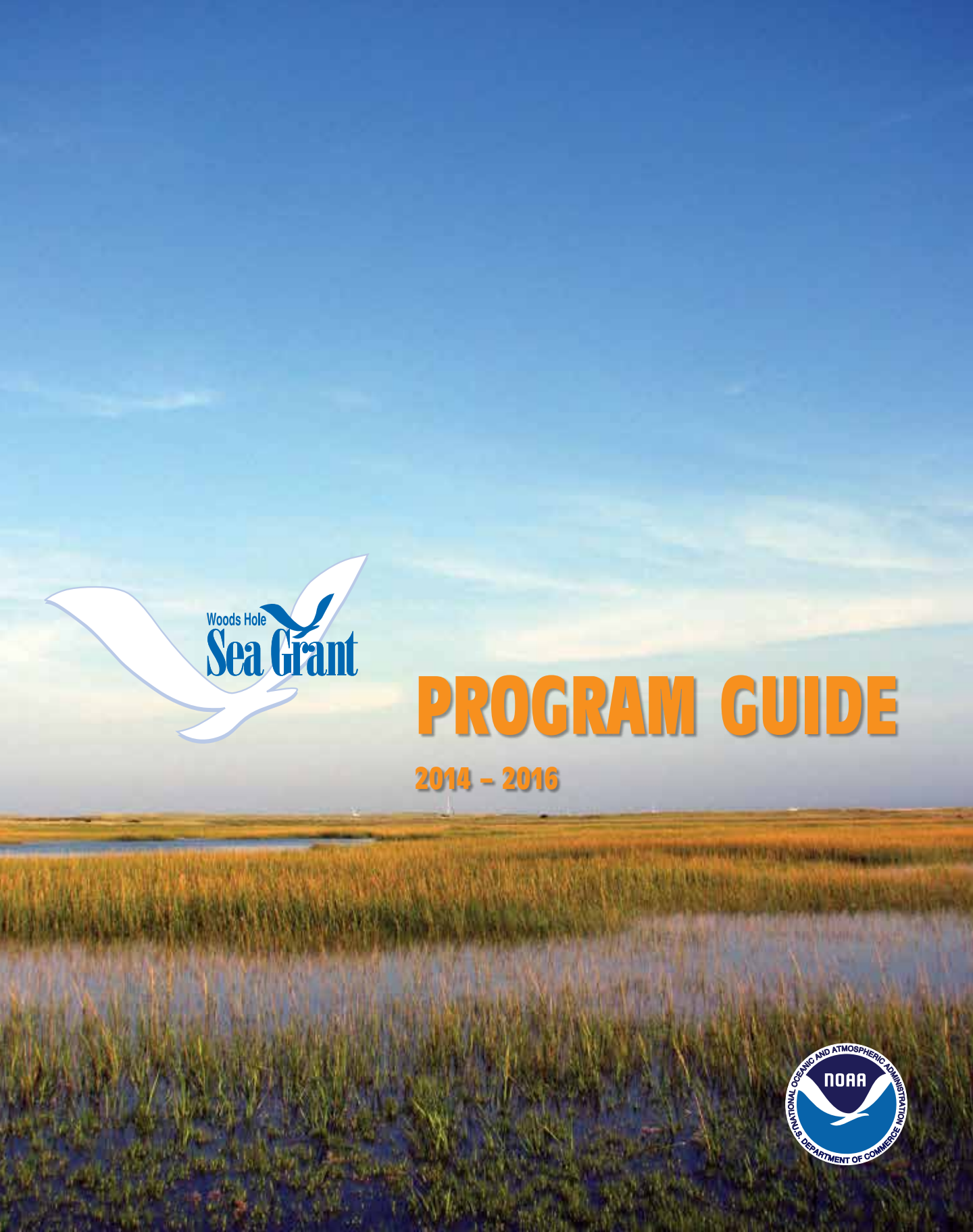

Woods Hole
Sea Grant
PROGRAM GUIDE
2014 – 2016
NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

Projects supported during the 2014-2016 funding cycle were selected to meet some of the objectives outlined in Woods Hole Sea Grant's new strategic plan—*Woods Hole Sea Grant in the 21st Century: Issues, Opportunities and Action for Massachusetts 2014-2017*. This plan addresses local, regional, and national issues and opportunities over the next several years and identifies ocean and coastal issues of importance, institutional resources, and potential partnerships in the Commonwealth of Massachusetts and the Northeast region of the United States. The major themes within this plan include:

Healthy Coastal Ecosystems

Sustainable Fisheries and Aquaculture

Resilient Communities and Economies

Environmental Literacy and Workplace Development

In developing the program portfolio for 2014-2016, consideration was given to scientific merit, relevance to meeting the goals of the strategic plan, the degree of community concern, the relevance to the National Sea Grant College Program goals, the opportunity for inter-agency collaboration, and the degree of public benefit. Issues and opportunities were also assessed on the basis of their relevance to other agency goals and strategic plans.

Judith E. McDowell, Director

Woods Hole Sea Grant

Introduction

During the 2014-2016 funding cycle, the Woods Hole Sea Grant Program is supporting 17 concurrent research projects (including three regional projects supported by the Northeast Sea Grant Consortium and one project supported by the Aquaculture NSI), 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: Healthy Coastal Ecosystems, Sustainable Fisheries and Aquaculture, Resilient Communities and Economies, and Environmental Literacy and Workplace Development. 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 vibrant marine extension program and a communications, public outreach, and education program. During the 2014-2016 biennium, the program will support additional research efforts funded under peer-reviewed regional and national competitions.

Major by-products of Woods Hole Sea Grant projects include publications, workshops, and presentations. Since 1971, programmatic support has resulted in more then 1,100 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, Clark University, Cornell University, Dauphin Island Sea Lab, Duke University, Northeastern University, University of Massachusetts at Boston, University of Massachusetts at Dartmouth, University of Rhode Island, Roger Williams University, U.S. Geological Survey, Virginia Tech University, Waquoit Bay National Estuarine Research Reserve, Wells National Estuarine Research Reserve, Great Bay National Estuarine Research Reserve, Stellwagen Bank National Marine Sanctuary, University of Porto (Portugal), and University of Roskilde (Denmark), in addition to numerous federal, state, and local agencies and partners, and private individuals.

History

The Woods Hole 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 33 individual programs located in each of the coastal and Great Lakes states, as well as Guam, to foster cooperation among government, academia, industry, and the private sector.

Sea Grant's affiliation with the Woods Hole Oceanographic Institution 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 in channeling the expertise of world-renowned ocean scientists toward the goal of meeting the research and information needs of users of the marine environment. Public and private institutions throughout the Commonwealth of Massachusetts and the Northeast participate in the Woods Hole Sea Grant Program.

Coastal Processes

Woods Hole Sea Grant's Coastal Processes Extension program helps to identify the risks and impacts associated with the region's coastal natural hazards. Partners include the U.S. Geological Survey, Cape Cod Cooperative Extension, and the Massachusetts Office of Coastal Zone Management, Cape Cod Commission, Federal Emergency Management Agency and coastal communities throughout the Commonwealth of Massachusetts.

Mapping of Longshore Sediment Transport and Littoral Cells

Longshore sediment transport is one of the most important nearshore processes affecting beach morphology, and directly influences a particular shoreline's potential to accrete, erode, or remain stable. Woods Hole Sea Grant and Cape Cod Cooperative Extension are actively mapping longshore sediment transport and littoral cells across Cape Cod. Products will include presentations and a map booklet showing the results of the study and describing the value of this management approach. The purpose of these maps and report is to provide a qualitative understanding of the motion of water and sediment in the surf zone.

Off-Road Vehicle Corridor Surveys

Beaches, dunes and near-shore areas are the most dynamic areas on the face of the earth, changing constantly in response to winds, waves, tides, storms, relative sea level rise, and human activities. These complex systems are often not well understood or documented, and some of the uses may degrade the resource. Off-Road Vehicles (ORV) are one use that has the potential to cause harm if the designated corridors are not maintained in the proper position. Woods Hole Sea Grant, working with Cape Cod Cooperative Extension, provides direct field assistance to local natural resource managers in order to map ORV corridors for public beaches, as well as follow up surveys. The results show how these dynamic systems need to be monitored during the season in order to reflect the current conditions of the resource. Reports and presentations, along with recommendations to follow an objective scientific methodology, are provided to natural resource departments, conservation commissions, and other stakeholders.

Town and Regional Technical Assistance

Woods Hole Sea Grant's coastal processes outreach focuses on providing the most up-to-date scientific and technical information relating to erosion control, flooding, human impacts on the beneficial functions of coastal landforms, relative sea level rise, and other coastal issues. We routinely work in the field with local officials across Cape Cod, the Islands and Southeastern Massachusetts, identifying and suggesting alternatives to minimize potential impacts from proposed shoreline development. We also provide workshops, field trips, training, lectures and one-on-one advisements.

Fisheries and Aquaculture

Woods Hole Sea Grant works with coastal communities to better inform decisions concerning living natural resources, through education, outreach, and applied research. With a focus on shellfish (important both commercially and recreationally) and nearshore coastal issues (e.g., eelgrass and water quality), we serve a diverse group including commercial shellfishermen, aquaculturists, natural resource managers, researchers, and members of the general public. The program partners with Cape Cod Cooperative Extension, the Southeastern Massachusetts Aquaculture Center, and the Barnstable County Shellfish Advisory Committee.

Oyster Restoration

In response to dwindling numbers of oysters, Woods Hole Sea Grant has worked with Cape Cod Cooperative Extension to restore banks of oysters along the shores of Cape Cod. Juvenile oysters, spawned in a hatchery and attached to pieces of shell, have been deployed in 11 towns. These oysters provide valuable habitat and may improve water quality, and eventually a nice catch for fishermen. Working closely with natural resource managers,

'living shorelines' are also being developed through the use of remote-set oysters, designed to stabilize the shoreline by ameliorating the effects of wind and water currents.

Eelgrass Restoration

To stem the tide of decline of eelgrass beds across the region, the program is exploring several methods of restoration of susceptibility of this valuable habitat. Most recently, ten potential areas for eelgrass restoration were explored and assessed for suitability. Three sites were chosen for exploring two methods of transplantation—clump vs. horizontal rhizome method. Pending the outcome of the test plantings, one or more of these sites may be chosen for larger scale restoration efforts.

Assessment of Shellfish Habitat

Woods Hole Sea Grant has helped to develop a simple, inexpensive means of assessing and comparing habitats in terms of shellfish survival and growth. This tool, now in its twelfth year of use, allows shellfish growers and natural resource managers to identify optimal sites for shellfish; it also provides a comparison within the region and across years. This tool has been used along the Massachusetts coastline and is now available on a training DVD to interested parties.

Management of Shellfish Diseases

Several diseases affect shellfish within this region. Although these diseases do not affect humans, they pose a significant hurdle to shellfish farmers and to sustainable management of the public shellfisheries. Woods Hole Sea Grant is working with growers, resource managers and scientists to develop reasonable protocols for movement of shellfish as well as improved culture methods to reduce losses. Four embayments are continuously monitored with water quality instrumentation that provide an additional measure of habitat conditions and increased understanding of parameters that may contribute to disease susceptibility.

Assistance to the Massachusetts Shellfish Aquaculture Industry

Woods Hole Sea Grant works closely with shellfish farmers, providing technical advice and information on issues of concern such as predator management, control of diseases and marketing issues. In 2004 a network comprised of more than 10 regional shellfish farmers was established to address these concerns through a unified scientific approach. Each year a new issue is addressed; results are disseminated and made available through bulletins, fact sheets, reports, and presentations.

Outreach and Education

Woods Hole Sea Grant's Outreach and Education Program (WHSGOEP) works with its target audiences—educators, students, coastal decision makers, citizens and research scientists and engineers—to provide them with the tools they need to make connections between ocean science information and ocean and coastal issues. The program is guided by the following objectives: (1) educators have access to ocean science content, including Sea Grant research results, and understand how to use this information to convey scientific concepts; (2) students have access to ocean science research and information to develop an appreciation for the oceans and an awareness of marine science related opportunities; (3) citizens have access to Sea Grant research applicable to their interests and needs; (4) coastal decision makers have access to the results of Sea Grant research and other research to increase their ability to design and develop environmentally sound policies; and (5) research scientists and engineers from the ocean science community have access to and participate in educational and outreach opportunities.

WHSGOEP uses a variety of program and products to accomplish our objectives: one-on-one advice, training programs, publications, web sites, workshops, and lectures. In collaboration with the extension program, outreach and demonstration projects in fisheries, aquaculture, and coastal processes are brought to local communities. Collaborative projects include workshops on aquaculture issues and shoreline erosion, production of DVDs and videos on extension activities, work with legislators on coastal issues, production of information brochures and workshop proceedings, hosting and facilitation of teacher workshops on a broad range of coastal issues, and publication of an electronic newsletter.

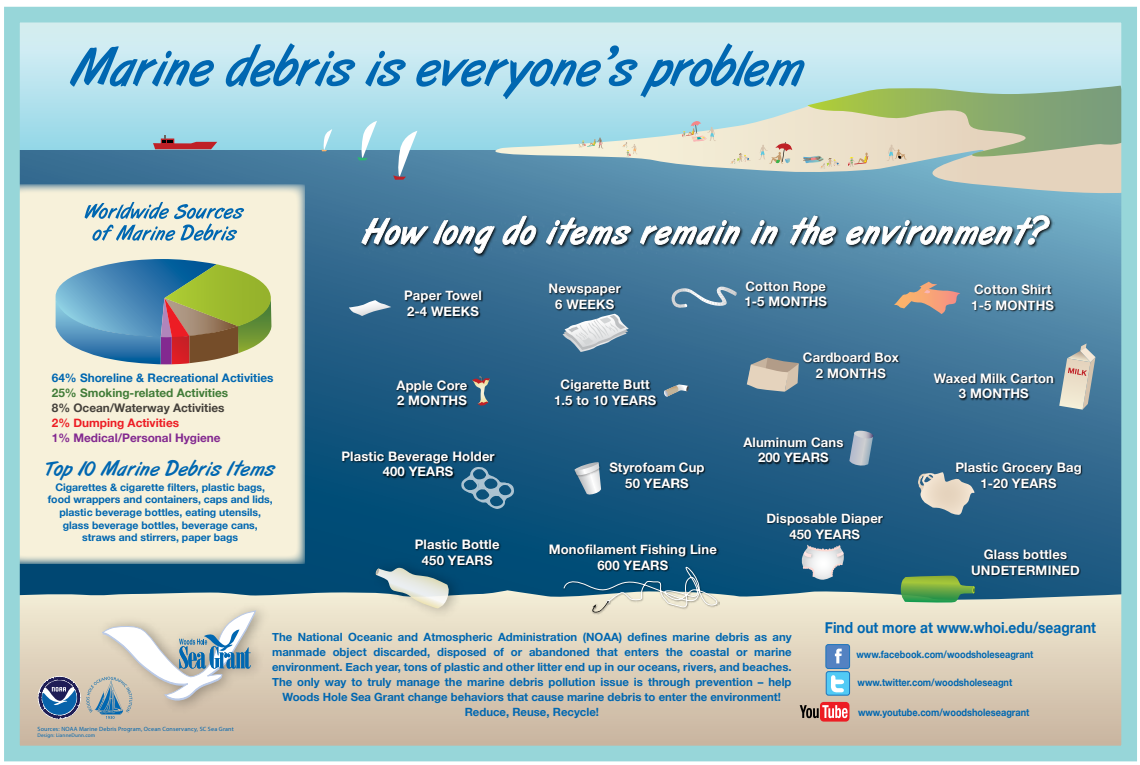
WHSGOEP relies on the Marine Outreach Guidance Group for input and advice on communication and educational activities. With participation by several MOGG members, WHSGOEP has developed and implemented educational programs designed to encourage users of our marine and coastal resources to explore, understand, and appreciate the value of these resources. We also participate in the Massachusetts Coastal Training Program (CTP) a unique, federal-state partnership to provide science-to-management training opportunities that address the challenges facing coastal communities. A partnership of the Waquoit Bay National Estuarine Research Reserve (WBNERR),

Massachusetts Coastal Zone Management (CZM) and Woods Hole Sea Grant, CTP provides support, training and technical information to communities, organizations, and agencies so that they can better manage the coastal resources that contribute to the economic and aesthetic vitality of coastal communities in Massachusetts. This partnership has resulted in the annual Cape Coastal Conference in addition to several training workshops each year.

Beach Cleanups/Marine Debris Workshops

Sea Grant is increasing local data collection efforts on source of regional marine debris through organization of community-based, volunteer-staffed beach cleanups and subsequent workshops.

The program is engaging 50 to 75 volunteers at each event and we plan to hold at least one event quarterly, with an increased effort of 3-4 during the final quarter of each year to coincide with Coastsweep, the International Ocean Conservancy efforts that occur each fall.



Teachers' Workshops

WHSGOEP continues to offer its extremely popular workshops for K-12 educators. Teachers are presented with ocean science-related background and examples for science teaching. Educators attending workshops have the ability to contact Sea Grant staff and scientists at WHOI to augment the workshop information and experience.

Boat Shrink Wrap Recycling Collection Initiative

The increased use of plastic shrink wrap to winterize boats has resulted in an interesting environmental issue that WHSG seeks to address through collection and recycling efforts for private individual owners. The program has a goal of 150 boats, or two Dumpsters, in 2015, with an increase of 10-20% in 2016.

Woods Hole Osprey Cam

WHSGOEP continues to manage the extremely popular Woods Hole Osprey Cam, along with related efforts to highlight effect of marine debris, poor water quality, climate change and other coastal issues on shorebirds. With an improved affiliated website, blog and expanded exposure through a story about the cam on the popular radio show "This American Life," the reach of the cam has increased.

Extension support

WHSGOEP coordinates media efforts for extension agents, including editing and providing project management for all brochures, web-based materials and bulletins.

HEALTHY COASTAL ECOSYSTEMS

Robinson.W. Fulweiler, Boston University

Examining Significant Changes to the Nitrogen Cycle in Waquoit Bay

The primary purpose of this project is to quantify how benthic metabolism in Waquoit Bay, MA, has changed over the last three decades. To test the hypothesis that benthic metabolism has significantly decreased over the last thirty years, the project will quantify sediment oxygen demand (SOD), inorganic nutrient (inorganic nitrogen and phosphorus), and sediment net N_2 and N_2O fluxes at five sites within the Waquoit Bay system including areas with bare sediments, macroalgae, and eelgrass. During the first project year, efforts will focus on measurement of these fluxes at five sites in Waquoit Bay on a bi-monthly basis. These stations represent different environmental conditions, including different salinities, different N loading rates, different rates of primary production, and, most importantly, different oxygen regimes. The results will be compared to previously collected data in the Waquoit Bay system and will allow a long-term comparison. During the second project year comparative studies of the pathways of nitrogen removal and net ecosystem metabolism (NEM) will be conducted. These studies are important because changes in pathways of nitrogen removal and net ecosystem metabolism may have important ecological consequences. This project will also resolve if variations in fluxes reflect just high year-to-year variability or a real ecological shift during the past three decades in Waquoit Bay.

Anne Giblin and Joe Valino, Marine Biological Laboratory, Ecosystems Center; and Gary Banta, University of Roskilde (Denmark)

The Impacts of Increased Nitrogen Loadings on Decomposition in Salt Marshes: Does Eutrophication Enhance Marsh Accretion or Erosion?

The goal of this project is to examine how nitrogen inputs to coastal areas affect sediment accumulation and decomposition in salt marshes. This topic has garnered increased attention recently as different investigators have come to different conclusions about the role nitrogen may play in increasing or decreasing the vulnerability of marshes to rising sea levels. Nitrogen plays a dual role in marsh ecosystems. Many studies have shown that increased nitrogen availability increases marsh grass biomass. Nitrogen may also allow for marsh grasses to better withstand environmental stresses and facilitate the colonization of plants into bare areas. Increased marsh biomass should lead to more organic sediment production and increase trapping of inorganic sediments. Nitrogen can also influence plant growth forms, change the relative allocation of above- and below-ground biomass, alter plant community structure, and change the rate at which plant detritus is grazed and decomposed. These changes have the ability to change the rate at which sediments are trapped and influence sediment structure below ground. However, nitrogen, in the form of nitrate is also an electron acceptor that can increase marsh organic matter (OM) decomposition. This would tend to decrease marsh sediment accumulation. However, it has recently been recognized that not all nitrate reduction in marshes is used by heterotrophs degrading organic carbon. There are also chemolithoau-

totrophic microbes present in marshes that may be using nitrate to oxidize sulfide and actually increase sediment C stocks. The ecological significance of nitrogen inputs on sediment accumulation and decomposition in salt marshes will be assessed.

Robert Howarth and Roxanne Marino, Cornell University

Nitrogen Pollution and Recovery from Nitrogen Pollution in a Seagrass-Dominated Estuary: A Whole Ecosystem Experiment

Nitrogen is the largest pollution problem in the coastal waters of the U.S., and shallow lagoon estuaries are particularly sensitive. Whereas the relationship of nitrogen pollution to seagrass loss and habitat degradation is known in broad brush, research to date conducted in West Falmouth Harbor, MA, has already demonstrated many surprises. These include a large increase in epiphytic biomass and associated nitrogen fixation on the seagrasses in the highly nitrogen-polluted inner harbor (SH) prior to the 2010 die-off; and the change in net ecosystem production, pH, and dissolved carbon dioxide that preceded (and may have been the proximate cause of) the die-off. These results indicate tipping points in the response of seagrass-dominated estuaries to nitrogen pollution, tipping points that are critical to understand if these estuaries are to be better managed. Such complex interactions and effects could only be observed in the context of the whole-ecosystem. Further study of the outer estuary (OH, where nitrogen pollution has increased since the loss of N retention by seagrasses in the inner estuary), will either confirm or modify our understanding of the processes leading to the 2010 die-off. This research also sets the stage for characterizing the recovery of the estuary as nitrogen load decreases in the future. To address these questions, the project will address the following objectives:

(1) measure the input of nitrogen to the estuary from the contaminated groundwater plume (to continue to estimate the load and determine the start of the recovery period);

(2) survey the distribution and biomass of seagrasses throughout the West Falmouth Harbor estuary;

(3) measure the biomass of epiphytic algae on seagrasses and associated rates of nitrogen fixation in the Outer Harbor where seagrasses still occur;

(4) measure nitrogen fixation by heterotrophic bacteria in the sediments in both SH and OH;

(5) measure oxygen and pH dynamics during the peak summer time in both SH and OH; and

(6) estimate rates of primary production, respiration, and net ecosystem production in SH and OH.

Laela Sayigh, Mark Baumgartner, James Partan, and Michael Moore, Woods Hole Oceanographic Institution

Development of an Automatic Mass Stranding Alert System

The goal of this project is to develop an acoustic method to predict cetacean mass stranding events (MSEs) that would greatly enhance response efforts, potentially reducing costs, injuries and mortalities. In order to achieve this goal, a digital acoustic

monitor (DMON) will be deployed in Wellfleet Harbor (MA) to collect acoustic recordings and generate automated detections of odontocete whistles. An additional DMON will be deployed outside the entrance to the harbor, in order to document how often odontocetes are detected in this area, both in situations when MSEs occur and when they do not. Detections outside the harbor could provide stranding responders with an even greater advanced warning, potentially further facilitating mitigation efforts for mass strandings. Data will be examined after recovery of the DMONs to determine whether automated detections faithfully represent odontocete whistles in the acoustic record and how often vocalizations are associated with MSEs. These data will be used to determine whether acoustic data can be used to predict mass strandings. Acoustic detections of odontocetes outside or within Wellfleet Harbor have the potential to enhance the ability of responders to mitigate MSEs. MSEs are costly both to the marine mammal species involved and to stranding responders. They also represent an enduring biological mystery, and this project may provide new insights to the biology of MSEs.

Jesús Pineda, Karl Helfrich and Victoria Starczak, Woods Hole Oceanographic Institution, José da Silva, University of Porto, Portugal, and David Wiley, Stellwagen Bank National Marine Sanctuary

Reconciling Distributional Patterns with Foraging Processes in an Ecological Hotspot: Aggregation of Humpback Whales, Prey Abundance and Distribution, and the Shoaling of Non-Linear Internal Waves

Cetaceans, sand lance, and elasmobranchs are major components of the Massachusetts Bay pelagic community. Even though the distributions of each group have changed over the decades, these organisms converge in relatively high abundance at Stellwagen Bank's (SB) southwest corner, a location that is arguably one of the most ecologically important areas within the Stellwagen Bank National Marine Sanctuary (SBNMS). The southern flank of SB lies within the Northern Right Whale Critical Habitat Area, and is heavily fished by the sport fishing recreational fleet during the blue fin tuna season in June to October. Whale watching boats are frequent in this area from spring through fall. Spatial density patterns of fishing trips indicate that the southern flank is an area of high use by the commercial fishing industry to catch ground fish, pelagic species, fin fish and invertebrates. It is not clear what processes makes SB's southern flank so important ecologically (and recreationally and commercially), but it may be related to the shallow topography and potential trapping of zooplankton and the frequent and predictable non-linear internal waves (NLIWs) that shoal onto the bank's southern flank. In this project Pineda et al. are examining three dominant species—humpback whales

Megaptera novaeangliae, small sharks *Squalus acanthias* (spiny dogfish), and their common prey, sand lance *Ammodytes spp*. —to understand how they interact and their response to physical processes that make SB's southern flank so rich in resources.

Jefferson Turner and Brian Howes, University of Massachusetts at Dartmouth

"Rust Tides" of the Toxic Dinoflagellate Cochlodinium polykrikoides in Buzzards Bay

The toxic dinoflagellate *Cochlodinium polykrikoides* has been increasing in frequency of blooms in Buzzards Bay, MA, over the last decade. It is a fish-killing harmful-algal-bloom species that has been expanding geographically across Asia, North America and Europe over the last two decades. This species was unrecorded in the only previous study of phytoplankton community composition in Buzzards Bay that covered the years of 1987-1998 (Turner et al., 2009 — *Marine Ecology Progress Series* 376: 103-122). However, over recent years, *C. polykrikoides* has formed massive blooms with "rust-colored" water discoloration in northern Buzzards Bay during August and September. The Turner laboratory has been conducting system-wide sampling of Buzzards Bay monthly since 1987. This study has produced numerous publications and student theses, a large amount of yet-to-be-published data, as well as archived samples for plankton community composition and abundance, and water quality parameters. This project will update the phytoplankton community composition time-series, with particular focus on the initial occurrence of *C. polykrikoides* and the inorganic and organic nutrient conditions, associated with the development of recent blooms. Objectives of the project include:

(1) to characterize patterns of phytoplankton abundance and community composition in archived phytoplankton samples, focusing first on summer/fall periods when *C. polykrikoides* blooms occur, working backward from most-recent to older periods to determine when this dinoflagellate first appeared in Buzzards Bay;

(2) to determine if *C. polykrikoides* blooms in Buzzards Bay in 2014 and 2015 are expanding their temporal and spatial presence compared to patterns for previous years;

(3) to determine patterns of appearance and abundance of *C. polykrikoides* in relation to those of other phytoplankton species that may utilize different nutrients, such as diatoms;

(4) to characterize levels of inorganic nutrients (nitrate, nitrite, ammonium, phosphate, silicate) in monthly surface samples collected year-round to test the hypothesis that blooms of *C. polykrikoides* are related to changes in inorganic nutrient levels;

(5) to characterize levels of dissolved and particulate organic nitrogen during sampling in June, July, August, September and October of 2014 and 2015 to test the hypothesis that blooms of *C. polykrikoides* are related to changes in organic nutrient levels.

If blooms of *C. polykrikoides* are expanding their temporal and spatial presence in Buzzards Bay, and such blooms are implicated in adverse effects on finfish, shellfish, or occurrence of anoxia/hypoxia, then changes in management of nutrients, and/or utiliza-

tion of recreational fisheries for finfish and/or shellfish may be prompted.

Sibel Karchner and Mark Hahn, Woods Hole Oceanographic Institution:

Molecular Risk Assessment in Wildlife Using a Non-Destructive Assay

Birds inhabiting coastal Massachusetts and other areas (Great Lakes) are exposed to substantial levels of dioxin-like compounds. The long-term objective of the proposed research is to understand the impact of environmental contaminants on aquatic birds and to assess differences in species sensitivity to contaminants via non-destructive methods. To attain this objective, this project will develop and apply an efficient and non-destructive assay for assessing the sensitivity of birds to dioxin-like environmental contaminants. The assay builds on previous Sea Grant-supported research that identified a critical role for the ligand-binding domain (LBD) of the aryl hydrocarbon receptor (AHR) and established an AHR-LBD assay. The specific aims are:

(1) to validate the AHR-LBD sensitivity assay by applying it to birds representing the three different sensitivity classes: high sensitivity (type 1), moderate sensitivity (type 2), and low sensitivity (type 3);

(2) to determine the dioxin sensitivity of the roseate tern, an endangered species, using the AHR-LBD assay with additional verification by other assays; and

(3) to establish and apply a non-destructive method for using bird feathers as a source of RNA or DNA for cloning of AHR LBDs for the AHR-LBD assay.

Carl Lamborg, Woods Hole Oceanographic Institution, John Logan, Massachusetts Division of Marine Fisheries, and Ruth Carmichael, Dauphin Island Sea Lab:

A History of Mercury Impacts to Waquoit Bay Clams

As part of work previously funded by Woods Hole Sea Grant and WHOI's Coastal Ocean Institute, this project will examine the effect of groundwater sources of mercury (Hg) on small coastal embayments and salt ponds, such as Waquoit Bay (Falmouth/Mashpee, MA). Previous work conducted by Lamborg demonstrated that submarine groundwater discharge (SGD) accounted for as much as 73% of all the inputs of this toxic metal to Waquoit Bay (Bone *et al*., 2007; Bothner *et al*., 2010). Funding from both United States Geological Survey (USGS) and Sea Grant supported work that helped to define the origin of Hg in SGD. It was determined that previously immobilized sedimentary Hg is transported from aquifers when they become anoxic following bacterial respiration of the carbon and nitrogen in wastewater plumes (Lamborg *et al*., in review). Thus, we now suspect that much of the Hg associated with SGD entering Waquoit Bay is indirectly the result of in-ground wastewater disposal within the Waquoit Bay watershed. Therefore, the loading of Hg to Waquoit Bay, and similar systems on Cape Cod and elsewhere, may be dramatically higher today than in the pre-European Settlement period. The investigators hypothesize that today's loads are 12 times higher than pre-settlement due to SGD-related fluxes and the three-fold increase in atmospheric deposition world-wide (e.g., Fitzgerald and Lamborg, 2003). We do not know, however, whether Waquoit Bay has in fact experienced this level of disturbance or

whether this perturbation has been felt by the Bay's biota. To answer this question, the project will measure natural archives of the history of the Hg and nutrient impact in Waquoit Bay and south shore salt ponds/bays: clam shells and sediment. Analysis of Hg and nitrogen stable isotope composition in the clam shells and sediment will allow the investigators to reconstruct a history of Hg loading to the system (sediments) and biota (clam shells) and thereby determine both the level of disturbance and the biogeochemical connection between Hg and nutrients.

SUSTAINABLE FISHERIES AND AQUACULTURE

Jeanette Wheeler, Lauren Mullineaux, and Karl Helfrich, Woods Hole Oceanographic Institution

Behavioral Responses of Competent Larval Oysters (Crassostrea virginica) to Chemical Settlement Cue in Turbulent Flow

The main goal of this project is to test larval oyster swimming behavioral responses to simultaneous hydromechanical and chemical settlement cues mimicking field conditions. Behavioral responses to water column cues may affect larval supply to adult benthic populations, an important consideration in the conservation of wild oyster populations. This study will address the following questions:

(1) how do larval swimming and diving behaviors change in the presence of a chemical settlement cue of varying background concentrations; and

(2) how do interactive effects of hydromechanical and chemical cues impact larval swimming and settlement behaviors.

Preliminary results suggest that oyster larvae swim upwards in turbulence alone. The investigators hypothesize that there exists a threshold chemical cue concentration that will initiate downward swimming (in a potential indication of settlement). In order to test this hypothesis, they will determine larval responses to combined hydromechanical and chemical cues in a flume experiment, in which for the first time the flow surrounding larvae will be actively quantified to decouple effects of turbulence from effects of chemical cues. Larval swimming will be filmed with a high-speed camera in a two-dimensional field of view illuminated with a near-infrared laser. Seawater will be well mixed with small tracer particles to quantify fluid flow surrounding larvae using a particle image velocimetry method previously developed by the investigators. Larvae will be exposed to a range of background chemical cue concentrations (specifically, the tri-peptide glycyl-glycyl-L-arginine) to determine changes primarily to their swimming velocity and diving frequency. The measurements of larval trajectories, local flow fields, and cue concentration will be used to develop a multiple regression model of larval swimming and diving responses to hydrodynamic and chemical cues. This project is the first to explore simultaneous effects of turbulent flow and chemical cues to larval behavior, using image analysis methods to isolate larval behavioral responses in flow. Results from this study may help inform management decisions for habitat restoration and conservation.

Roxanna Smolowitz, Roger Williams University, Hauke Kite-Powell, Woods Hole Oceanographic Institution, and John Brawley, Saquish Scientific

Research to Inform Regulatory Decisions on the Management of Vp in MA Shellfish Growing Areas

The pathogen, *Vibrio parahaemolyticus* and *Vibrio vulnificus*, exhibit exponential growth with increased temperature and are naturally occurring in Massachusetts' coastal waters. Mandatory shellfish closures occurred during summer 2013 in several coastal communities in Massachusetts due to an alleged public health threat from Vp. This closure event highlighted the need for a better understanding of the behavior and trends of Vp and Vv populations in Massachusetts' coastal waters. The objective of this project is to improve understanding the public health risk from Vp and Vv within the context of oyster cultivation and harvesting practices, and thereby support the improvement of risk management for this pathogen. Specific tasks to meet this objective include:

(1) determine the total and relative abundances of potentially pathogenic Vp and Vv at selected oyster harvest locations over time;

(2) determine the relationship between total and pathogenic levels of Vp and environmental factors such as water temperature, phytoplankton stock, particulate matter, and surficial organic matter;

(3) identify variability of Vp and Vv levels and investigate and design monitoring programs that will decrease human health risks; and

(4) monitor the occurrence of pathogenic genes of Vp in areas sampled and relate those findings to human illness.

Joel Llopiz, Woods Hole Oceanographic Institution

Beyond Fish Passage: Variability in Nursery Habitat and its Influence on the Feeding, Growth, and Survival of the Early Life Stages of River Herring

When considering the remarkable low population sizes of river herring despite seemingly sound management efforts, it is evident that new insight and novel approaches are needed to better understand why alewife and blueback herring populations are not recovering as fast as they should. Because of the influence that only slight changes in larval survival can have on adult recruitment levels—and the distinct dearth of information on how larval river herring respond to variable conditions—this project will substantially add to our understanding of the factors that may be contributing to the continued poor health of local river herring populations along the entire Atlantic coast. In essence, the rationale for this study is to go "beyond fish passage" and take an ecosystem-level approach to understanding what determines the successful reproduction of the adults that do reach spawning habitat. The major objectives of the project are to:

(1) examine the environmental conditions of the nursery habitat of larval and early juvenile alewives and blueback herring (i.e., 'river herring') in four contrasting systems by measuring a suite of physicochemical parameters and zooplankton composition and abundance; and

(2) evaluate the variability on the diets and feeding success of river herring larvae from the different systems, and how these feeding-related variables relate to environmental conditions, especially zooplankton abundance and composition.

RESILIENT COMMUNITIES AND ECONOMIES

Serena Moseman-Valtierra and John D. Kirby, University of Rhode Island, Jianwu Tang, Marine Biological Laboratory, and Kevin D. Kroeger, USGS Coastal and Marine Science Center

Shifts in Greenhouse Gas Emissions and Productivity of Coastal Wetlands in Response to Anthropogenic N Loading and Rising Sea Level

As some of the earth's most productive ecosystems, coastal wetlands substantially affect global C cycles, but they currently face degradation from anthropogenic inputs of reactive nitrogen, inundation by rising sea levels, and complex effects of global climate change. Functional impacts of these stressors on coastal wetlands need to be mechanistically understood in order to maintain and maximize their valuable productivity. Recent work has shown that anthropogenic N inputs can significantly stimulate nitrous oxide (N_2O) fluxes from coastal salt marshes that may have consequences for ecosystem feedbacks on global climate. In this project Moseman-Valtierra et al. will measure potential greenhouse gas (GHG) emissions and net primary productivity in coastal marshes under a range of realistic nitrogen (N) loads and inundation (sea) levels. Using an existing gradient in N loading and elevation among salt marshes of Waquoit Bay, MA (WB-NERR), they will test the hypotheses that net N_2O emissions and ecosystem respiration from coastal marshes increase under conditions of N loading, with sufficient changes to potentially offset a substantial portion of the net CO_2 uptake from the atmosphere; that plant productivity in each marsh is related to N loading rate; and that GHG emissions from salt marsh sediments vary as a function of soil elevation and inundation. The project complements a larger project conducted at Waquoit Bay National Estuarine Research Reserve ($1.3 million grant, funded by the NOAA NERRS Science Collaborative) to generate science and management tools that will support coastal wetlands as potential international carbon markets that aim to incentivize investment in tidal wetland restoration and preservation.

Steve Elgar and Britt Raubenheimer, Woods Hole Oceanographic Institution

Modeling Shoreline Morphological Evolution

Similar to many coasts, the shoreline of Martha's Vineyard is undergoing tremendous morphological change. Near Katama Bay, sediment transport is affecting water quality, navigation, local oyster farms, beach erosion, tourism, and homes and structures. Moreover, strong currents near Norton Point are a hazard to swimmers (there are several drownings yearly) and have a large effect on local tourism. Consequently, there is a need to model this system, both to address scientific hypotheses and to provide a tool to perform simulations for different scenarios, such as sea level rise, increasing frequency and strength of storms, and engineering efforts. The primary objectives of this project are

to assess: (1) that migration of the inlet is a result of a combination of large nor'easters and hurricanes, more frequent, but more moderate wave events, and strong tidal flows; (2) that the timing of storms relative to flood and ebb flows and the storm duration are important to the morphological evolution; (3) accretion inside the bay is caused by sand carried alongshore and subsequently transported into the inlet during flood flows; and (4) closure of the inlet occurs when a large storm coincides with one or more spring flood tides, carrying sand into the inlet. The investigators will test these hypotheses using a combination of numerical model simulations and existing field measurements obtained during conditions ranging from Hurricanes Irene and Sandy to calm periods before and after the storms. Additional field measurements of waves, currents, and bathymetry were made during summer 2013 (funded by Elgar's National Security Science and Engineering Faculty Fellowship). Interested collaborators include the USGS, Cape Cod Cooperative Extension, the Trustees of Reservations, the Edgartown Harbor master, conservation commissions, environmental groups, home owners, coastal engineers, shellfish farmers, fishermen, and swimmer safety personnel.

Robert Johnston, Clark University, Klaus Moeltner and Christine Blinn, Virginia Tech University, and Christine Feurt, Wells National Estuarine Research Reserve

Coastal Hazards and Northeast Housing Values: Comparative Implications for Climate Change Adaptation and Community Resilience

The project will combine coastal hazards, property value and other data with economic models to answer three questions central to Northeast coastal adaptation:

(1) How do property values and tax bases in Northeast communities respond to coastal hazards, and do these responses create incentives to build/rebuild in risk-prone areas or undertake private adaptations?

(2) How do property values and tax bases respond to adaptation actions undertaken by states, municipalities or homeowners/developers?

(3) What do results imply for future scenarios of property values and tax bases in Northeast communities, under alternative SLR and hazard projections?

The project will be implemented in coordination with partners and communities involved in Northeast coastal adaptation including the Wells National Estuarine Research Reserve (NERR), Great Bay NERR, Waquoit Bay NERR, and Nature Conservancy in Connecticut. Project results will enhance the ability of communities to choose adaptations with intended and desirable economic consequences. First, results will enable policymakers and the public to understand the effects of current hazard vulnerability on property values and the tax base, replacing unsupported claims with reliable empirical evidence. Second, the project will provide information that policymakers can

use to forecast property value and tax base implications of alternative adaptation measures. Third, future scenarios mapping will provide information to support community dialogue and visioning. The project builds upon extensive prior work of the investigators coordinating natural/social science data to forecast economic outcomes and using results in partnership with stakeholders and policymakers to inform management.

Porter Hoagland, Di Jin, and Hauke Kite-Powell, Woods Hole Oceanographic Institution; and John Duff, University of Massachusetts at Boston:

Buy Out or Build Back? A Comparative Assessment of Approaches to Employing Public Funding to Vulnerable Coastal Properties in the Northeastern United States

Although the kinds of coastal properties, the types of vulnerabilities, and the natural forces at play are remarkably similar across the region, local communities and coastal states exhibit much variability in their policy choices. Given varying effectiveness and costs, this diversity of policy approaches implies that some communities may have been tempted to satisfy parochial micro-motives at society's expense through reductions in resilience to future hazards. For communities and States in the Northeast, it is now critical that an assessment be undertaken of the disaster response and mitigation policies currently in place. Further, these policies should be compared with other prospective policies that are potentially beneficial but presently underutilized. The objectives of the project are;

(1) to carry out legal and economic research on the laws and policies of the Northeast coastal states and their local communities in order to help inform ongoing socio-economic assessments of options for disaster responses and mitigation programs;

(2) to examine currently available legal and fiscal/economic mechanisms;

(3) to evaluate zoning and other police power oriented regulatory measures in the States;

(4) to assess in a comparative manner condemnation laws and policies;

(5) to characterize the history and scope of inverse condemnation ("takings") jurisprudence in the States;

(6) to undertake economic evaluations of the promise and prospects of alternative forms of build-backs or buy-outs; and

(7) to elucidate the comparative costs and benefits associated with the implementation of public funding or regulatory efforts.

Jonathan Grabowski and Matthias Ruth, Northeastern University: Social and Ecological Factors Influencing Shoreline Hardening in the Northeast:

Implications for Vulnerability, Resilience, and Informed Decision Making

Coastal populations are growing, and this is adding to the mounting strain on coastal ecosystems. This trend is particularly problematic given that habitats naturally distributed in coastal ecosystems contribute a disproportionately large array of highly valuable ecosystem services. The goal of this project is to identify whether human vulnerability in coastal populations is tied to shoreline development and the integrity of coastal and marine habitats. Furthermore,

the investigators seek to identify the degree to which social capital, environmental connectedness, and adaptive capacity in coastal communities is linked to human and ecological resilience. In addition, the project aims to provide managers with insights regarding the degree to which shoreline armoring influences perceptions of and acceptance of ocean-based wind energy development. Finally, the project will assess the efficacy of coastal policy at protecting shorelines and reducing human vulnerability in order to reveal which coastal shoreline policies should be implemented vs. those that are less successful. The specific objectives of the project are:

(1) to identify potential linkages among shoreline development, coastal and marine habitats, ecosystem services and human vulnerability throughout the northeastern U.S.;

(2) to characterize linkages between social capital, environmental connectedness, resilience and adaptive capacity;

(3) to determine the extent to which coastal development and armoring affects perceptions and acceptance of ocean-based wind energy development; and

(4) to examine the effectiveness of coastal policy at protecting shoreline habitats, ecosystem services and reducing human vulnerability to natural disturbances.

ENVIRONMENTAL LITERACY AND WORKFORCE DEVELOPMENT

Laela Sayigh and Kathy Patterson, Woods Hole Oceanographic Institution, and M. Carla Curran, Broader Impacts, LLC

Experiential Learning for the Visually Impaired: Eavesdropping on Marine Mammal Conversations

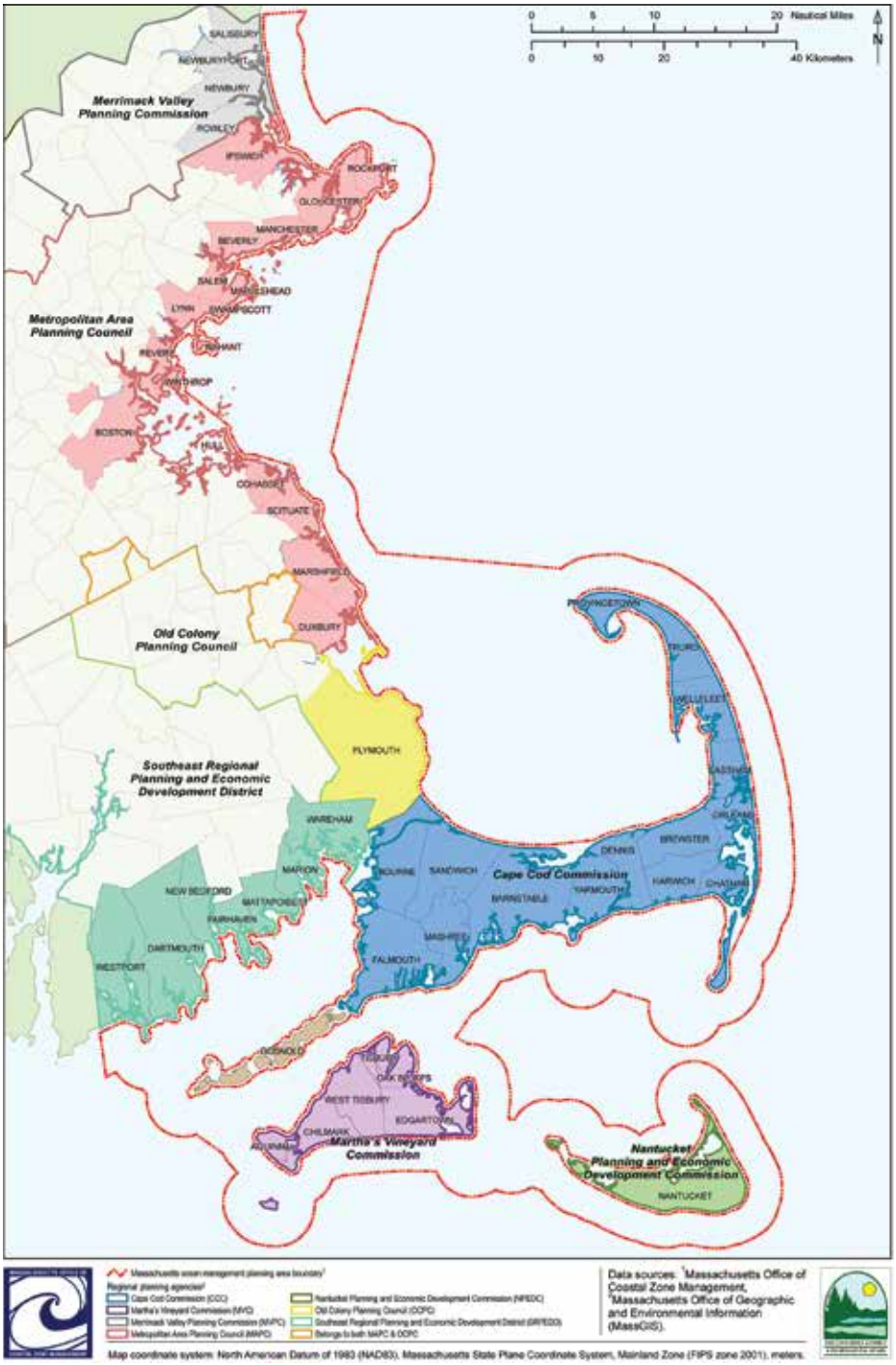
The objective of this project is to develop a new K12 activity and marine mammal exhibit that can be used in conjunction with the activity and kiosk currently being developed for use at the Woods Hole Oceanographic Institution Ocean Science Exhibit Center. The proposed activity will focus on making science accessible to visually impaired students by utilizing a large archive of recordings of marine mammal vocalizations that are available at the WHOI Marine Mammal Center. The exhibit will showcase the wide range of marine mammal research projects ongoing at WHOI, and will include hands-on demos as well as an informative backdrop display. The specific project objectives are:

(1) to develop a new K12 activity geared toward visually impaired students, that incorporates marine mammal sounds;

(2) to test the above activity at the Perkins School for the Blind;

(3) to present the results at a scientific meeting and publish them in a peer-reviewed education journal; and

(4) to develop a new marine mammal exhibit at the WHOI Ocean Science Exhibit Center that highlights current marine mammal research at WHOI. The project will incorporate a new technology—the voice activated computer system "Ubi,"—to enable visually impaired students to use it at their own pace.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Metropolitan Area Planning Council
Old Colony Planning Council
Southeast Regional Planning and Economic Development District
Cape Cod Commission
Martha's Vineyard Commission
Nantucket Planning and Economic Development Commission
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NEWBURYPORT
NEWBURY
ROWLEY
IPSWICH
ROCKPORT
GLOUCESTER
MANCHESTER
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MASHPEE
FLYMOUTH
WAREHAM
MARION
NEW BEDFORD
MATTAPOISETT
FAIRHAVEN
DARTMOUTH
WESTPORT
OAK BLUFFS
TISBURY
WEST TISBURY
EDGARTOWN
CHILMARK
ALDANAN
NANTUCKET
Massachusetts ocean management planning area boundary
Regional planning agencies
Cape Cod Commission (CCC)
Martha's Vineyard Commission (MVC)
Merrimack Valley Planning Commission (MVPC)
Metropolitan Area Planning Council (MAPC)
Nantucket Planning and Economic Development Commission (NPEDC)
Old Colony Planning Council (OCPC)
Southeast Regional Planning and Economic Development District (SRPEDD)
Belongs to both MAPC & OCPC
Data sources: Massachusetts Office of Coastal Zone Management, Massachusetts Office of Geographic and Environmental Information (MassGIS).
Map coordinate system: North American Datum of 1983 (NAD83), Massachusetts State Plane Coordinate System, Mainland Zone (FIPS zone 2001), meters.

Woods Hole Oceanographic Institution Sea Grant Program

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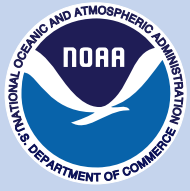
DESIGN:
LianneDunn.com



Woods Hole Oceanographic Institution Sea Grant Program

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