Narragansett Bay
Research Reserve

Technical Report

2009:5

Methods and Protocols for Eelgrass Mapping in Rhode Island: Recommendations from the Rhode Island Eelgrass Mapping Task Force

Kenneth B. Raposa, Ph.D.
Research Coordinator, NBNERR

Mike Bradley
Research Associate; URI Environmental Data Center

January 2009

Technical Report Series 2009:5

Task Force Members:

Peter V. August – URI Coastal Institute
Mike Bradley – URI Environmental Data Center
Caitlin Chaffee – RI Coastal Resources Management Council
Giancarlo Cicchetti – USEPA
Marci Cole – Save The Bay
Chris Deacutis – Narragansett Bay Estuary Program
Janet Freedmen – RI Coastal Resources Management Council
Rob Hudson – Save The Bay
Charles LaBash – Director, URI Environmental Data Center
Andy Lipsky – USDA Natural Resources Conservation Service
Chris Powell – Fish & Habitat Biologist
Bob Stankelis – Narragansett Bay National Estuarine Research Reserve
Kenny Raposa – Narragansett Bay National Estuarine Research Reserve
Sue Tuxbury – NOAA National Marine Fisheries Service

Background

Eelgrass Mapping

Eelgrass (*Zostera marina* L.) is a common species of submerged aquatic vegetation found in shallow, quiescent areas of temperate estuaries. Eelgrass is important because it provides habitat for ecologically and commercially important fish and shellfish species, stabilizes sediments, and filters particles from the water column (Dennison et al. 1993; Fonseca 1996). It also functions as an excellent indicator of water quality due to its rapid response to both nutrient concentrations (via shading from opportunistic macroalgae and epiphytes) and in situ light levels. For these reasons, monitoring programs often target eelgrass in order to track long-term trends in eelgrass itself and, by extension, estuarine water quality.

A number of approaches exist for quantifying the distribution, extent, coverage, and biomass of eelgrass in a given estuary. Researchers in the Gulf of Maine have established a tiered hierarchical approach for New England estuaries, which quantitatively assesses eelgrass at three levels of detail, scope, and scale (Neckles et al. in prep). Tier 1 is the broadest level and utilizes aerial photography and remote sensing techniques to map eelgrass distribution (presence/absence) over relatively small scales (1;5,000 to 1:24,000) throughout an entire estuary or embayment. Tier 2 is less expensive, more site-specific, and provides some level of percent cover of eelgrass without utilizing aerial photography. This scale of monitoring is considered a rapid assessment technique whereby percent cover and other metrics are assessed annually by boat using a stratified-random set of sampling points. The most detailed eelgrass assessments are derived from Tier 3 monitoring (analogous to SeagrassNet [Short et al. 2002]), in which measurements of eelgrass biomass and other metrics are made repeatedly over multiple time scales within a site. While each method (or Tier) has its limitations, a complete picture of eelgrass condition at multiple scales can be achieved over the long-term if each Tier is incorporated into a comprehensive eelgrass monitoring program.

Eelgrass Mapping Task Force

As a follow-up to the 2006 Tier 1 Narragansett Bay eelgrass mapping project, the Rhode Island Eelgrass Mapping Task Force was established to review the status of eelgrass mapping in the State and to set long-term goals for mapping and monitoring eelgrass in Rhode Island on an estuary and statewide scale. The Task Force brings together leading scientists in Rhode Island with backgrounds in estuarine ecology, restoration ecology, estuarine health, GIS, and fisheries management. The primary goal of the Task Force is to establish methods, protocols, and recommendations for long-term eelgrass mapping in Rhode Island waters. Currently, the only consistent monitoring of eelgrass is conducted by Save The Bay at two sites (Fort Getty, Jamestown and T-wharf, Prudence Island) following SeagrassNet protocols (i.e., Tier 3) (Short et al. 2002). Tier 1 level mapping efforts in RI have been conducted in 1996 (Huber et al. 1996), 2000 (coastal ponds only), and 2006 (Bradley et al. 2007). Tier 2 monitoring has not yet been attempted in Narragansett Bay. Since Tier 3 is already being implemented, this document focuses on the methods and protocols for Tier 1 and Tier 2 levels of eelgrass mapping. Tier 1 methods and protocols (remote sensing techniques) are based on project specifications for the 2006 mapping project (Bradley et al. 2007), as well as the comments and recommendations of the Task Force. The Tier 2 methods and protocols are a synopsis of the Neckles et al. (in prep) methods.

The general recommendations of the RI Task Force are as follows:

- A strategy that mirrors the Neckles et al. (in prep) tiered approach for mapping and monitoring SAV should be implemented in RI,
- Rhode Island waters should include Narragansett Bay, the salt ponds (coastal lagoons) along the south shore of Rhode Island including Briggs and Quicksand Ponds in Little Compton, and Block Island (Fig. 1),
- Additional SAV species found in RI waters such as *Ruppia maritima* should be included in the mapping and monitoring program,
- Tier 1 mapping should be conducted on 3-year intervals (or 3-5 years as funding allows).

Tier 1- Mapping Eelgrass in Rhode Island Using Remote Sensing Techniques

<u>Aerial Photography Acquisition</u>

The RI Task Force recommends the following for aerial photography specifications and acquisition (more detailed specifications should be used when purchasing photography):

- Basic NOAA Coastal Change Analysis Program (C-CAP) protocols (Dobson et al. 1995) should be followed to determine when to acquire aerial photography (i.e., at low tide, maximum biomass, minimal water turbidity [as measured by secchi disks], and low wind, minimal cloud cover, and solar glare),
- The vendor should have access to the latest photogrammetric technology including but not limited to airborne GPS and intertial measurement units (IMU) and digital photographic sensors,
- Photography or digital imagery should be true-color,
- Scale of the photography or digital imagery should be less than or equal to 1:20,000,
- Products must include prints, transparencies, digital orthophotography (both compressed and uncompressed digital file formats), and FGDC-compliant metadata,

- Scale of the orthophotography should be at least 1:5000 (+/- 14 feet – horizontal National Map Accuracy Standard (NMAS) for 1:5000 scale data) with a 1 ft pixel resolution,
- Geographic coordinate system for the orthophotography should be RI State Plane Feet, NAD 83 datum,
- All photographic products must be approved by project leaders before final delivery.

Photointerpretation

For each Tier 1 mapping effort, the focus of the photointerpretation phase will be to quickly and thoroughly identify areas on the imagery thought to be eelgrass (i.e., areas in need of groundtruthing) and not necessarily to make precise delineations of eelgrass extent. Areas to be groundtruthed will be identified using a mirror stereoscope and photographic prints, transparencies, and on-screen digital orthophotography. Clues such as the presence of mounds of eelgrass wrack on shore, historical eelgrass data, and shoreline geomorphology will all be used to facilitate delineations. In addition, local knowledge from shell fishermen, conservation groups, State agencies, and others will be incorporated as much as possible. Initial eelgrass areas are delineated by 'heads-up' or on-screen digitizing using the digital imagery as a backdrop. Through this technique, delineations are automatically georeferenced into the coordinate system of the digital orthophotography (RI State Plane Feet, NAD83). This will eliminate recompilation errors and guarantee that NMAS are met. The minimum mapping unit will be roughly 500 m^2 or 0.125 acres. A copy of the initial photointerpreted polygons generated in this first pass will be set aside as a GIS layer.

Field work and ground-truthing

Eelgrass photo-signatures from true-color aerial photographs are highly variable and can be flight-specific. To address this, every effort will be made to conduct groundtruthing during the same growing season as when the photographs were taken. As a means of ensuring better coordination and accuracy of the product, the photointerpreter will also be involved in ground-truthing process, which should occur during low tide. A copy of the photointerpreted GIS delineations will be taken into the field and viewed simultaneously with georeferenced digital aerial photography or ancillary geospatial data using a GIS-enabled GPS device. Viewing current position, GIS delineations, and digital aerial photography in real-time eliminates the need for using hard-copy maps (and the related guesswork with locating landmarks on maps and in the field) as the primary method of navigating to delineations, thus speeding up the groundtruthing process considerably. Therefore, it is strongly recommended that GIS-enabled GPS units be utilized during the groundtruthing effort.

Under reasonable time and personnel constraints, an effort will be made to visit all delineations, locate the center of each delineation, and if eelgrass is present, to determine the deepwater edge and the extent of the bed (Fig. 2). If eelgrass is not present, the benthic habitat will be identified and noted, and included in the final GIS database. Even at low tide, deep water edges of eelgrass beds will not necessarily be seen from the boat; therefore use of an underwater video camera is strongly recommended during all field work. The edge of an eelgrass bed is considered to occur when cover drops to about 5-10%. Fathometer signals are a reasonable proxy for locating the deep water edge of eelgrass beds if no underwater camera is available on a particular day. GPS data points should be collected and coded for presence of eelgrass each time the camera is deployed to the Bay or lagoon bottom. In order to estimate errors of omission and commission during the photointerpretation process, additional GPS data points will be collected and coded for presence of eelgrass at distance intervals along the shoreline or in an area where eelgrass is known to occur (e.g., the East Passage of Narragansett Bay). Delineations will then be re-digitized in the field if possible, or in the lab using the points from the GPS as a guide.

Data Products

Digital aerial imagery plus a richly attributed GIS database (including FGDC-compliant metadata) of all delineations coded for habitat type will be produced. Eelgrass delineations will include deepwater edge and extent corrections from field data. Other attributes in the GIS database will include: whether the delineation was groundtruthed (Y/N), whether the deepwater edge was determined (Y/N), method of groundtruthing (e.g., video, snorkel, fathometer), and method of identification (e.g., photointerpreted, historical, anecdotal). These additional fields will be critical for future trends analysis. In addition, a report detailing the methods, results, and conclusions will be produced. This report will quantify changes and trends in eelgrass cover and distribution over time based on comparisons with previous mapping efforts.

Tier 2 - Rapid Assessment Monitoring

Specific methodologies for Tier 2 monitoring remain under development in estuaries in the Gulf of Maine (Neckles, personal communication). It is expected that these methods will be completed in early 2009, with a peer-reviewed manuscript and protocol resulting. However the basic design of the Tier 2 approach may provide the basis to begin this type of monitoring in Narragansett Bay, RI.

The first step is to define the study area and develop a grid overlay. Determination of the appropriate grid cell size depends on the statistical power/rigor desired and logistical feasibility. In Pleasant Bay MA, Neckles et al. (unpublished data) used a grid comprised of 500 m hexagonal cells with 200 cells total for the bay (Fig. 3). In their study, Neckles et al. found that a cell size twice the original was as statistically powerful as the original cell size for detecting change. Cells three times as big were statistically weak, and therefore not recommended for Pleasant Bay. The Environmental Protection Agency's Environmental Monitoring and Assessment Program (EMAP) protocols (on which the

Tier 2 method is roughly based) generally call for the same number of samples among estuaries, necessitating the use of varying cell sizes depending on the size of the estuary. For example, Tier 2 monitoring in Narragansett Bay might require larger grid cells than used in Pleasant Bay due simply to the larger size of Narragansett Bay. With this protocol, each cell is visited and all parameters are collected from a small number of subsamples whose locations have been randomly chosen. Power analyses indicate that four subsamples are the minimum number required for statistical purposes (Neckles, personal comm.).

Once the study area and grid overlay are established, the specific data to be collected from each grid cell needs to be determined. For example, in Pleasant Bay, MA, Neckles et al. collected data for eelgrass percent cover, canopy height, shoot length, number of leaves per shoot, and water depth. The collection of some of these data types requires certain equipment and personnel. For example, percent cover is determined using a small camera mounted facing down in a vertical frame ending in a quadrat. This apparatus enables a picture to be taken in a known area from which percent cover can be derived. Similarly, the quantification of shoot characteristics may require the use of snorkelers or divers. Ultimately, the specific parameters chosen for monitoring must be logistically feasible and meet the needs of the individual study.

<u>Using Tier 2 Monitoring in Narragansett Bay</u>

It is proposed here that a pilot effort be conducted in summer 2009 to establish Tier 2 eelgrass monitoring in Narragansett Bay, RI. The goal would be for a multi-institutional team coordinated by the Narragansett Bay National Estuarine Research Reserve to test the field methods, collect baseline data, and develop a more refined annual protocol based on results from the pilot effort. The 2009 pilot effort would include:

- Establishing an overlay grid for an area of interest in Narragansett Bay. It is proposed that this area will be a subset of the Bay to include only areas where eelgrass was found in 2006 (i.e., from the north end of Prudence Island to the south shore of Newport and Sakonnet Point). Grid cells should also only be established within certain depths where eelgrass is known to grow in Narragansett Bay (e.g., from shore to approximately 15 feet in depth; cells will not be established in deep waters where eelgrass is not expected to grow),
- Randomly selecting a location in each cell and four subsample areas per location to visit during the rapid assessment,
- Conducting the rapid assessment at all grid cells over a brief number of consecutive days (e.g., 2-3) around the peak in eelgrass biomass/cover, and
- Collecting a set of simple parameters to describe eelgrass characteristics at each site. These parameters should be informative, should suit the needs of Narragansett Bay research and management communities, and should be able to be collected rapidly. Potential examples include presence/absence, percent cover, canopy height/shoot length, leaves per shoot, light extinction (Kd), macroalgae composition and cover, water quality (e.g., temperature, salinity, dissolved oxygen), and water depth.

This effort will result in baseline data for the parameters chosen and will lead to an understanding of the amount of time, money, and effort this Tier 2 approach requires. This will provide a framework for a subsequent discussion of whether it is worth refining and continuing this effort in the future. It will also help determine if this effort would be worthwhile to extend into Rhode Island's coastal ponds and around Block Island. If it is decided that Tier 2 monitoring should continue at a regular interval (e.g., every 1-2 years), then the methods should be refined/adapted based on the results of the pilot effort and the resultant protocol should be included in any eelgrass mapping or monitoring program that is advanced by the Rhode Island Eelgrass Task Force for funding.

Project Significance

Eelgrass plays a critical role in the health of temperate estuaries, but this resource has not been consistently monitored over the long-term in Narragansett Bay, RI. It is recommended by the RI Eelgrass Mapping Task Force that a comprehensive plan for monitoring eelgrass distribution, extent, and condition be adopted and implemented in Narragansett Bay. Previous mapping efforts have already provided coastal managers with critical information for assessing potential impacts from coastal development, but this information needs to be updated at regular intervals to account for changes in eelgrass over time. It is even more critical to establish a long-term mapping and monitoring program at the present time in light of upcoming reductions in wastewater treatment nutrient inputs to the Bay. Eelgrass responds rapidly to changes in water column nutrient concentrations and light levels, and should prove to be an effective indicator of the ecological effects of these nutrient reductions. The tiered monitoring approach recommended by the Task Force and outlined here should be a top priority for consistent funding in the State of Rhode Island. Specifically, funding should be provided to 1) conduct Tier 1 mapping of eelgrass throughout RI waters at 3-5 year intervals, and 2) conduct Tier 2 rapid assessments of eelgrass in the Bay at 1-2 year intervals, once the protocol has been refined after the pilot phase.

Budget

It is estimated that it will cost approximately $100,000 to $150,000 to conduct each Tier 1 mapping effort every 3-5 years. This estimate is based on the cost of the 2006-7 project, and it includes funds to acquire and photointerpret the aerial photographs. It does not cover any in-kind funds that would be needed to cover the costs of groundtruthing each effort. At this point, it is not possible to determine the cost of each Tier 2 rapid assessment until the pilot phase is completed. However it is anticipated that the higher funding estimate ($150,000) would be sufficient to cover the costs for conducting both Tier 1 and Tier 2 eelgrass monitoring simultaneously.

References

Bradley, M., K. Raposa, and S. Tuxbury. 2007. Report on the analysis of true color aerial photography to map and inventory *Zostera marina* L. in Narragansett Bay and Block Island, Rhode Island.

Dennison, W.C., R.J. Orth, K.A. Moore, J.C. Stevenson, V. Carter, S. Kollar, P.W. Bergstrom, and R.A. Batiuk. 1993. Assessing water quality with submersed aquatic vegetation: habitat requirements as barometers of Chesapeake Bay health. BioScience 43(2): 86-94.

Dobson, J.E., E.A. Bright, R.L. Ferguson, D.W. Field, L.L. Wood, K.D. Haddad, H. Iredale III, J.R. Jenson, V.V. Klemas, R.J. Orth, and J.P. Thomas. 1995. NOAA Coastal Change Analysis Program (C-CAP): Guidance for Regional Implementation. U.S. Department of Commerce, Seattle, W.A. NOAA Tech. Dept. NMFS 123.

Fonseca, M.S. 1996. The role of seagrasses in nearshore sedimentary processes: A review. Pages 261-286 in C. Roman and K. Nordstrom (eds.), Estuarine Shores: Hydological, Geomorphological and Ecological Interactions. Blackwell, Boston, MA.

Huber, I. 1996. Report on the Analysis of True Color Aerial Photographs to Map Submerged Aquatic Vegetation and Coastal Resource Areas in Narragansett Bay Tidal Waters and Near Shore Areas, Rhode Island and Massachusetts. Natural Resources Assessment Group, Department of Plant and Soil Sciences, University of Massachusetts, Amherst, MA.

Short, F.T., L.J. McKenzie, R.G. Coles, and K.P. Vidler. 2002. SeagrassNet Manual for Scientific Monitoring of Seagrass Habitat. Queensland Department of Primary Industries, QFS, Cairns, Australia.

Figure 1. Extent of the proposed eelgrass mapping area that includes Narragansett Bay (and Mount Hope Bay), the coastal ponds, and Block Island.

Figure 2. The basic strategy for groundtruthing eelgrass delineations is to collect video and GPS data at the middle and edges of the polygon (intersections of the arrows and the green line).

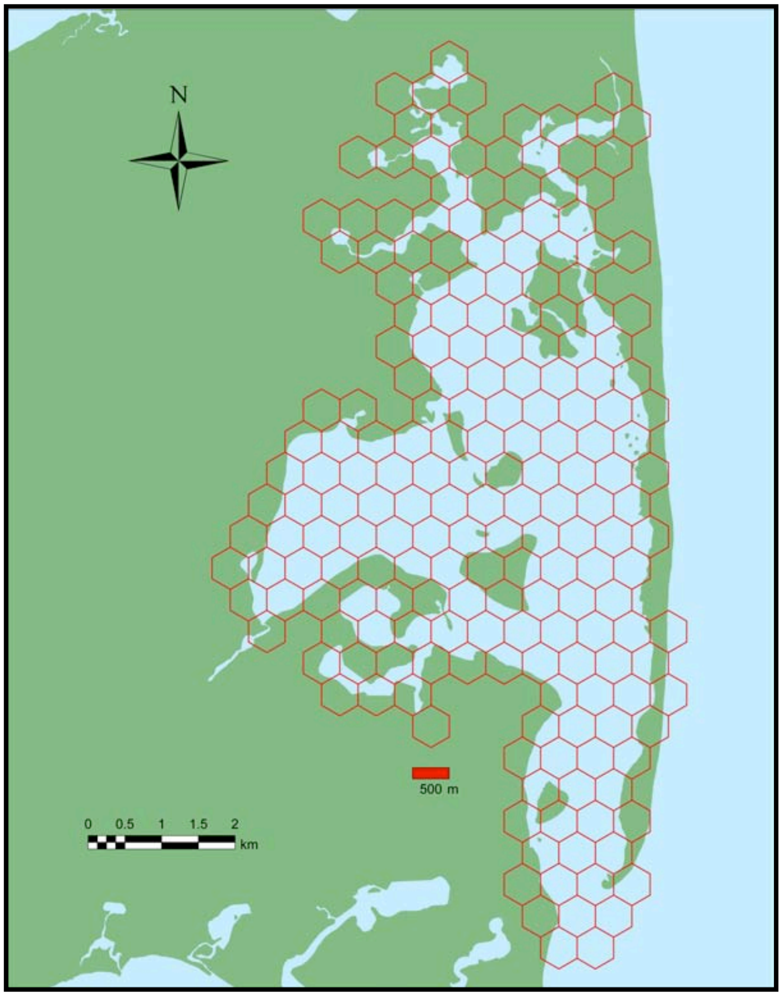

Figure 3. Pleasant Bay, MA, showing hexagonal overlay grid for Tier 2 eelgrass rapid assessment monitoring (from Neckles et al., unpublished data).