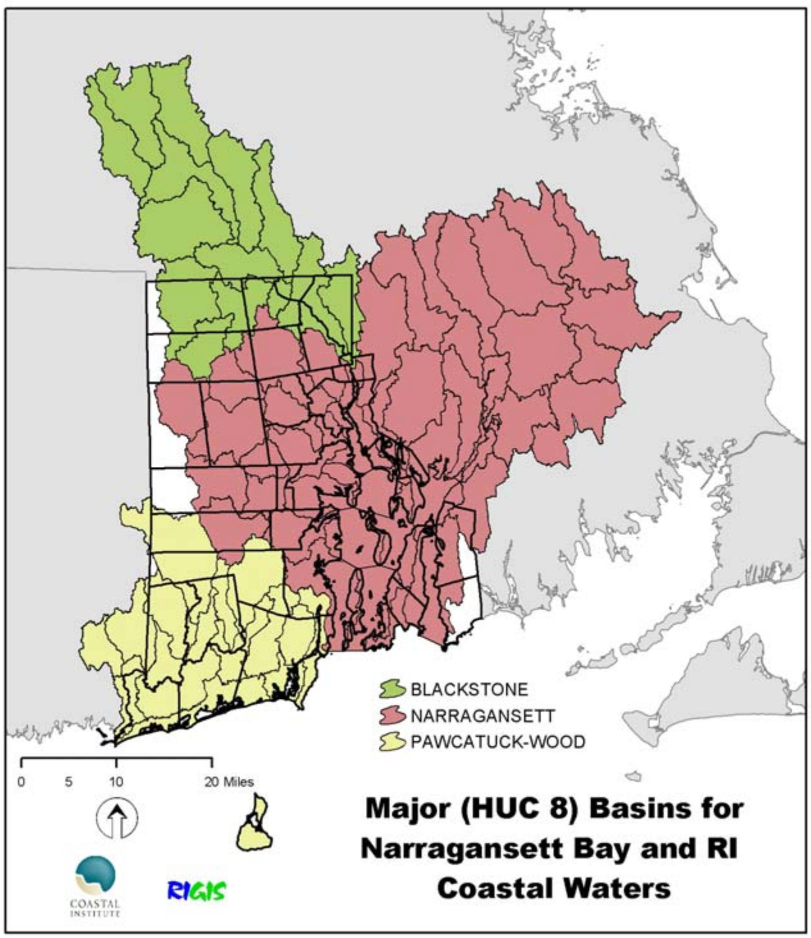
Rhode Island Environmental Monitoring Collaborative

Report to the

Rhode Island Bays, Rivers, and Watersheds Coordination Team

A Strategy to Begin Development of an Environmental Monitoring Framework to Support Systems-level Planning for Rhode Island's Bays, Rivers, and Watersheds



January 2005

1. Executive Summary

This constitutes the first annual report of the RI Environmental Monitoring Collaborative (RIEMC) and is submitted to the RI Bays, Rivers, and Watersheds Coordination Team for review, adoption, and conveyance to the governor and General Assembly. Our major findings, conclusions, and recommendations are as follows:

1. We developed a succinct and clear statement of the Purpose and Principles of the RIEMC. The bases for this were the statutes that created the RIEMC -- R.I.G.L. Chapters 46-23.2 and 46-31.

2. We updated the database of monitoring activities in the State of Rhode Island. The current list of monitoring programs describes 102 separate monitoring initiatives and is in Appendix A of this report.

3. In order to ensure that the most appropriate methods, technologies, and indicators are being used in the RI environmental monitoring framework, we recommend the establishment of a grants-in-aid program to support monitoring demonstration projects, development of monitoring data synthesis and communication, development of new monitoring methods, and the purchase of monitoring technology. These funds would not be used to support ongoing monitoring programs.

4. The RIEMC spent considerable time reviewing and commenting on the RI Department of Environmental Management (DEM) water monitoring strategy. This comprehensive framework covers many of the monitoring issues before the RIEMC and represents three years of work by DEM. The DEM has been very responsive to our input and has provided us multiple revisions of the strategy over the past few months. We will continue to work with DEM in finalizing the document over the next month.

5. The RIEMC strongly endorses the DEM water monitoring strategy and urges the state to fund this effort and initiate its implementation.

6. Many of the environmental indicators that the RIEMC was asked to develop monitoring plans for were not included in the DEM water monitoring strategy. The RIEMC sought and received monitoring recommendations from distinguished members of the scientific and resource management community in RI. The resulting supplemental monitoring recommendations cover the following themes:

    - Monitoring Land Use Change in Coastal and Riparian Buffers
    - A Plan for Benthic Monitoring
    - Zooplankton -- An Indicator of Benthic and Estuarine Condition
    - Monitoring Growth Rates of the Quahog, *Mercenaria mercenaria*, in Rhode Island's Coastal Waters

- Monitoring the Growth Rates of Juvenile Winter Flounder and Tautog in Narragansett Bay: An Indicator for Estuarine Condition
- Eelgrass Monitoring
- Invasive Species Monitoring
- Macroalgal Monitoring of Upper Narragansett Bay

These plans are described in detail in Appendix B of our report. We strongly recommend that the Coordination Team, the Science Advisory and Public Advisory Committees of the Coordination Team, and the RIEMC review these recommendations, refine them where necessary, and integrate them with the statewide water monitoring strategy developed by DEM

7. The RIEMC strongly supports the update of the RIGIS land use dataset to the 2003/2004 digital orthophotography for the state. These data are the foundation for many monitoring and resource assessment activities. The land use dataset update is managed by the RI Statewide Planning Program.

8. The RIEMC recommends a systematic review of the institutional capacity of the agencies carrying our monitoring activities to distribute their data via the Internet. We also recommend that the RIEMC provide technical support when feasible for making data accessible via the Internet.

9. We recommend that the RIEMC constitutes a short-term advisory team to define the high priority data sets required for environmental emergency response and natural resource damage assessment; assess the quality, availability, and spatial/temporal resolution of existing priority data sets relevant to emergency response; and identify data gaps and develop a proposal to fill the gaps with new or enhanced data.

10. The RIEMC should work closely with the Public Advisory Committee of the Coordination Team to develop and implement a communications strategy to ensure broad and timely dissemination of monitoring information to the diversity of audiences we must serve. We recommend regular publication of monitoring results, assessments, and syntheses in RI's leading publications on Bay and coastal issues -- the *Narragansett Bay Journal* and *41 Degrees North*. Furthermore we recommend that the RIEMC host an annual conference to review and disseminate environmental monitoring information.

11. The RIEMC requires a modest operating budget to secure staff to assist in its continued operation.

2. Contents

3. Introduction

The RI Environmental Monitoring Collaborative (RIEMC) was established by statute (R.I.G.L. Chapter 46-23.2) [1] in the 2004 legislative session. The same session also created the RI Bays, Rivers, and Watersheds Coordination Team (R.I.G.L. Chapter 46-31) [2]. The RIEMC was made a standing committee of the Coordination Team pursuant to R.I.G.L. 46-31. The reporting path for the RIEMC is somewhat confusing because of the timing of the legislative approval of the Collaborative and Coordination Team. R.I.G.L. 46-23.2 requires that the RIEMC report directly to the Governor and General Assembly. At the time of passage of this bill, the legislation creating the Coordination Team had not yet been approved. R.I.G.L. 46-31 clearly states that the RIEMC reports to the Coordination Team, which in turn reports to the Governor and General Assembly. The Collaborative follows the reporting structure defined in R.I.G.L. 46-31 and subsequently confirmed in correspondence from the sponsors of the legislation [3].

This report covers the first six months of work of the RIEMC and is hereby submitted to the Coordination Team as required in R.I.G.L. 46-31. The recommendations and conclusions offered here represent a consensus of the members of the RIEMC. Our timeline was, however, uncomfortably short and it would have been desirable to spend more time deliberating over the issues discussed herein. We look forward to working with the Coordination Team and its Advisory Committees to further refine the conclusions and recommendations we offer here.

3.1. Charge to the RI Environmental Monitoring Collaborative

The powers and duties of the RI Environmental Monitoring Collaborative are as follows (From R.I.G.L. § 46-23.2-6.):

1. *To effectuate and implement a state monitoring strategy that addresses critical state resource management needs, including, but not limited to, water quality protection, water pollution control, fisheries and wildlife management, habitat restoration, coastal management, public health protection and emergency response and that assesses and tracks environmental health and function.*

   Within six (6) months of its enactment, the collaborative shall adopt a statewide monitoring strategy that will provide cost-effective and useful policies, standards, protocols and guidelines for monitoring programs undertaken for the waters of the state, that will support system level planning. This strategy shall be reviewed and updated every three (3) years. This strategy shall include the following elements:

   (i) An inventory of existing monitoring programs;

   (ii) An outline of additional monitoring programs the state needs;

[1] http://www.rilin.state.ri.us/Statutes/TITLE46/46-23.2/INDEX.HTM
[2] http://www.rilin.state.ri.us/Statutes/TITLE46/46-31/INDEX.HTM
[3] http://www.ci.uri.edu/Projects/RI-Monitoring/Docs/Rep_ENaughton_Memo.pdf

(iii) A list of indicators that will be used to measure the health of the marine habitats of the state;

(iv) A list of data standards and protocols that will be used on a reasonable and consistent basis by monitoring programs that contribute data to the state monitoring system;

(v) A mechanism for data sharing among all monitoring programs that enables both monitors and users to securely access monitoring data via the internet and to retain the integrity of such data;

(vi) A plan to provide data from the state marine monitoring system for disaster prevention, preparedness, response and recovery efforts in the marine environment; and

(vii) A communications strategy to provide for public access to monitoring data.

2. *To assist with the development and implementation of a state water monitoring and assessment program, developed consistent with guidance issued by the United States Environmental Protection Agency, and to augment and implement such a program to achieve the purposes of this strategy set forth in subsection (1) of this section.*

3. *To prepare an annual report in the month of January to the governor and general assembly on the activities for the preceding year as well as the predicted financial needs of the system for the upcoming fiscal year.*

4. *To enter into data sharing agreements with federal and state agencies, municipalities and nongovernmental organizations for the purposes of coordination and management of monitoring data and programs.*

5. *To accept grants, donations and contributions in money, services, materials, or otherwise, from the United States or any of its agencies, from this state and its agencies, or from any other source, and to use or expend those monies, services, materials or other contributions in carrying out the purposes of this chapter.*

6. *To enter into agreements for staff support that it deems necessary for its work, and to contract with consultants for the services it may require to the extent permitted by its financial resources.*

3.2. Members of the RI Environmental Monitoring Collaborative

The membership of the RIEMC is explicitly defined in the legislation creating the Collaborative. As permitted by statute, we added a number of Institutional Partners who currently lead important environmental monitoring programs in Rhode Island or the region.

<u>Collaborative Members</u>

Peter August, *Coastal Institute at the University of Rhode Island (Chair)*
Jeff Willis, *Coastal Resources Management Council*
Sue Kiernan, *Department of Environmental Management, Water Quality Section*
Arthur Ganz, *Department of Environmental Management, Fisheries Section*
Ernest Julian, *Department of Health*
Linda Green, *URI Watershed Watch*
John King, *URI Graduate School of Oceanography*
Thomas Uva, *Narragansett Bay Commission*
John Stachelhaus, *RIGIS*
Charles LaBash, *URI Environmental Data Center*

<u>Institutional Partners</u>

Jim Campbell, *US Geological Survey*
Margherita Pryor, *EPA Region 1*
Norman Rubinstein, *EPA Atlantic Ecology Division*
Donald Pryor, *RI Bays, Rivers, and Watersheds Coordination Team Science Advisory Committee*
Chip Young, *RI Bays, Rivers, and Watersheds Coordination Team Public Advisory Committee*
Ken Raposa, *NOAA Prudence Island Estuarine Research Reserve*
David Gregg, *RI Natural History Survey*
Barry Costa-Pierce and Ames Colt, *RI Sea Grant*
Bryan Milstead and Beth Johnson, *U.S. National Park Service Inventory and Monitoring Program*
Marci Cole, *Save the Bay*
Christopher Deacutis and Richard Ribb, *Narragansett Bay Estuary Program*

<u>Assisted By</u>

James Boyd, *Coastal Institute (RIEMC administration)*
Erin Myers, *Coastal Institute (RIEMC administration)*
Deb Coty, *Coastal Institute (RIEMC administration)*
Frank Toohey, *Citizen (Database support)*

4. Purpose and Core Principles

We adopted a set of core principles that guide the work of the RIEMC; they were extracted from the statutes that created the Collaborative. The Principles statement was created to clearly define the scope, scale, and role and the RIEMC and was approved by the Collaborative at the 16 December 2004 meeting.

Purpose:

The RIEMC will provide:

1. Coordination of environmental monitoring activities by state, federal, and non-governmental organizations.
2. Review and comment on new and existing monitoring programs.
3. Leadership in identifying future monitoring needs.
4. Assistance in disseminating monitoring data and results.

Principles:

1. The composition and detailed scope work for the RIEMC are defined in R.I.G.L. 46-23.2 and § 46-31-9 (e). The RIEMC reports to the RI Bays, Rivers, and Watersheds Coordination Team.
2. The geographic scope of the RIEMC is Narragansett Bay, Rhode Island Sound, Block Island Sound, Little Narragansett Bay, and the watersheds of these coastal and estuarine systems. When possible and appropriate, monitoring activities shall include watershed regions in Connecticut and Massachusetts.
3. The RIEMC focuses on programs to monitor status and trends in air, water (fresh and marine), land, physical, and biological components of environmental systems. It does not address programs to monitor status and trends in social or economic systems; this is the purview of the RI Economic Monitoring Collaborative. The initial priority monitoring indicators are listed in R.I.G.L. § 46-31-9 (e).
4. Monitoring programs must have a clearly stated goal and objectives. Priority themes for RIEMC initiatives include monitoring to:
    a. support natural resource management,
    b. ensure public health and safety, and
    c. track ecosystem changes resulting from natural (e.g., extreme weather, climate change) or human-induced perturbations (e.g., nutrient reduction programs, commercial harvest of renewable resources).
5. Monitoring programs shall use generally accepted methods, protocols, and quality assurance procedures, and those used must be clearly stated in the description of the monitoring program.
6. Data obtained in monitoring programs must be made available after quality assurance procedures have been applied. Data shall be posted on the Internet as soon as possible and practical.
7. Monitoring programs must include interpretation of data in a timely manner. Interpretation and synthesis of monitoring data shall be made public over the Internet and by other means of communication, including technical reports and articles, public presentations, and the popular broadcast and printed media.
8. New monitoring initiatives should be submitted to the RIEMC for review to ensure that the data to be collected are able to support the information needs of as broad an audience as possible. Descriptions of new programs must include:

a. The goal of the initiative. Explanation of why this is important and relevant. How will the monitoring be coordinated with potential users of the data?
b. The measurable objectives of the program.
c. The methods and protocols followed, including indicators measured and QA procedures followed.
d. Explanation of how the data will be interpreted including assessment of critical thresholds, measurement error, and temporal and spatial variation.
e. Explanation how and when the results of the interpretation will be made public
f. Explanation of how and when raw and summarized data will made available.
g. Description of resources (monetary, personnel, equipment, supplies) required to conduct monitoring.

5. Communication and Activities of the RIEMC: The First Six Months Work

The RIEMC conducted its work in the following ways.

LISTSERV -- A LISTSERV was established to foster electronic communication among members of the RIEMC and interested parties. The LIST is called RIMONITORING and an on-line archive of all communications is available [4] The LIST is open and anyone can subscribe [5]. The purpose of the LIST is to promote discussion and interaction of the monitoring community.

Web Site -- A web site [6] for the RI Environmental Monitoring Collaborative was established and is maintained by the URI Coastal Institute and the Environmental Data Center.

Meetings -- Three meetings were held with the members of the Collaborative. Agendas and minutes are available online [7].

6. Recommendations of the RI Environmental Monitoring Collaborative to the RI Bays, Rivers, and Watersheds Coordination Team

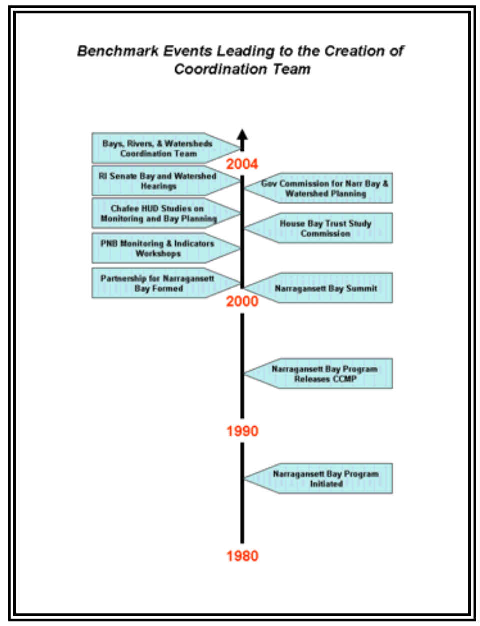
<u>6.A. Background.</u> The RI Environmental Monitoring Collaborative was given a number of specific tasks to address in this report. Despite a tight timeline and no staff support, we have made excellent progress on meeting the initial charges to the RIEMC. The order of presentation of our recommendations follows the charges presented to the

[4] http://pete.uri.edu/archives/rimonitoring.html
[5] http://www.ci.uri.edu/Projects/RI-Monitoring/listserv.htm
[6] http://www.ci.uri.edu/Projects/RI-Monitoring
[7] http://www.ci.uri.edu/Projects/RI-Monitoring/Meetings/Meetings.html

RIEMC in R.I.G.L. § 46-23.2-6. The charges are set off to distinguish them from our responses.

6.B. Recommendations

> 6.B.1. Charge: *Within six (6) months of its enactment, the collaborative shall adopt a statewide monitoring strategy that will provide cost-effective and useful policies, standards, protocols and guidelines for monitoring programs undertaken for the waters of the state, that will support system level planning. This strategy shall be reviewed and updated every three (3) years.*



Completion of this charge is a massive undertaking. It will be many years before a complete and efficient monitoring program is operational for the bay, coast, and watersheds. In the early stages of developing a system-wide monitoring program, review and refinement should be an ongoing process, not one that only happens every three years. Despite the magnitude and complexity of the task, much work toward developing a statewide monitoring strategy was completed or already underway when the RIEMC was conceived. Through the work of the Narragansett Bay Estuary Program [8], the Bay Summit (2000) [9], the Partnership for Narragansett Bay [10], the Chafee-HUD grant research [11], the House Bay Trust initiative [12], and the Governor's Narragansett Bay and Watershed Planning Commission [13] a considerable amount of effort had been invested in developing a comprehensive monitoring framework for Narragansett Bay, coastal RI, and watersheds.

The DEM water monitoring strategy [14] that is near completion is the foundation for a statewide environmental monitoring framework. DEM has been working for the last three years to develop this plan that encompasses monitoring strategies for both freshwater and marine surface waters performed by DEM and other entities. The RIEMC has reviewed multiple drafts of this document and provided comments and recommendations to DEM. DEM is completing final revisions based on recent comments and will make available a final draft of the water strategy in early February 2005 for consideration by the Coordination Team as part of its review of the RIEMC

---

[8] http://www.nbep.org/
[9] http://www.nbep.org/summit/index.html
[10] http://www.ci.uri.edu/Projects/PNB/default.html
[11] http://www.ci.uri.edu/Projects/PNB/Chafee-HUD-grants.htm
[12] http://www.rilin.state.ri.us/gen_assembly/baytrust/btsc.htm
[13] http://www.ci.uri.edu/govcomm/
[14] http://www.ci.uri.edu/Projects/RI-Monitoring/Docs/DEM_WQ_Mon_Jan5_05.pdf

report. DEM will also need to submit a final draft to the EPA for review and comment in advance of a September 2005 deadline for finalizing water monitoring strategies.

Some indicators that we have been asked to develop monitoring strategies for were not directly addressed in the DEM water strategy as they were outside the scope of the strategy or involve the collection of data not routinely used in the water program. Therefore, we assembled teams of the best scientists in the state to develop supplemental plans for monitoring to meet the specific charges to the RIEMC. They have done an excellent job and their recommendations are given later in this report. Full descriptions of their monitoring plans are given in Appendix B. The supplemental monitoring plans must be refined after continued review by the RIEMC; review by the RI Bays, Rivers, and Watersheds Coordination Team; electronic discussion via the RIEMC LISTSERV; and meetings as required. With funding, much of the supplemental monitoring we recommend can begin in the summer of 2005.

6.B.1.a. Charge: *[Develop] An inventory of existing monitoring programs;*

The Partnership for Narragansett Bay (PNB) initiated an inventory of monitoring programs in RI in 2001. The RIEMC recently updated the inventory to be as current as possible. The criteria for inclusion in the inventory follows the definitions established in the PNB review. These are:

> <u>Definition</u>: *Environmental Monitoring is repetitive or continuous measurements or observations of environmental variables recorded over time for the purpose of determining a condition or identifying a trend or change.*
>
> <u>Time Period:</u> *The monitoring cycle depends on the variable(s) measured. For example, water nutrients may need to be sampled weekly in order to characterize a system, but metals in sediments may need to be sampled only once every two years. In general, five years or cycles would be considered a monitoring program (as opposed to a survey or a baseline). The time period can both reach into the past and stretch into the future. It is important to include monitoring programs that might have ended, but have created long-term datasets that provide insight into changes in the Bay and watershed ecosystems.*
>
> <u>Spatial or Ecological Extent</u>: *Monitoring can be at a single site or of a single species, or of multiple sites or multiple species.*
>
> <u>Type of Variable(s)</u>: *Although social or economic variables, such as census data or land values may be useful for relationships, only measurements of biotic and abiotic environmental parameters are considered in this review.*
>
> <u>Ecosystems:</u> *We will include monitoring of environmental variables from any and all ecosystems in Rhode Island: air, land, saltwater, and freshwater.*
>
> <u>Geographic Boundaries</u>: *The database will focus on monitoring programs within Rhode Island and its coastal waters.*

It would require additional time and staff to expand this review to include Massachusetts and Connecticut-based programs. Indeed, we are cognizant that some active monitoring programs in RI are not yet included in our inventory. They can be added at a later time when time and staff resources permit. Nevertheless, the members of the RIEMC provided many important updates to the database and the summary we offer in Appendix A is the best available.

The inventory is stored and managed in a Microsoft Access database. The complete list is rather lengthy and is available online [15] and is included in Appendix A.

6.B.1.b. Charge*: [Develop] An outline of additional monitoring programs the state needs;*

This will be an ongoing task for the RIEMC. Indeed, we embrace the concept of adaptive management in guiding the implementation of a long-term monitoring program for RI's coast, bays, and watersheds. As we learn more of our monitoring needs, and as the resource management issues change and evolve, we will need to adjust what we monitor, how we do so, when we do it, where we monitor, how the data are assessed, and how the information is communicated to our audiences.

We cannot be passive and complacent in our review of needs and opportunities for environmental monitoring in RI. To that end, we recommend that the RIEMC administer an annual grants program to support monitoring demonstration projects, development of monitoring data synthesis and communication, development of new monitoring methods, and the purchase of monitoring technology. Through this grants program we will challenge the resource management and scientific communities to provide the RIEMC new and innovative ways to ensure our monitoring programs are performing as best they can. The grants program would be a competitive process and we would provide four (4) grants per year for a maximum of $30,000 per grant. This is a very modest amount to invest in monitoring research and development, but would have excellent leverage power with extramural granting agencies. Use of these funds would be fully consistent with the Core Principles of the RIEMC (Section 4). With technical assistance from the Science Advisory Committee of the RI Bays, Rivers, and Watersheds Coordination Team, the RIEMC would develop the RFP and evaluation criteria to ensure the investment would advance and enhance implementation of a comprehensive, coordinated state and watershed-wide monitoring strategy. Grant administration would be managed by the URI Coastal Institute, as was done with the Chafee-HUD grants in support of the work of the Partnership for Narragansett Bay. Academic, state, federal, non-governmental organizations, and private institutions would be eligible to apply for funding. RIEMC grants would not be used to support ongoing monitoring activities; these should be funded through other channels such as agency budgets.

[15] http://www.ci.uri.edu/Projects/RI-Monitoring/Database/Update/Rpt_Agency.pdf

Budget [16]

Grants-in-Aid (4) for Research, Demonstration, or Synthesis	$120,000
Grant Administration	$5,000
TOTAL	$125,000

> 6.B.1.c. Charge*: [Develop] A list of indicators that will be used to measure the health of the marine habitats of the state.*
>
> Specifically, we were charged to develop monitoring plans for the following indicators:
>
> *(1) land cover or uses within the shoreline buffers (and riparian zones in watersheds);*
> *(2) water temperature, salinity, and pH;*
> *(3) concentrations of nitrogen, phosphorous, dissolved oxygen, and bacteria;*
> *(4) water flows and circulation;*
> *(5) species assemblages and relative abundances of finfish, shellfish, and benthic macroinvertebrates; and*
> *(6) presence of aquatic nuisance (and invasive) species.*

The majority of the indicators listed above are included in the DEM water monitoring strategy which includes monitoring by other state institutions, and thus represents a single comprehensive plan for RI's bays, rivers, coasts, and watersheds. The DEM plan incorporates a large number of indicators in order to meet the data needs of various state management programs and, in some cases, to be consistent with federal requirements.

The comprehensive monitoring framework under development by the RIEMC is broader in scope than the DEM water monitoring strategy. The statutes that created the RIEMC specifically called for monitoring some indicators that were not directly addressed in the DEM water monitoring strategy and focused on data needed to support decision-making among a number of different state water programs. Some indicators, such as land use change, were simply outside the scope of the water monitoring strategy. In other cases, DEM acknowledged the need to further evaluate the most appropriate technical protocols to measuring certain indicators before identifying the best monitoring approach. This step is needed to ensure the data are useful to the resource managers within DEM and among the other state agencies who would use the information. For example, the presence of aquatic nuisance and invasive species falls into that category. Likewise, the DEM strategy addressed monitoring benthic macroinvertebrates in rivers and streams but noted that monitoring for this indicator in estuarine or marine waters and lakes required further evaluation.

---

[16] Budget figures here do not include indirect costs. These may be charged depending on the source of funds and the institution administering them

The specific indicators adopted in the DEM plan and those articulated in the statutes creating the RIEMC were priority metrics in recent assessments of critical ecological indicators for Rhode Island [17] (e.g., Chafee-HUD project, PNB workshops, 2005 Rivers Council Riparian Buffer Report [18], 2005 CRMC/Sea Grant Coastal and Riparian Buffer Workshop). Identification of the priority indicators was the product of many years of study and deliberation by Rhode Island's resource management and scientific communities.

The RIEMC established, within its membership and partner institutions, teams to prepare supplemental monitoring plans for the measures not included in the DEM water monitoring strategy. These teams developed monitoring plans using the respected scientists in the State who already have data, personnel, experience, and the scientific resources to bring to bear on the monitoring tasks assigned to us. The themes covered in our supplemental monitoring recommendations are described below and reviewed in detail in Appendix B. The supplemental monitoring programs are:

- Monitoring Land Use Change in Coastal and Riparian Buffers
- A Plan for Benthic Monitoring
- Zooplankton -- An Indicator of Benthic and Estuarine Condition
- Monitoring Growth Rates of the Quahog, *Mercenaria mercenaria*, in Rhode Island’s Coastal Waters
- Monitoring the Growth Rates of Juvenile Winter Flounder and Tautog in Narragansett Bay: An Indicator for Estuarine Condition
- Eelgrass Monitoring
- Invasive Species Monitoring
- Macroalgal Monitoring of Upper Narragansett Bay

The supplemental monitoring programs that follow address the environmental indicators prescribed by the statutes defining the charges to the RIEMC. The recommended programs for new monitoring initiatives are briefly summarized here and full descriptions are available in either the DEM water monitoring strategy or Appendix B of this report. The DEM water monitoring strategy also includes cost estimates for the monitoring activities it recommends. Year 1 budgets for new initiatives are provided below with detailed 5-year budgets presented in Appendix B.

It is important to note that the RIEMC has not yet scrutinized these programs in technical detail. We will do this over the next few months and we look forward to working with the Coordination Team in the review, assessment, and refinement of these monitoring recommendations. Nevertheless, they directly address the parameters we were charged by statute to address and that fell outside the realm of the DEM water monitoring strategy. They represent an excellent starting point in the process to fill in obvious gaps in our environmental monitoring enterprise.

[17] http://www.ci.uri.edu/Projects/RI-Monitoring/Docs/Comparison%20of%20Key%20Indicator%20Metrics.pdf
[18] http://www.ci.uri.edu/Projects/RI-Monitoring/Docs/RCRiparianBuffer.pdf

6.B.1.c.1. *Land cover or uses within the shoreline buffers*

Land cover change assessment was not addressed in the DEM report. We offer a plan to measure this for the Bay, coastal Rhode Island, and their watersheds. We have included riparian buffers to this charge. The quality of riparian habitats (vegetated or covered by impervious surfaces) influence the amount and quality of fresh water entering our rivers and streams that flow into the Bay. Riparian buffers, like coastal buffers, are critical habitats that protect our marine and freshwater resources. These are the conclusions of recent (winter 2005) assessments by the CRMC and RI Rivers Council [19].

As instructed by statute, we are taking a watershed approach to coastal and riparian buffer monitoring. The protocol that we have adopted here is the only practical approach when mapping such a large area -- 2,200 square miles encompassing three states. Our protocol will provide mapping resolution suitable for HUC12 and municipal-scale assessment (approximately 2-5 acres minimum mapping unit). Higher resolution mapping of coastal and riparian buffers can be accomplished for little cost once the RIGIS land use data are updated using the 2003/2004 color orthophotography being developed by RIDOT. The Rhode Island Statewide Planning Program (Department of Administration) is scheduling an update to the RIGIS land use dataset using the new orthophotography and this is scheduled to occur in 2006. Once the RIGIS land use data are updated, mapping coastal and riparian buffers at a resolution of 0.5-1.0 acre can be done within Rhode Island. A full watershed-wide assessment can not be done at this scale because comparable land use data for Massachusetts and Connecticut are not available or compatible with the Rhode Island data.

Because of the critical role of the RIGIS land use dataset to support monitoring and resource management in RI, the RIEMC strongly endorses the planned update of the RIGIS land use data by the RI Statewide Planning Program.

Project Title [20]: Monitoring Land Use Change in Coastal and Riparian Buffers

Principal Investigators

David W. Gregg, Executive Director, Rhode Island Natural History Survey
Charles LaBash, Director, Environmental Data Center, Dept. Natural Resources Science, URI
Y.Q. Wang, Director, Laboratory for Terrestrial Remote Sensing, Dept. Natural Resources Science, URI

Summary: We will measure watershed-wide indices of land cover that are critical to managing water quality in coastal ecosystems. Furthermore, we will measure changes in land cover at five year intervals using remote sensing data. The indices we will monitor are impervious surface, land cover in coastal and riparian buffer zones, and land cover composition in the watersheds for Narragansett Bay and coastal Rhode Island (encompassing all of RI, a large area of MA, and a portion of eastern CT; a total area of

[19] http://www.ci.uri.edu/Projects/RI-Monitoring/Docs/RCRiparianBuffer.pdf
[20] See Appendix B. for a full description of this project and a 5-year budget

2,200 square miles). Status and trend information on these indices, aggregated by management units such as drainage basins and municipalities, are standard metrics in water resource management. Recent (2005) workshops and publications by the RI Coastal Resources Management Council, the Sea Grant Program, and RI Rivers Council [18] have shown that knowledge of land use in coastal and riparian buffer regions is one of the highest priority indicators of fresh and estuarine water quality. Classification and interpretation of data, accuracy assessment, aggregation of data into reporting units, and assessment against thresholds will be undertaken using a team-based approach coordinated by RINHS and involving land cover change experts at the University of Rhode Island and the University of Connecticut.

Overview: The goal of this initiative is to provide measurements of land cover that are relevant to water quality in Narragansett Bay and coastal RI because they reflect the quantity and quality of runoff into its tributaries and estuaries. The focal indices -- impervious surface, land cover within coastal and riparian buffers, and land cover type -- will be quantified using remote sensing data with 15m resolution. This is a rapid and cost-effective approach that can be used across the entire, three-state Bay watershed area on a regular basis. The total area to be assessed is the entire watershed region (2,200 square miles) described in the Comprehensive Watershed and Marine Monitoring Act of 2004 (R.I.G.L. 46-23.2). This encompasses all of Rhode Island, large areas of Massachusetts, and a section of Connecticut. Within the project area, the monitoring indices will be reported every five years for sub-areas that are relevant to management, including HUC-12 drainage basins (these are the smallest watersheds shown on the cover map of this report) and municipalities, or other Areas of Interest (AOI) as necessary.

Monitoring of land cover is a straightforward approach to the quantification of the state of, changes in, and anthropogenic threats to two major contributors to Rhode Island's waters--surface runoff and groundwater/surface exchange. It does not require extensive and costly ground-truthing or manual aerial photo interpretation. The methods we will use have been described in detail in the peer-reviewed literature and represent best practice for measuring patterns in land cover over large areas.

The three indicators we will measure are:

Impervious Surface: Runoff from man-made surfaces is the leading source of pollution in United States' estuaries, lakes, and rivers (Arnold and Gibbons 1996, Booth and Jackson 1997). Because of the effect of impervious surface on water systems and its role in transportation and concentration of pollutants, the amount of impervious surface in an area is a powerful indicator of pollution in adjacent surface waters (Arnold and Gibbons 1996). Impervious surface is any impenetrable material that prevents infiltration of water into the soil. Urban pavements, rooftops, roads, sidewalks, parking lots, driveways and other manmade concrete surfaces are examples of impervious surfaces found in urban and suburban landscapes. Quantification of the percentage of impervious surface in a landscape, therefore, has become an increasingly important tool for water quality management nationwide (Civco et al. 2002), and quantification of impervious surface and impervious surface changes is essential for watershed quality monitoring and impact analysis in Rhode Island, as well.

Coastal and riparian land cover: Coastal and riparian buffer, the area of land along streams, rivers, coastal waters, and other open water bodies, is essential to water quality and the ecology of aquatic systems because it protects streams from erosion and scouring, provides wildlife habitat, and removes sediment and nutrients from rain runoff and groundwater draining from lands adjacent to the water body (Allen 2004, Rosenblatt et al. 2001). Loss of riparian and coastal buffer habitats contributes to degradation of water quality (Booth and Jackson 1997).

Coastal buffer monitoring was requested in the statute that created the RI Environmental Monitoring Collaborative. Identification and assessment of riparian and coastal buffer condition statewide using remote sensing, and the incorporation of these results into the statewide watershed monitoring strategy were principal recommendations of the RI Rivers Council in its 2005 report on riparian buffers (RIRC 2005 [see footnote 18]).

Land cover: Existing reports and case studies provide strong evidence that urbanization and suburban sprawl negatively affect stream ecosystem condition and result in water quality problems such as loss of habitat, increased temperatures, sedimentation, and loss of fish populations (USEPA 1997, 2000). Project PI Y. Q. Wang and his students estimated that between 1970 and 1995, Rhode Island residential area increased 55.5%, commercial area increased 87.6%, industrial area increased 60.7%, and waste disposal area increased 102% (Novak and Wang 2004). However, high resolution land cover information and changes in land cover have not been compiled for the entire Narragansett Bay watershed area.

There are many isolated mapping projects that measure land cover in small areas within the Bay basin. These studies, however, use varying sources of data of different levels of resolution, different classification systems, and ultimately result in statistical summaries that are difficult or impossible to aggregate over the entire watershed for Narragansett Bay. These studies are, nonetheless, complementary to the proposed long-term monitoring because they help establish or refine interpretive models, impact thresholds, and management strategies.

RINHS is proposing to monitor a region that includes substantial areas of neighboring states (see cover of the RIEMS report). The advantage of our approach is the ability to develop community and small watershed inventories of land use and impervious surface, as well measuring land cover patterns in the larger regional context within which RI sits. This approach will leverage regional expertise in remote sensing for land use with participation by expert working groups in CT and MA who will work with the RI team to make sure technical decisions are appropriate, share data on land use for watershed areas in adjacent states, and participate in interpretation. Ultimately, to understanding water quality in Narragansett Bay, equivalently detailed assessments of land cover state and trends in RI and in a substantial area of MA and CT will be necessary.

Year 1 Budget $125,250

6.B.1.c.2. *Water temperature, salinity, and pH*

These are addressed in a comprehensive manner in the DEM water monitoring strategy. A number of baseline monitoring programs, implemented by DEM, NBC, URI, as well as federal agencies and volunteer programs, collect data that support measuring these indicators in the various types of waterbodies (coastal, estuarine, rivers and streams, lakes and ponds) that comprise our freshwater and marine ecosystems.

6.B.1.c.3. *Concentrations of nitrogen, phosphorous, dissolved oxygen, and bacteria*

These are addressed in a comprehensive manner the DEM water monitoring strategy. The parameters are a part of key baseline monitoring programs being developed which includes the fixed-station monitoring network in the Bay, monitoring of rivers and streams, and volunteer-based monitoring of lakes and ponds. Additionally, the state bathing beach and shellfish programs collect pathogen data (bacteria). The DEM plan identifies some gaps in current collection efforts and proposes strategies to reduce these gaps, including the rotating basin approach for rivers and rotating assessments of coastal embayments and ponds. It should be noted that while nutrients are routinely measured in both lake and river monitoring programs, DEM has not proposed routine measurements of these parameters in the Bay at this time. Determining how best to address the nutrient parameter in estuarine waters will be a refinement to the DEM water monitoring strategy.

6.B.1.c.4. *Water flows and circulation*

Water flows are measured through a stream gage network that is maintained by USGS in cooperation with the State (DEM and RI Water Resources Board [WRB]). The number of active gages currently in operation is not sufficient to meet state program needs. The DEM water monitoring strategy recommends funding to expand the number of gages consistent with the priorities already established by the Joint WRB-DEM Streamflow Committee. The DEM water monitoring strategy provides detailed discussion of this critical issue.

Data on the currents in the Bay are being measured on an on-going basis by the Physical Oceanographic Real-Time System (PORTS) maintained by NOAA. Other data on circulation have been developed through on-going and past studies, including those funded via the Narragansett Bay Estuary Program as part of its initial work between 1985-1990. Circulation data are critical to support modeling efforts addressing both the hydrodynamics of the Bay and coastal waters, as well as the fate and transport of pollutants discharged into coastal waters.

Beginning in 1995, as part of TMDL development, DEM retained a local scientific consulting firm (Applied Science Associates, Narragansett, RI) and organized a Technical Advisory Committee (TAC) consisting of experts and other stakeholders to calibrate a model to develop a water quality restoration plan for the Providence and Seekonk Rivers. It has recently been determined that successful calibration of the mass transport component of the model is prevented due to complexities encountered when modeling the interaction between the deep channel and shallow flanks of these waterbodies. The modeling problem has not been easily resolved and DEM will continue to work with the TAC and stakeholders to determine the appropriate next steps. More recently, NBC has contracted with physical oceanographers from URI to develop and refine a model intended to address circulation and thermal/chemical transport for the Upper Bay and Providence and Seekonk Rivers.

Additional details on circulation modeling and hydrodynamics are available in the DEM water monitoring strategy.

6.B.1.c.5. *Species assemblages and relative abundances of finfish, shellfish, and benthic macroinvertebrates*

Demersal (bottom-dwelling) finfish and shellfish are monitored by the DEM and their work is included in the DEM monitoring strategy. Fish and shellfish will be valuable indicator species to assess the effects of nutrient reductions in Narragansett Bay. The following projects describe how secondary productivity in fish and shellfish, the benthic macroinvertebrate community, and zooplankton should be monitored to measure changes in Bay condition; especially with respect to the anticipated decline in nutrient inputs. In addition, we include a plan to monitor the condition and extent of a sentinel benthic habitat -- eelgrass -- in near-shore regions of the Bay and coastal ponds. Eelgrass habitat is one of the most important ecological communities in support of fish and shellfish populations.

Project Title [21]: A Plan for Benthic Monitoring

Principal Investigator:
Candace Oviatt, Graduate School of Oceanography, University of Rhode Island, Narragansett, R. I. 02882

Summary: The goal of this study is to assess the impact of nutrient reduction and climate trends on benthic fauna in Narragansett Bay.

Overview: Sessile fauna of the benthos can be easily re-sampled and respond to conditions in the overlying water and deposited sediments, and represent excellent biomarkers for monitoring anthropogenic and climate change. Previous surveys

[21] See Appendix B. for a full description of this project and a 5-year budget

provide quantitative measures of inter-core and inter-grab variability and inter-annual community variability (Holohan 1999, Ellis 2002). Recent core data from a relatively clean North Jamestown station may be viewed on the GSO web site. The abundance of opportunistic species provides a record of anthropogenic disturbances like anoxia, bottom trawling for fish and toxic pollutants. Abundance and biomass of animals provide a measure of the nutrient environment in the overlying water. A recent survey of benthic fauna demonstrated a close relationship to total nitrogen in the overlying water column (Figure 1). The abundance of small polychaetes in late spring may be an indicator of climate change. During the recent climate trend of warm winters, grazing by zooplankton and benthic fauna has limited the expression of a winter – spring diatom bloom reducing the reproductive potential of benthic polychaetes (Oviatt 2004, Oviatt et al. 2002, Keller et al. 2001, Ellis 2002).

Objectives:
In order to assess the status of benthic fauna in Narragansett Bay during the current trends of climate change and nutrient input, we propose to establish and maintain a long term monitoring program to:

1. To measure the abundance, biomass and growth of benthic fauna of soft bottom communities at Conimicut Pt., Mt Hope Bay, Greenwich Bay, North Jamestown and Fox Island.
2. To measure the re-colonization and growth of fauna recruiting to azoic sediments placed at each station location.

Year 1 Budget: $33,391

Project Title [22]: Zooplankton -- An Indicator of Benthic and Estuarine Condition

Principal Investigators:
Barbara Sullivan and Candace Oviatt, Graduate School of Oceanography, University of Rhode Island, Narragansett, R. I. 02882

Summary: The goal of this monitoring is to assess the impact of nutrient reduction, low oxygen events and climate trends on zooplankton in Narragansett Bay.

Overview: Zooplankton are the most abundant resource in the water column for larval fish and other predators and are critical to survival and growth of various species of fish (Houde 1978; Hunter 1981). Zooplankton growth rates respond rapidly to nutrient availability via phytoplankton production and thus, their abundance can be expected to decrease with planned nutrient reduction in Narragansett Bay. Zooplankton are also sensitive indicators of climate trends because their phenology (seasonality) is highly dependent upon water column temperature, for example via temperature dependent production and hatching of resting eggs, or temperature dependent initiation of reproduction (e.g., Sullivan and MacManus 1986). During warmer winters zooplankton

[22] See Appendix B. for a full description of this project and a detailed 5-year budget.

grazing apparently prevents initiation of the winter-spring bloom (Oviatt 2004). Sullivan (in review) has documented a dramatic summer decline in copepods in response to increased predation by ctenophores in early summer; whereas, during colder climate periods ctenophores did not become abundant until fall. Zooplankton species are also sensitive indicators of activity in the benthic habitat. Zooplankton abundance was directly related to benthic animal abundance in a nutrient gradient experiments conducted in mesocosms (Doering et al. 1989, Sullivan et al. 1991). Our data show zooplankton abundance and diversity to be sensitive measures of benthic activity in relatively well-mixed systems like Narragansett Bay. Thus when the upper bay stratifies and the benthos suffers summer hypoxia and anoxia, zooplankton thrive. We will evaluate a large data set on zooplankton which is available from around the Bay surveys conducted by the National Marine Fisheries Service Nu-shuttle Optical Plankton Counter (OPC). Samples from Fox Island and two additional summer stations would provide ground truth data to validate OPC samples.

Objectives:

1. To evaluate zooplankton from samples already collected from Fox Island weekly.
2. To take new samples from North of Prudence Island and Greenwich Bay bi-weekly in summer.
3. To describe and quantify zooplankton responses to changing conditions in Narragansett Bay and compare this to the long term record of zooplankton populations available since 1999.
4. To evaluate impacts of observed patterns or changes on the Bay ecosystem food web and on living resources that depend on zooplankton for food.

Year 1 Budget = $ 32,080

Project Title [23]: Monitoring Growth Rates of the Quahog, *Mercenaria mercenaria*, in Rhode Island's Coastal Waters

Principal Investigators:
Scott Nixon, Betty Buckley, and Steve Granger
Graduate School of Oceanography, University of Rhode Island
Narragansett, RI 02882

Summary: This project will monitor the annual growth rate of Rhode Island's signature marine animal and official state bivalve as it is influenced by changing habitat and climate. Habitat changes will likely occur as nutrient reductions are implemented in Narragansett Bay. These changes will result in an increase in bottom water oxygen concentrations while decreasing the supply of organic matter. It is not known how these trends will interact and impact the quahog population. If recent warming trends continue, growth rates may be enhanced. Much less is known about the growth rates of

[23] See Appendix B. for a full description of this project and a detailed 5-year budget.

the hard clam in other Rhode Island waters, including the salt ponds and Little Narragansett Bay, and we recommend a rolling monitoring plan to document rates in these systems and provide a comparative baseline among the ponds. These areas may experience continuing nutrient enrichment and will also be exposed to climate change.

Overview: Virtually all of the previous monitoring programs in Rhode Island coastal waters have focused on measurements of concentrations or standing crops – concentrations of chlorophyll, oxygen, or nutrients, for example, and the numbers or weights of animals per unit area or in a standard tow. Much can be learned from these static measurements and many of them will almost certainly and quite rightly be continued by the new Monitoring Collaborative. But they do not capture the underlying biological dynamics that will in large measure determine the standing crops over time. The basic and most fundamental of the rate processes that lead to biomass and abundance changes include the photosynthesis or primary production of the phytoplankton and the growth rates or secondary production of the animals. While we are not aware of any proposals to monitor directly the primary production in Narragansett Bay or other Rhode Island coastal waters, the surface oxygen measurements from the various buoy-mounted sensors in the bay will provide a useful relative measure of this process, at least in the bay.

The growth rates of animals are often thought to be too difficult or expensive to measure and they are, therefore, seldom included in routine monitoring programs. While it is certainly true that a total assessment of secondary production in the bay or even a salt pond would be a very ambitious and costly undertaking, it is possible using standard modern techniques to measure the growth rates of carefully selected species of animals that may serve as indicators of overall secondary production. We believe that the hard clam or quahog, *Mercenaria mercenaria*, is an obvious choice for Rhode Island's coastal marine ecosystems. It is arguably the state's signature marine resource and people care about it for historical, cultural, and economic reasons. It is also widely distributed in the state's coastal environment and easily collected. And there is a tradition of measurements and modeling of hard clam growth in the bay extending back over half a century (Pratt and Campbell 1956, Kremer and Nixon 1978, Bernstein 1988, Jones et al. 1989).

Driven by the interests of anthropologists (because quahog shells are abundant in prehistoric shell middens) and fisheries managers, standard techniques have been developed that now allow us to measure the annual growth rate of individual clams over the course of their often long lives (up to about 40 years). This is possible because the clams essentially stop growing during the colder months and this is reflected in the structure of the shell. In effect, shells collected from living clams can be sectioned, polished, and read like tree rings to reveal the annual growth increment between the time of set and the time of death of the animal (Kennish 1980, Kennish et al. 1980, Grizzle and Lutz 1988, McManamon and Bradley 1988, Jones et al. 1989, Bernstein 1993). A sampling of the population at one time thus provides information about growth during the preceding years, especially during the first decade of the animal's life when growth rates are most rapid (Jones et al. 1989). This feature makes it possible for us to gain a good measure of inter annual variability with a low sampling frequency, so that we need sample each bay or salt pond only once every five years or so. This allows us to adopt a rolling sampling strategy to monitor Narragansett Bay, the salt ponds, and Little Narragansett Bay with a relatively modest budget. As described in more detail below, we will use many of the same stations and the same techniques used in an earlier study of quahog growth in Narragansett Bay by Jones et al. (1989), thus allowing us to build on the 26 year growth record they developed for the bay between 1959 and 1984. By collecting some animals that are about 20 years old, we may be able to assemble an almost continuous growth record for the bay going back almost half a century – a powerful foundation for interpreting changing growth rates in the future.

Studies of quahog growth rates have shown that they respond to changes in nutrient input/food supply (Pratt and Campbell 1956, Chalfoun et al. 1994, Weiss et al. 2002, Carmichael 2004), temperature (Jones et al. 1989), current speed (Grizzle and Morin 1989), and sediment type (Pratt and Campbell 1956, Grizzle and Morin 1989). The latter two factors should be of minor importance since we will be looking primarily at changes in particular sites over time. Because quahogs are filter feeders that are tolerant of hypoxia and even short periods of anoxia, we believe that the two most important changes that will influence their growth in the bay and salt ponds will be changes in food quantity and quality and in temperature. However, it is also possible that we will be able to detect periods when the animals close their shells and do not feed due to hypoxic/anoxic conditions. These may be recorded in the daily growth lines laid down during summer and make the quahog growth rates a good recorder of oxygen stress. In a companion effort being submitted to the Monitoring Collaborative, we propose to monitor growth rates of juvenile fish which are sensitive to dissolved oxygen. In other words, we see the quahog growth rates as an important part of a matrix of measures that should be used to assess the higher lever productivity of the bay and salt ponds – the juvenile fish growth studies we are proposing and the benthic infauna and zooplankton monitoring being proposed by Candace Oviatt are also critical for developing a balanced and comprehensive assessment of higher trophic level health and productivity in Rhode Island's coastal environment. The rate measurements these programs will provide are designed to help with interpreting and understanding the results of what we hope will be continuing monitoring of the standing crops of zooplankton, benthos, and finfish by RIDEM Marine Fisheries, The Bay Window, and URI-GSO.

Objectives:

1. To measure the annual growth rates of an important filter feeding bivalve along the axis of Narragansett Bay, in Mt. Hope Bay, in Greenwich Bay, in all of the salt ponds, and in Little Narragansett Bay on a five year rolling cycle to document spatial variability within and among systems.
2. To provide sensitive quantitative data on how the growth of quahogs in all of these areas responds to changes in nutrient loading and climate.
3. To provide an indicator of secondary production in Rhode Island coastal waters that is independent of commercial pressures and gear selectivity.

Year 1 Budget = $ 35,104

Project Title [24]: Monitoring the Growth Rates of Juvenile Winter Flounder and Tautog in Narragansett Bay: An Indicator for Estuarine Condition

Principal Investigators:
Scott Nixon, Betty Buckley, and Steve Granger
Graduate School of Oceanography, University of Rhode Island
Narragansett, RI 02882

Summary: This proposal seeks funding to monitor the growth rates of two of the most important fin fish in Narragansett Bay, the winter flounder (*Pseudopleuronectes americanus*) and the tautog (*Tautoga onitis*). Our focus will be on juvenile young–of-the - year fish that have successfully passed through larval stages which are exposed to very high mortality. The growth rates of juvenile fish are strongly influenced by food availability, dissolved oxygen concentrations, and temperature – all factors of great concern in the bay. Our sampling would be carried out in collaboration with the RI DEM juvenile finfish surveys. Growth rates would be measured throughout the summer at five stations along the axis of the bay, Greenwich Bay, and the Providence River using the RNA/DNA ratio method developed at the Narragansett National Marine Fisheries Service Laboratory, a technique which has become standard in the field. We believe that the growth rates of these two species can serve as excellent indicators of the interaction of habitat quality (including oxygen conditions and food supply) and climate change on the secondary production of demersal or bottom feeding fish in the bay. In addition, the growth rate measurements, unlike abundance measurements, do not respond directly to fishing pressure.

Overview: Virtually all of the previous monitoring programs in Rhode Island coastal waters have focused on measurements of concentrations or standing crops – concentrations of chlorophyll, oxygen, or nutrients, for example, and the numbers or weights of animals per unit area or in a standard tow. Much can be learned from these static measurements and many of them will almost certainly and quite rightly be continued by the new Monitoring Collaborative. But they do not capture the underlying biological dynamics that will in large measure determine the standing crops over time. The basic and most fundamental of the rate processes that lead to biomass and abundance changes include the photosynthesis or primary production of the phytoplankton and the growth rates or secondary production of the animals. While we are not aware of any proposals to monitor directly the primary production in Narragansett Bay, the surface oxygen measurements from the various buoy-mounted sensors in the bay will provide a useful relative measure of this process.

The growth rates of animals are often thought to be too difficult or expensive to measure and they are therefore seldom included in routine monitoring programs. While it is certainly true that a total assessment of secondary production in the bay would be a very

[24] See Appendix B. for a full description of this project and a detailed 5-year budget.

ambitious and costly undertaking, it is possible using standard modern techniques to measure the growth rates of carefully selected species of animals that may serve as indicators of overall secondary production. We believe that the winter flounder (*Pseudopleuronectes americanus*) and the tautog (*Tautoga onitis*) are compelling choices for Rhode Island's coastal waters. Both species are of commercial and recreational importance, both are well known to Rhode Islanders, and both are at historically low levels and deserve great attention. It is also important that both species feed on the bottom and their growth is almost certainly strongly influenced by dissolved oxygen concentrations in the bottom waters (Bejda et al. 1992, Meng et al. 2001, Stierhoff & Tagget 2004) and the flux of organic matter from the water column to the benthos. Thus these species may respond markedly to increases in dissolved oxygen in the bottom waters resulting from nutrient reductions in sewage treatment plant discharges. They may also be affected by potential reductions in the production of phytoplankton in the bay due to reduced nutrient inputs and/or to changes in the timing of organic inputs to the bottom associated with the presence or absence of the winter-spring phytoplankton bloom (Oviatt 2004).

It is also important that unlike many species of fish that are found in Narragansett Bay, the local abundance of winter flounder and tautog is critically dependent on successful reproduction, survival, and growth in bay waters. Both species reproduce in the bay and, after a brief planktonic larval period, settle in specific habitats (Dorf & Powell 1997, Meng & Powell 1999). Tagging studies have shown only limited movement of juveniles away from the area of initial capture (Pearcy 1962, Saucerman & Deegan 1991, Able & Fahay 1998). As adults, both species spend a portion of the year in deeper water to avoid temperature extremes, but they return to specific areas within the bay with a high degree of site fidelity (Saila 1962, Cooper 1966 1967, Powell 1991). As a result, the growth rate results will apply to specific areas of the bay and may tell us much about site specific responses to changing conditions along the pollution gradient in the bay.

While other monitoring programs will document the concentrations of oxygen in bottom waters in the bay, water temperatures, and, perhaps, the magnitude and seasonal distribution of primary production, these measures will not tell us how the demersal fin fish will be responding to the interaction of these and other factors. The best and most practical indicator of that will be the juvenile growth rate measurements proposed here. Of course, we can not claim that all demersal species will respond in the same way, but the responses of winter flounder and tautog will be important in their own right and may serve as an instructive proxy for the overall bottom fish community.

Objectives:

1. To measure the growth rates of juvenile winter flounder and tautog, two of the most important demersal fish species in Narragansett Bay, at five stations along the axis of the bay, including Greenwich Bay and the Providence River.
2. To correlate the growth rates of the juveniles of these species with other monitoring data on dissolved oxygen, temperature, chlorophyll, and surface dissolved oxygen anomaly data (an indicator of water column productivity),

benthic infauna biomass, and the growth rates of the quahog, a filter feeding benthic species.

3. To assess the interactive effects of anthropogenic activities and climate on secondary production of the benthic finfish community.

Year 1 Budget = $24,640

Project Title [25]: Eelgrass Monitoring

Principal Investigators:

Michael Traber, University of Rhode Island, Laboratory of Estuarine Ecology and Coastal Biogeochemistry, Laboratory of Terrestrial Remote Sensing
Scott Nixon, University of Rhode Island, Graduate School of Oceanography
Y.Q. Wang, University of Rhode Island, Laboratory of Terrestrial Remote Sensing
Andy Lipsky, USDA , Natural Resource Conservation Service
Sue Tuxbury, Save The Bay

Summary: Eelgrass, *Zostera marina*, is a submerged aquatic plant that was once widespread throughout RI coastal waters. Less than a century ago, vast eelgrass meadows sustained one of the most significant bay scallop fisheries in New England and large populations of migratory waterfowl, such as the Atlantic Brandt. Hurricane damage and disease outbreaks of the 1930's followed by water quality degradation over the past 70 years, have caused wide spread loss of eelgrass in Rhode Island and the North Atlantic. Recent studies in Rhode Island indicate that less than 100 acres of eelgrass remain in Narragansett Bay. Eelgrass is recognized as a critical marine resource and is protected by state and federal regulations. Although millions of dollars are currently being invested in RI to restore eelgrass populations, the state does not have a comprehensive plan to monitor the health and extent of RI eelgrass populations. This proposal suggests a two tiered approach of mapping and annual vegetation surveys to develop a long-term eelgrass monitoring plan. This project will be a collaborative between the, URI Laboratory of Estuarine Ecology and Coastal Biogeochemistry, URI Laboratory of Terrestrial Remote Sensing, USDA Natural Resources Conservation Service and Save The Bay. The monitoring results will be compiled into an annual report. The annual report will be presented to the RI Monitoring Collaborative and published on the RI Restoration Portal Website. An eelgrass monitoring program will have significant benefits for coastal restoration planning, environmental permitting, and quantifying one of the state's premiere environmental indicators.

---

[25] See Appendix B. for a full description of this project and a detailed 5-year budget.

Overview: Eelgrass (*Zostera marina* L.) is a submerged aquatic vegetation (SAV) that has been recognized as a critical marine resource and is currently protected by both Federal (Clean Water Act; 33 U.S.C. 26 Section 1251 et seq.) and State legislation (RI Coastal Resource Management Plan, Section 300.18). Eelgrass is a vital resource for an abundance of marine life, including economically important finfish and shellfish. The health and vitality of eelgrass beds is a direct indictor of estuarine productivity and function (Orth et al. 1993). The RI Coastal Resources Management Council (CRMC) is the Rhode Island coastal zone management agency charged with implementing the Coastal Resources Management Plan. The goals of the CRMC are to preserve, protect and where possible, restore SAV habitat (CRMP 300.18.C.1). Even with this federal and state legislation in place, Rhode Island currently does not have a long-term monitoring program for SAV. Routine monitoring and mapping of Rhode Island's SAV habitat will be essential to coastal managers and researchers by making it possible to follow trends in health and aerial extent of the local populations. It will also be essential to document the success of the significant restoration efforts in the state to determine whether the success or failure of a restoration site is due to natural variability. Furthermore, many CRMC assents, given to private landowners to erect dock/pier structures over eelgrass populations, stipulate that vegetative monitoring be conducted by applicants. However, no program is in place to compare data obtained for eelgrass dock, pier monitoring and unimpacted reference sites. These trends, linked with other monitoring programs such as water quality and fisheries yield, will help to build a clear picture of the status of Rhode Island's coastal marine habitats.

We proposed that the monitoring plan be two tiered. Tier one will utilize 1:5000 true-color aerial photography to map the coverage of eelgrass habitat throughout Rhode Island's coastal waters. The results from this delineation will be compared to previous mapping results to investigate large-scale changes, either gain or loss, of eelgrass habitat in Rhode Island. We propose this be conducted every five years. Tier two will be an annual diver based survey of the health of four representative eelgrass beds based on the internationally accepted Seagrass Net protocols. This survey will focus on monitoring the health of eelgrass beds which may vary annually. Tier two will be conducted twice annually.

Year 1 Budget = $ 150,000

6.B.1.c.6. *Presence of aquatic nuisance (and invasive) species*

We advance two plans for monitoring invasive and nuisance species. The first (Gould and Endrulat) establishes a system-wide monitoring and reporting scheme for invasive plants and animals in RI. The second (Deacutis, Thornber, and Prell) provides a monitoring plan for macroalgae in the Upper Bay; a nuisance species of urgent concern in RI.

Project Title [26]: Invasive Species Monitoring

Principal Investigators:
Lisa Gould, Senior Scientist, Rhode Island Natural History Survey
Erik Endrulat, Data Manager, Rhode Island Natural History Survey

Summary: A chief goal of coordinated environmental monitoring should be to identify small problems in time to prevent them from growing, and invasive species is one area where diligent monitoring and a planned response could save a great deal of effort, money, and damage by preventing or limiting introductions of harmful species. RINHS proposes to set up a central coordination system and data repository for invasive species in Rhode Island, and to work with existing monitoring programs to initiate invasive species monitoring at selected sites.

Overview: Nuisance or invasive species are plants, animals, or microorganisms that have been introduced into a region and that have an effect on the naturally occurring ecosystems and/or human health and activities. As global trade and transportation have increased we are seeing and will continue to see more introductions and more invasions (e.g., Cohen and Carlton 1998, Ruiz et al. 2000). Invasive species are a direct threat to environmental stability in Rhode Island and hence to its economy and the health of the human population.

Estimates of the cost of nuisance species vary enormously but are generally measured in billions of dollars spent each year in the United States alone (e.g., Pimental et al. 2000) to combat and control invasive species and deal with their effects on: agriculture (e.g., Africanized honeybee, Mediterranean fruit flies, cheatgrass); human health (e.g., West Nile virus, Asian Tiger Mosquito carrying dengue fever); forest products (e.g., Gypsy Moth, Sudden Oak Death, Asian Longhorned Beetle); human infrastructure (e.g., effect of the Zebra Mussel and Asiatic Clam on water supply systems); commercial fishing and *shellfishing* (e.g., introduction of pathogens such as MSX [*Haplosporidian nelsoni* killing Eastern Oysters], fouling of gear [e.g., Chinese Mitten Crab], direct predation on commercial species [e.g., Green Crab] and/or habitat degradation that affects commercial species [e.g., the ctenophore, *Mnemiopsis leidyi*); the Lace Bryozoan, *Membranipora membrancea*; the seaweed *Codium fragile* ssp. *tomentosoides*], and invasive sea squirts [tunicates]); property values and recreational activities (e.g., Water Chestnut and Eurasian Water-milfoil taking over freshwater ponds); and overall ecological disruption (e.g., *Phragmites* and Purple Loosestrife dominating wetland habitats). For excellent overviews of the impact of invasive species, see McKnight (1993) and Mooney and Hobbs (2000).

A basis for a cost estimate of invasive species control in RI is made possible by data provided by the Maine Department of Environmental Protection [27]. Mechanical or chemical means of controlling invasive species on freshwater lakes can cost from $200 to

---

[26] See Appendix B. for a full description of this project and a detailed 5-year budget.

[27] www.state.me.us/dep/blwq/topic/invasives/invcost.pdf

$2,000 per lake-acre per year. There are 24,735 lake-acres in Rhode Island (2,658 in the Scituate Reservoir alone); at an in-between figure of $1,000/year, if all of our lakes and ponds were in need of nuisance species control, it would cost ~$25 million a year. This figure does not include property value loss and losses to fishing, recreation, and ecosystem health. And less easy to measure but no less important, effects on the integrity and beauty of the natural landscape, that gift of "a sense of place" we so value, and indeed, rely on for tourist dollars. Clearly, an ounce of prevention is called for!

Rhode Island has an abundance of nuisance species in terrestrial, freshwater, estuarine, and marine habitats. The state has all the major routes for invasions: Rhode Island is "The Ocean State," so we have ballast water and fouled hulls and gear; a vibrant nursery trade and ardent gardeners; aquaculture and scientific research; the pet and aquarium trade; diverse ethnic communities that value a wide range of foods, including carp and kudzu; commercial and recreational boating and fishing; and international travelers and visitors. These risks are amplified by growing, largely unregulated Internet trade in animals and plants.

So far Rhode Island has been very lucky and has no official records for Eurasian Water-milfoil, Water Chestnut, Zebra Mussel, Chinese Mitten Crab, Kudzu, or Giant Snakehead, to name some of the big concerns. With diligent monitoring and a planned response, we may be able save a great deal of effort, money, and damage by preventing or limiting introductions of such harmful species.

In order for the state of Rhode Island to have an effective early detection, monitoring, and response program for invasive species, there needs to be centralized coordination and the following components should be in place:

1. A *long-term plan* for monitoring the state's terrestrial, freshwater, estuarine, and marine systems.
2. *Integration* of on-going nuisance species *monitoring efforts* into this central plan, and enhancing other on-going monitoring efforts to include invasive species monitoring.
3. *A rapid response system*: There is a very serious time element involved with invasive species: once they are detected they need to be responded to rapidly, as established infestations are very hard—and therefore costly—to eradicate or even keep under control.
4. Resources for *entering, integrating, and assessing monitoring data* and invasive sightings, with a mechanism to make sure that all the pertinent agencies/organizations/citizens in the state know where to send these data/reports.
5. A *system for "vouchering"* (identifying and archiving) specimens: people who can do field visits, identify specimens brought in, and/or get specimens to the appropriate taxonomic experts for verification, and a place to locate, gather, or properly house reference materials, including samples from the field. This becomes especially important (and time-consuming) when volunteer programs are involved, and when obscure taxa (such as many plant and invertebrate groups and mircroorganisms) need to be identified.

Where introducing a species is a crime, or where this may result in claims for criminal or civil damages, specimens must be identified by recognized experts and handled according to the rules of evidence.

6. *Collaboration with industry/trade concerns, regulatory agencies, and other decision makers*, to ensure that policies and regulations do not encourage, and are effective in, preventing new introductions of potentially invasive species that might affect human health, economic activities, and ecosystem functioning.
7. *Networking and information sharing* with regional and national invasive species programs: Numerous regional and federal programs deal with invasive species, and with appropriate coordination, Rhode Island could benefit from this support network in its efforts to protect itself. There exist ideas, data, and protocols that could be adapted for use in Rhode Island, and other jurisdictions have experience with invasions that Rhode Island can learn from.
8. *Public education and outreach*: Through media releases, published outreach materials, seminars/workshops, and the Internet, engagement of the public can be Rhode Island's front line defense against invasive species, and is cost effective.

The following is an example of the need for central coordination and rapid response. The Asiatic Clam (*Corbicula fluminea*) is now established in Tiogue Lake in Coventry, RI. A specimen of the clam was brought to the RI Natural History Survey office in 2002 by RIDEM's Lori Gibson, who reported that it had been found by RIDEM biologist Charles Brown in July 2000. In December 2004, a conversation with URI Watershed Watch staff member Elizabeth Herron revealed that Watershed Watch volunteers had also found the clam in Tiogue Lake, and that the infestation was now well established; she didn't know if the clams have begun to move into the Pawtuxet River. It is unknown what the effects of this infestation are or will be in Rhode Island. In other parts of the country it is known to displace native bivalves, clog water distribution systems, and alter aquatic ecosystems. However, it might not now exist at this site if: 1) this lake had been regularly monitored for aquatic nuisance species and the clam reported at the very beginning of the infestation, and 2) there had been a rapid response program in place.

Year 1 Budget = $ 96,400

Project Title[28]: Macroalgal Monitoring of Upper Narragansett Bay

Principal Investigators:
Christopher Deacutis, Narragansett Bay Estuary Program
Carol Thornber, University of Rhode Island, Department of Biological Sciences
Warren Prell, Brown University, Dept. of Geological Sciences.

[28] See Appendix B. for a full description of this project and a detailed 5-year budget.

Summary: We propose to develop a rapid baseline and trend survey for macroalgal distributions, primarily the green alga *Ulva*, in Upper Narragansett Bay. Over the past few decades, large blooms of macroalgae have become common, widespread, and problematic in Narragansett Bay and other shallow bays worldwide. However, little is currently known about the distribution and movement of these macroalgal blooms. This study will commence a monitoring program for mapping the density, location, and spread of macroalgae during its months of peak summertime abundance.

Overview: Increases in "green tides" (blooms of marine green macroalgae) in shallow nearshore habitats have become problematic worldwide. These blooms are frequently attributed to the eutrophication of coastal waters due primarily to anthropogenically-based nutrient additions of nitrogen and phosphorous (Fletcher 1996). Blooms frequently negatively impact seagrass beds and fisheries, change the composition of sediment infaunal communities, and create large piles of rotting biomass on beaches (Fletcher 1996, Raffaelli et al. 1998, Granger et al. 2000). Blooms may also drift between subtidal and intertidal habitats while alive, impacting both of these marine habitats (Merceron and Morand 2004).

Within the past two decades, green tides have become increasingly abundant in Narragansett Bay. These green tides have had numerous negative impacts upon our bay and associated shoreline (Deacutis 2004). Since 1979, the RIDEM F&W has conducted seasonal trawls across Narragansett Bay to track changes in benthic fish communities. In the last 10-15 years, excessive macroalgae biomass at many shallow (<6m) stations has obstructed the use of RIDEM's trawls, because the biomass causes premature closure of the nets (Tim Lynch, RIDEM F&W, pers. comm.). As a result, Greenwich Bay was eliminated from the trawl program, and, as of 2004, trawls were no longer attempted in waters north of a line from Rocky Point to North Point on Popasquash Point. This indicates that green tides are real, prolonged events in Narragansett Bay. The amount of biomass present, although not regularly quantified by RIDEM F&W, demonstrates that green tides should not be ignored in Narragansett Bay.

Monitoring areas with heavy macroalgal cover is important because of the response of macroalgae to large local nutrient loads in shallow areas (such as the nutrients added by sewage treatment facilities) and the influence large macroalgal blooms can have in removing and sequestering nutrients from the water column. This can cause other water column parameters to appear as if low nutrient conditions exist (low chlorophyll a, high water clarity, and extreme low nitrogen levels). McGlathery et al. (1997) have shown that actively growing macroalgal mats can efficiently sequester nutrients normally cycling from the sediments into the overlying waters, limiting water column nutrient levels and pelagic productivity in some areas. These same areas can experience sudden decreases in dissolved oxygen due to increased respiration, as well as blooms of phytoplankton as the mats decompose and sequestered nutrients are released (McGlathery et al. 2001). Since these benthic organisms are part of the initial response of estuarine systems to excess nutrients, lack of macroalgal monitoring would miss a potentially significant part of the system response signal as nutrient loads change (Meng et al. 2004). Because of the nutrient sequestering ability, macroalgae may lag behind phytoplankton in response to changes in nutrient loads since some macroalgal species can sequester $\geq$ a 5- day storage capacity (McGlathery et al. 2001).

Year 1 Budget = $36,623

6.B.2. Charge: *[Develop] A list of data standards and protocols that will be used on a reasonable and consistent basis by monitoring programs that contribute data to the state monitoring system;*

Protocols are described for each of the monitoring activities advanced here. Suffice it to say, our Principles statement specifically address this point and all new monitoring initiatives must include careful assessment of the methods used. Over time, the RIEMC should consider establishing a list of data standards relevant to Bay and watershed monitoring. Such an inventory has already been developed National Water Quality Monitoring Council's Methods and Data Comparability Board for water quality standards [29].

6.B.3. Charge: *[Develop] A mechanism for data sharing among all monitoring programs that enables both monitors and users to securely access monitoring data via the Internet and to retain the integrity of such data;*

Some pieces of a data sharing system are already in place. The RIGIS system [30] provides secure, reliable, and efficient Internet access to geospatial data. The NARRBAY.ORG [31] web site is a robust portal page and can accommodate many types of data relevant to environmental monitoring in RI. Many of the state agencies have excellent data distribution experience and capacity, for example the Narragansett Bay Commission's EMPACT system [32], the Department of Health Beach Monitoring Program site, DEM's suite of Internet Map Servers (IMS) [33], and IMS sites developed by the Coastal Resources Management Council [34]. Nevertheless, we have considerable work to achieve total Internet access to critical environmental monitoring data and information for RI. There are a number of reasons why a monitoring program does not provide ready Internet access to data and information.

1. *Confidentiality prohibits unlimited data access.* The RIEMC respects the need to keep some monitoring data confidential for reasons of legal implications or personal privacy.
2. *The data have not been adequately checked for accuracy*. The RIEMC does not support making data available that have not undergone basic quality assurance checks. Releasing flawed data is unacceptable.

[29] http://wi.water.usgs.gov/methods/tools/wqde/index.htm
[30] http://www.edc.uri.edu/rigis/
[31] http://www.narrbay.org/default.htm
[32] http://www.narrabay.com/empact/
[33] http://www.state.ri.us/dem/maps/index.htm
[34] http://www.narrbay.org/mapping/interact-maps.htm

3. *The data are too voluminous*. This is the case for some of our digital imagery datasets. Access to these data (via RIGIS) requires physical conveyance on CD/DVD media. The RIEMC can provide technical assistance to monitoring enterprises that do not have the capacity to provide data in optical media (see below).
4. *The monitoring agency, as a matter of policy, does not wish to provide public access to data and information*. The reasons for this might relate to ownership of data, or the need to keep data private until scientific publications or technical have been written and published. The RIEMC feels strongly that any data collected with public funds (state or federal) must be made available in digital format as soon as possible.
5. *The monitoring agency does not have the technical capacity to provide Internet access*. The RIEMC can provide Internet access to digital monitoring data and information (see below).
6. *The monitoring agency is developing technical capacity to be able to provide Internet access to relevant monitoring data, but is not able at the present time*. This is a tricky matter and needs careful assessment. Some RI public agencies that collect vast volumes of monitoring data, for example the DEM, have little to no ability to provide Internet access to these data. Unless significant changes are made with respect to budget allocations, resolution to these technical shortfalls will remain.

We recommend that a modest budget be provided to the RIEMC to: 1) cover the cost of providing basic Internet access (via RIGIS, NARRBAY.ORG, or another portal site) for data collected by institutions that do not have the technical capacity to do so, and 2) perform a systematic assessment of data dissemination capacity within RI's monitoring community. We would develop a comprehensive data distribution strategy and report on this in the January 2006 RIEMC report to the Coordination Team. The budget for this is:

Personnel (0.6 FTE)	$45,000
ADP Charges	$5,000
Supplies	$1,500
Travel	$1,500
TOTAL	$53,000

Data sharing alliances might naturally occur when the scientific and resource management community understands the data needs of the monitoring and decision-making community. In the Communications section (6.B.5) we propose an annual conference to bring the data gatherers and data users together for an annual day-long briefing on who is doing what, what the monitoring information needs of the community, data gaps, and opportunities for collaboration and partnership might be.

6.B.4. Charge: *[Develop] A plan to provide data from the state marine monitoring system for disaster prevention, preparedness, response and recovery efforts in the marine environment; and*

The data requirements in environmental emergency response (EER) and natural resource damage assessment (NRDA) are more focused than those that have been defined and discussed in the context of an overall monitoring framework for the Bay, coasts, and watersheds. Emergency response and NRDA protocols require select environmental data. These data help responders identify and protect the most sensitive natural resources, measure injuries to those resources, estimate damages, and plan remediation. For example, the locations, diversity, abundance, and impact to certain species or habitats (eelgrass, shellfish, lobsters, commercially important finfish, sea birds, marine mammals) are always of high priority in emergency response management and damage assessment.

The DEM Office of Emergency Response and the URI Coastal Institute have collaborated since 2000 to develop plans and protocols for scientific response to coastal environmental emergencies [35]. In the summer of 2004, an administrative system was developed to rapidly engage members of the scientific community in supporting environmental emergency response. Data collection protocols for response and damage assessment have now been systematically compiled and vetted through the EER and scientific communities. Although RI is fortunate in having relatively current Environmentally Sensitive Index (NOAA ESI) data for the region [36], there are other data that are critical in emergency response.

Therefore, the RIEMC recommends that the Collaborative constitutes an advisory team to accomplish three tasks:

1. Define the high priority data sets for environmental emergencies and NRDA.
2. Assess the quality, availability, and spatial/temporal resolution of existing priority data sets identified in task 1.
3. Identify data gaps and develop a proposal to fill the gaps with new or enhanced data.

The Advisory Team will be composed of experts in environmental emergency response and natural resource damage assessment. It will be a small group, combining the expertise of university, private, and state/federal institutions – in particular, URI, Brown University, environmental consulting firms (such as ASA, SAIC), the Narragansett Bay Estuary Program, the National Estuarine Research Reserve, and the Office of Emergency Response and the Office of Water Resources in the RI DEM. The Advisory Team will provide a report and proposal to the RIEMC by the end of 2005. This report will be included in the annual RIEMC report to the Bays, Rivers, and Watersheds Coordination Team in January 2006.

---

[35] http://www.ci.uri.edu/projects/bartsci/
[36] www.edc.uri.edu/riesi/

The cost of this task is:

Personnel (0.2 FTE for 6 months)	$9,100
Supplies and Copying	$1,500
In-state Travel	$750
TOTAL	$11,350

6.B.5. Charge: *[Develop] A communications strategy to provide for public access to monitoring data.*

The RIEMC is committed to ensuring that information dissemination is an integral component of all RI monitoring programs. This is clearly stated in the statutes that created the RIEMC and the Core Principles we have adopted. The audience for the monitoring data and assessments are varied and includes scientists, decision-makers, resource managers, and the general public.

We propose to host an annual meeting of the RI environmental monitoring community. The purpose of the meeting would be to showcase novel and long-running programs, introduce new monitoring initiatives, discuss data and technology needs, present results of monitoring data assessment and synthesis, and identify fruitful areas for partnership and collaboration. The conference would be organized by the RIEMC and be open to all interested parties.

A communication element is present in each of the supplemental monitoring programs advanced here and it is addressed in the DEM water monitoring strategy. Furthermore, it is a major component of the implementation framework of the Coordination Team Scope of Work. The RIEMC will work closely with the Coordination Team Public Advisory Committee (PAC) to ensure that monitoring data and information are embedded within the larger communications context of the Coordination Team. This will ensure an accountability factor in the RIEMC's work, and allow for adaptive management to occur.

We recommend that one issue of the Narragansett Bay Journal (published by the Narragansett Bay Estuary Program) and one issue of 41 Degrees N (joint publication of RI Sea Grant and the Coastal Institute) be dedicated each year to communicating data, and synthesis of the condition of the Bay and watershed to their audiences. These two publications have a combined distribution up to 150,000. Both are heavily circulated within the full watershed including Massachusetts and Connecticut.

The budget for dedicated issues for the Bay Journal and 41N consists of design, layout, and printing expenses.

Annual Budget

Design, Printing, Mailing ($10,000/issue/year)	$20,000
TOTAL	$20,000

6.B.6. Charge: *To assist with the development and implementation of a state water monitoring and assessment program, developed consistent with guidance issued by the United States Environmental Protection Agency, and to augment and implement such a program to achieve the purposes of this strategy*

Beginning in September 2004, the RIEMC has been providing review and comment on a comprehensive statewide water monitoring strategy by the DEM. The most recent draft provided to the Collaborative became available in early January [37] and the following represent comments from the RIEMC. The members of the RIEMC were asked to comment via the LISTSERV so alternative views could be provided and discussed. All the postings of the LISTSERV can be reviewed in the archives of the LIST [38].

The RIEMC strongly supports the draft DEM water monitoring framework. DEM has been extremely responsive to suggestions offered by the RIEMC and the current draft of the water monitoring strategy contains many recommendations offered by the RIEMC. It will be very important that the DEM plan be reconciled with the RIEMC report (this document). We hope this will occur as the RI Bays, Rivers, and Watershed Coordination Team evaluates the recommendations we advance in this report.

The following bulleted list are significant comments offered by members of the RIEMC on the most recent draft of the DEM strategy.

- The EPA National Coastal Assessment (EPA NCA) should be more prominently addressed in the RI monitoring framework. The EPA NCA is already a major player in Bay monitoring. The station-based sampling creates a great deal of important data, and EPA NCA funds have been used (and will likely be used in the future) to support the fixed-station buoy monitoring in the Bay. NCA, like Bay Window, is one of the major contributors to Bay monitoring and we need to better integrate the NCA data stream into the overall data system. The RIEMC should take an active and aggressive role in seeing that this happens over the next year.
- The need for a DEM monitoring coordinator is clear. For example, examine the monitoring inventory the RIEMC has updated (on the RIEMC web site). RIDEM is the major player (as it should be) for environmental monitoring programs in RI. To accomplish any within-agency coordination, cohesion, standards, reporting, synthesis, data management, etc., there needs to be a single point of contact for monitoring and this person should report to senior administration of

[37] http://www.ci.uri.edu/Projects/RI-Monitoring/Docs/DEM_WQ_Mon_Jan5_05.pdf
[38] http://pete.uri.edu/archives/rimonitoring.html

DEM. Monitoring is heavily embedded within the three core divisions of DEM (natural resources, environmental protection, policy and admin); a single monitoring coordinator high in the agency should be appointed and charged with seeing that DEM collects the data, gets the data to the community of users (within and outside DEM), assesses the data on a timely basis, and effectively communicates the results of the monitoring within and outside the agency. The RIEMC strongly supports this recommendation.

- Does the RI Water Resources Board have funding to enhance the USGS gaging station network? There is across the board need for enhancing the USGS gaging network. The RIEMC strongly recommends that funding be secured to maintain and expand the USGS gaging network of rivers and streams in RI.
- Accurate land use information and current digital imagery for RI are central to many of the activities proposed in the DEM monitoring plan, as well as some of the supplemental monitoring plans advanced here. The RI Statewide Planning Program in the Department of Administration is the lead agency that develops these data which are distributed through the RIGIS system. The Statewide Planning Program is considering a 5-year cycle time to update imagery and the land use data with the next update scheduled in 2006. Given the importance of these data to so many monitoring endeavors (as well as all planning and environmental programs in RI and local communities), we strongly support the plan for a 5-year update cycle for land use data.
- Several gaps in the DEM framework still have only a cursory discussion, specifically those regarding biological monitoring of freshwater communities and bioinvasives in both fresh and salt water. As the draft rightly notes, monitoring organism communities is a direct approach to many of the overall monitoring goals but the draft doesn't provide any guidance on how to fill in those gaps where they remain, for instance how to finish the IBI for biomonitoring in RI, who needs to participate, or how this important planning would be funded. Without a better idea of what will eventually be deemed necessary in terms of biological monitoring, the section on resources required for implementing biological monitoring could have to be changed substantially.
- A topic in the DEM water monitoring framework that requires elaboration is monitoring bioinvasives. Monitoring for bioinvasives and nuisance aquatic plants urgently needs to be addressed, but we believe monitoring for these would be done better (and cheaper) as part of a comprehensive state-wide invasive species monitoring strategy and response plan that was coordinated with, but was not dependent upon a water quality monitoring plan. The invasive species monitoring program advanced in this report provides such a comprehensive, statewide approach.

6.B.7. Charge: *To prepare an annual report in the month of January to the governor and General Assembly on the activities for the preceding year as well as the predicted financial needs of the system for the upcoming fiscal year*

This constitutes our first annual report to the RI Bays, Rivers, and Watersheds Coordination Team to review, approve, and forward to the Governor and General Assembly. Included in this report (Section 8) is a comprehensive budget to accomplish the monitoring proposed in the DEM water monitoring strategy and the activities recommended by the RIEMC.

6.B.8. Charge: *To enter into data sharing agreements with federal and state agencies, municipalities and nongovernmental organizations for the purposes of coordination and management of monitoring data and programs*

The RIEMC has not had the need or opportunity to enter into any new data sharing agreements with other institutions.

6.B.9. Charge: *To accept grants, donations and contributions in money, services, materials, or otherwise, from the United States or any of its agencies, from this state and its agencies, or from any other source, and to use or expend those moneys, services, materials or other contributions in carrying out the purposes of this chapter.*

The RIEMC is poised and ready to accept funds to continue its work. With staff support, we will be able to pursue extramural grant funding to assist in financing monitoring activities in RI.

6.B.10. Charge: *To enter into agreements for staff support that it deems necessary for its work, and to contract with consultants for the services it may require to the extent permitted by its financial resources.*

The RIEMC is poised and ready to engage staff and consultants as funds become available.

7. Administrative Budget

The RIEMC requires staff support to continue its work. The costs of performing the work to date have been borne by the members of the RIEMC and the URI Coastal Institute, or have been done after hours by members of the Collaborative. This is not sustainable for the long-term. For the RIEMC to responsibly conduct the work required of it, we request 1 FTE for staff support along with some minor budget items. The responsibilities of the staff would be to prepare for meetings, organize the annual monitoring conference, communicate monitoring questions and issues to the RIEMC, administer the grants program, develop a data sharing policy, work with the Coordination Team staff in developing the monitoring element of the systems-level plan, develop grant proposals to fund RIEMC activities, and assist in the preparation of the annual report. The budget for RIEMC operations for the 2005 calendar year is:

Personnel (salary and benefits, 1FTE)	$60,000
Supplies	$4,500
Transportation	$1,500
TOTAL	$66,000

8. Total Budget Recommendations

The costs associated with the monitoring activities that we recommend are consolidated in the following table.

Program Element	**FY 2006 Cost**	**5-Year Cost**
Monitoring Grants	$ 125,000	$ 625,000
Internet Access for Monitoring Data	$ 53,000	$ 265,000
Emergency Response Data Inventory	$ 11,350	$ 56,750
RIEMC Administration	$ 66,000	$ 330,000
Communication	$ 20,000	$ 100,000
Shoreline Buffer Monitoring	$ 125,250	$ 222,700
Benthos Monitoring	$ 33,391	$ 177,278
Zooplankton Monitoring	$ 32,080	$ 170,317
Shellfish (Quahog) Monitoring	$ 35,104	$ 127,413
Fish (Flounder and Tautog) Monitoring	$ 24,640	$ 124,875
Submerged Habitats Monitoring	$ 150,000	$ 320,000
Invasive Species Monitoring	$ 96,400	$ 489,542
Macroalgae Monitoring	$ 36,623	$ 153,823
TOTAL	**$ 808,838**	**$ 3,162,698**

The RIEMC fully supports the implementation of the DEM water monitoring strategy. The additional FY 2006 funding required to do so is $ 1,757,106 [39]. The total cost for implementing the monitoring activities recommended here and the funding required to implement the DEM monitoring plan is:

DEM Water Monitoring	$ 1,757,106
RIEMC Monitoring Cost	$ 808,838
TOTAL	**$2,565,944**

[39] From January 3, 2005 draft document