EDUCATION AND OUTREACH

The PIE LTER has developed links with local teachers and students, citizens, conservation organizations, and local, state and federal agencies. We support a broad, well-rounded suite of activities. We expect our education/outreach program to further expand, as we actively seek additional support from other federal agencies (e.g., NOAA), the Commonwealth of Massachusetts, and private foundations. Our long-term goal is to establish a 'Coastal Outreach" office at our study site that would serve to integrate and promote our interactions with interested parties throughout New England, similar to the Hubbard Brook Research Foundation.

EDUCATION

Our goals are to: 1) excite kids and teachers about coastal science, 2) to train the next generation of scientists, 3) to develop an environmentally conversant citizenry, and 4) inform the local stakeholders about our LTER-related research.

LTER Schoolyard: This program has been highly successful as a result of collaboration with Mass Audubon and the Governor's Academy, and additional NSF funds (EdEn and Expanded Schoolyard supplements.) Teachers at the Governor's Academy, especially Susan Olezsko, implement science modules for high school students using student monitoring of ribbed mussels and intertidal marsh plant distribution. The approach and methods were developed in conjunction with LTER scientists and the data are included in the PIE database and website. (http://ecosystems.mbl.edu/pie/data/student/schlyard.thm). Mass Audubon has implemented, with partial support from the LTER, a 5^{th} –12^{th} grade science education program "The Salt Marsh Science Project" (http://www.massaudubon.org/saltmarsh). This program focuses on the invasion of *Phragmites australis* in salt marshes. Under the guidance of Mass Audubon, students monitor transects to analyze vegetation changes, and measure porewater salinities in relationship to the vegetation. Students monitor the spread of invasive species including the common reed (*Phragmites australis*) and purple loosestrife (*Lythrum salicaria*) and study fish communities. Students' research has paralleled that of LTER and collaborating scientists. SMS serves an average of 1000+ students per year and 40 teachers from 11 schools per year.

Mass Audubon's Education Coordinator and LTER education Representative, Elizabeth Duff, trains local teachers in the field protocols, classroom lessons, and data entry and analysis procedures. Duff works in partnership with these teachers, implementing the SMS program. On field trips, students collect real data of interest to scientists. Scientists assist with data analysis, interpretation and feedback. An annual conference, allows participants to share their findings, and to learn from each other. Student data is shared via the SMS web site.

Reaching a Broader Community: In addition to maintaining this highly successful Schoolyard program, Duff has helped forge links between teachers and PIE-LTER research and local school curriculum. Since 2004, 20 teachers have attended the PIE-LTER All Scientists Meeting (ASM). At ASM workshops teachers have connected with PIE researchers - brainstorming ways research connects to the Massachusetts Science Frameworks, and discussing ways that LTER scientists can help support teaching goals. To help teachers better understand the scientific presentations and to help researchers better communicate with a lay audience (i.e., drop the jargon), we developed a glossary of scientific terms, and developed and presented a PowerPoint slideshow with suggestions for scientists presenting to non-scientists. From the brainstorming sessions, we identified several PIE-LTER research areas best suited for connecting to schoolyard and local educational programs. We developed and delivered 3 courses on climate change and coastal

communities, with 4 PIE scientists presenting LTER research to a total of 60 teachers. Four LTER scientists (including students) shared their research on striped bass in an "Ocean Science Education Institute" for 50 youth and adults. These scientists also assisted a team of educators in developing and piloting curriculum based on LTER bass research. The Ocean Science Institute is a component of the Gulf of Maine Institute, which receives additional support from the Massachusetts Environmental Trust, NSF via the Center for Ocean Science Educational Excellence (COSEE), Mass Audubon and GE via the Corporate Wetlands Restoration Partnership. Duff has worked to develop a partnership with the Harvard Forest LTER by enrolling teachers from the PIE region in the HFR Schoolyard study of "Bud's Leaves and Global Warming." To help the greater community learn more about LTER science we have written and published articles about LTER research in Mass Audubon's "Connections" magazine.

It is particularly challenging to maintain a strong Schoolyard Program given the vagaries and fluctuations in funding. During years of "extra" support the SMS program was able to serve a greater proportion of urban students, including those from the lower income Dorchester and East Boston neighborhoods. While during baseline funding, the SMS "reach" drops from about 1500 students to about 1000.

Undergraduates and REU's: Each summer the LTER and associated projects support 2 or more students in the NSF Research Experience for Undergraduates program. Each student works closely with a principal investigator and either post-doc or research assistant. Students typically help out with the various field activities that are occurring at Plum Island (thereby gaining a broad research experience), plus they conduct their own independent research projects. Each student is required to prepare a poster and short manuscript describing their research project. Students typically participate in the Marine Biological Laboratory Annual Scientific Meeting and present their research reports or they present their reports at the Audubon facility at Joppa Flats in Newburyport. See Appendix I for list of students and project titles.

MBL offers an undergraduate Semester in Ecosystems Science (full 15 credits) annually. Over the past 4 years, PIE investigators have supervised numerous students with independent projects that are related to our aquatic research at PIE (see Appendix I).

Over the past several years, 81 undergraduates have been affiliated with the PIE LTER

Graduate Students, Post-docs and Research Interns: Perhaps our most effective means of education is through graduate student training, post-doctoral fellowships and research assistant internships. Over the past 3 years PIE has supported 35 graduate students, 27 of whom were directly affiliated with PIE. We have supported 8 Post-docs at the Marine Biological Laboratory and collaborated with 8 others from MIT. We typically offer 2 research assistant fellowships (RAF) to recent college graduates prior to beginning graduate school. In the past several years we have supported 8 RAFs, most of whom have gone on to graduate school in ECOSYSTEM science (see appendix I).

Science Writers: Each summer the Marine Biological Laboratory supports a course for professional science writers (TV, newspaper, journal, etc). These people play a critical role in our society, as they try to inform the public of the excitement and concepts that scientists work on. An informed public is the cornerstone of a democratic society. Public support for science depends on effective channels of communication between science and the general public. Over the past several years, many of these writers have been exposed to ecosystem research looking at

N loading from land to coastal systems. This past summer a writer initiated a story on the "low water" situation in the Ipswich River.

OUTREACH

Our goal is to communicate our findings to individuals, organizations (NGOs), and government agencies that will use our research results to better manage local and regional coastal resources. We support four types of activities: communicating what we do, advising NGOs and government agencies on issues of concern to them, collaborating with NGOs and government agencies on environmental research, and applying our scientific knowledge through public service. We have established communications and partnerships on four major issues: intertidal marshes, coastal eutrophication, watershed resource management and fisheries (Table EO-1).

Our primary outreach effort is communicating with the public, NGOs, government agencies, and other scientists. We reach the public through a variety of mechanisms including talks (e.g., Deegan at the Newburyport and Ipswich Rotary Clubs), newsletters (e.g., *Earthkeepers* article on eutrophication), magazines (e.g., *MBL Catalyst* highlighted Hopkinson's involvement in promoting ecosystems services-based management), brochures (e.g., the PIE LTER brochure), and community-wide open houses (e.g., at our Marshview Field Station in Newbury, MA). In addition, we have developed 'Adopt-a-bass' and 'Adopt-a-herring' programs and web pages (http://www.Ipswich-riverherring.com/index.html) to engage the public in our research. To reach our scientific peers we communicate with journal publications (listed as an Appendix to this report) and presentations at national and international scientific society meetings.

We also seek opportunities to advise various NGO and government agencies on issues where we have developed knowledge resulting from LTER research. Wollheim and Hopkinson have attended numerous workshops sponsored by the Ipswich River Watershed Association dealing with low flow issues in the Ipswich River and we also serve on their Technical Advisory Council. Others of us have been involved in workshops with Mass CZM, Region 1 EPA, NMFS, and USFWS discussing issues such as marsh dieback, sea level rise, marsh invasives, and eutrophication. Jim Morris and Linda Deegan have advised US Senators and Representatives and their staffers (SC and Mass) on issues of sea level rise and coastal eutrophication. Morris has also discussed the ramifications of sea level rise on coastal systems through activities organized by the Heinz Center.

PIE LTER has established several research collaborations with several NGOs and government agencies. Mather has been working with several state and federal agencies as well as NGOs in studying striped bass and the recovery of river herring in the Plum Island system. Wollheim and Hopkinson have collaborated with the Ipswich River watershed association in monitoring river health. Several of us worked with a diverse group of NGO's and state and local agency people to develop a proposal to wisely manage growth in the Ipswich River watershed. Several of us have also helped Mass DEP and the PRNWR in restoring historically impounded salt marshes in the system. And several of us have also been working with NOAA and CZM in developing a digital elevation model and map of marsh plant species distribution through remote sensing (LIDAR and multispectral). Our annual 'All Scientists Meeting' has been an excellent way to get our information to our partner organizations and government agencies.

We use our scientific knowledge in providing several public services. Linda Deegan serves on the Falmouth Conservation Commission. Anne Giblin organized and spearheaded the construction of a "science-theme playground" in Falmouth. Jane Tucker serves on the Falmouth

Coastal Resources Working Group. Several of us have advised students and served as judges for school science fairs (including Garritt, Tucker, Hopkinson, Giblin, Morris).

Finally, the PIE LTER has an extensive outreach arm through the activities of PI Robert Buchsbaum, who through the Audubon Society, interacts directly with the local and state management community. He is a member of the Great Marsh Salt Marsh Restoration Team, a committee organized by the Massachusetts Wetlands Restoration Program under the Massachusetts Office of Coastal Zone Management. Participants include staff from a variety of state and federal agencies: MA CZM, NOAA, USFWS (Parker River National Wildlife Refuge – PRNWR)), the EPA's Massachusetts Bays Program, Wells National Estuarine Research Reserve, other nonprofits, and local governments. He provides updates to this committee about LTER activities and opportunities for collaboration. He is also an active member of the Gulf of Maine Council on the Marine Environment Habitat Monitoring Subcommittee. This committee has focused on monitoring salt marsh in the Gulf of Maine region. Buchsbaum has brought to the attention of this committee the work at the LTER, our network of SET tables, our marsh vegetation transect work, and our regular monitoring of water column. He has been on the organizing committee of two symposia examining the extent and cause of this phenomenon in New England. PIE has not experienced vegetation dieback to any unusual extent, but it is instructive to those in other parts of New England to relate our observations to theirs. He has also consulted with staff from the Massachusetts Wetlands Restoration Program about salt marsh haying, worked with the PRNWR and 8 Towns and the Bay Organization to develop a proposal to study the spread of Phragmites australis and discussed mercury contamination in salt marsh sparrows at the PRNWR and advised the Refuge on experimental design.

Table EO-1. PIE LTER outreach activities and target audiences

Societal Issue	Civic Organizations, NGOs and Local Agencies	Massachusetts State Agencies	Federal Agencies
Sea Level Rise **Wetland Restoration** **Wetland Survival**	Mass Audubon Society Merrimack Valley Planning Commission Essex County Greenbelt Association (ECGA) Donnelly Foundation Nature Conservancy Heinz Center 8 Towns and the Bay	Dept of Environmental Protection (DEP) Coastal Zone Management (CZM) Dept of Fish and Game Mass Geographic Information System (Mass GIS) Wetlands Restoration Program Mass Dept of Conservation and Recreation (DCR)	NRCS – Westford Service Center USFWS National Wetlands Inventory (NWI) Parker River National Wildlife Refuge USEPA - Atlantic Ecology Division (AED)
Sewage Effluent **Discharge** **EUTROPHICATION**	Ipswich River Watershed Association (IRWA) Parker River Clean Water Association (PRCWA) Island Futures Group Towns of Ipswich, Rowley, Newburyport	DEP DCR Water Resources Commission Mass Bays Program Division of Marine Fisheries (DMF)	USEPA – Atlantic Ecology Division (AED) Congressional Staffs, eg., Delahunt
Low River Flow **River Restoration, Dam Removal and Beavers** **Land Use Change and "Smart Growth"**	IRWA PRCWA Horizon Foundation Essex County Community Foundation Audubon Society ECGA Nature Conservancy Town of Ipswich	EOEA DEP DCR Mass GIS Water Resources Commission	 USGS USEPA – AED NRCS