2012 Mapping Submerged Aquatic Vegetation (SAV) in Rhode Island Coastal Waters

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INTRODUCTION

Eelgrass (*Zostera marina* L.) is a type of submerged aquatic vegetation (SAV), which grows in quiescent embayments along the northeast and northwest coasts of the United States. Eelgrass plays a crucial role in the health of coastal systems because it provides critical habitat for juvenile marine life, helps stabilize surface sediments, and aids in filtering particles from the water column (Dennison et al., 1993; Fonseca, 1996). Eelgrass has been deemed a critical marine resource and is currently protected by both Federal (Clean Water Act; 33 U.S.C. 26 section 1251 et seq) and Rhode Island (RI Coastal Resource Management Plan, Section 300.18) legislation. Widgeon grass (*Ruppia maritima*) is another SAV species found in more brackish Rhode Island waters. Anecdotal information suggests that several beds of widgeon grass have been expanding in recent years.

Mapping the distribution and extent of eelgrass is a critical first step in understanding, managing, and protecting shallow-subtidal estuarine habitats. Map data provides essential baseline information for government agencies, town planners, and the scientific community. Neckles et al., 2012 proposed a 3-tiered hierarchal strategy for mapping and monitoring SAV in estuaries. The smallest scale of these tiers (Tier 1), utilizes true-color aerial photography whereby photo signatures of SAV are interpreted and delineated using orthophotography (aerial photographs with the distortion removed) (Neckles, 2012).

Tier 1 mapping efforts have been conducted in Narragansett Bay in 1996 (Huber 1996) and again in 2006 (Bradley et al 2007). Following the 2006 mapping effort, an SAV task force was convened with the goal of establishing mapping methods and protocols for SAV that are feasible and consistent over the long-term in Rhode Island (Raposa and Bradley 2009). The overall goals of this project were to: (1) conduct a complete and comprehensive survey of SAV (primarily eelgrass and to a lesser extent widgeon grass) statewide for 2012; (2) examine trends of SAV from 2006, 2009, and 2012; and (3) to review the recommendations of the RI Eelgrass Taskforce with respect to Tier 1 mapping efforts. To address the second goal, two previous Tier 1 mapping efforts will be used for comparative purposes: the Narragansett Bay and Block Island project that was conducted in 2006 (Bradley et al., 2007) and an effort focused on the coastal ponds (Quonochontaug, Ninigret, Green Hill, Potters, and Point Judith ponds) of Rhode Island conducted in 2009 (unpublished).

METHODS

<u>Aerial Photography Acquisition</u>

Digital four-band (true color and infra-red) aerial photographs of Narragansett Bay, Block Island, and the coastal ponds were taken by a photogrammetry vendor (PhotoScience Inc.) on June 28th and 30th 2012. The photographs were taken following NOAA Coastal Change Analysis Program (C-CAP) protocols (Dobson et al., 1995). Based on C-CAP, photographs were taken at a low sun angle, two hours within low tide, when wind and atmospheric haze where minimal, and when water clarity was high. Water clarity was measured by volunteers using secchi disks as target dates for acquisition of aerial photography approached. The vendor was chosen by utilizing the NOAA Coastal Services Center (CSC) Coastal Geospatial Contract Vehicle (http://www.csc.noaa.gov/idiq/geospatial.html).

Shortly after the photography was acquired, samples were sent to project leaders and to NOAA CSC personnel for review and comment. After approval, photography was ortho-rectified (distortions removed), color balanced, mosaicked, and projected to the Rhode Island State Plane Feet (NAD83) coordinate system by the photogrammetry vendor.

Accuracy assessments of the orthophotography product were done by the vendor using GPS control points. Locations of features (e.g. manholes, parking lot lines) on the ground and also visible in the photography were compared and statistically analyzed. The listed accuracy of the orthophotography was +/- 2 m, which corresponds to a scale of 1:2400 following National Map Accuracy Standards. The pixel resolution of the orthophotography was 0.5 m.

By September 2012, 1,396 individual orthophotography tiles (101 gigabytes) were delivered on external hard drives to the URI Environmental Data Center. The photography was copied to a lab server for internet distribution utilizing ArcGIS 10.0 Server Image Service technology. As a result, the orthophotography could be viewed in ArcMap (and the web) utilizing one data connection instead of 1,396, to save time.

Photo-interpretation

Initial SAV delineations and areas to be ground truthed were identified by eye and digitized on-screen by hand using the orthophography as a base map. In order to enhance the digital signature of SAV beds, the spectral statistics of the orthophotography were manipulated to increase the contrast between pixels of the same color (Fig. 1). Data sets from 2006 and 2009 (including GPS ground truth points) were also used as supplemental sources to aid in photo interpretation. Areas that have historically supported SAV were targeted first for the photo interpretation of new beds. However, to avoid any bias, digitizing of the 2012 polygons was always done with historical data sets turned off. All digitizing was conducted at a scale of 1:1500.

Field work and ground-truthing

Ground truthing in the field was conducted by motor boat or kayak between September 25th and October 25th, 2012 (eight field days total). Observations of eelgrass wrack lines were also made as a clue to the presence of an eelgrass bed in the area. Because SAV photo-signatures from true-color aerial photographs are highly variable and can be flight specific, ground-truthing was conducted during the same year as when the photographs were taken (2012). We began the field work during the last week of September 2012. Presence of SAV was determined using an underwater video camera (SeaViewer, Inc.) In shallower waters, boat observations (looking over the side) or a view scope (http://tinyurl.com/acl39k8) was used to identify SAV.

Initially, the goals of ground truthing were to verify digital photo signatures of SAV and assess the imagery quality for identification of the deep water edge of SAV beds. After one field day, less time was spent determining the deepwater edge after it became clear that it was visible in the orthophotography (in most cases). Instead, we focused on ground truthing new beds or areas of gain or loss when compared to the 2006 and 2009 delineations.

Initial SAV delineations and imagery tiles were taken into the field and viewed simultaneously with GPS position using a Trimble GPS device. Viewing GIS delineations and GPS location in real-time eliminated 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 ground truthing process considerably.

GPS data points were collected and coded for presence of SAV within and at the edge of SAV beds. The edge of an eelgrass bed was considered to occur when cover dropped to approximately 5-10%. GPS points were differentially corrected using the Trimble GPS Analyst ArcGIS Extension. After processing, 90% of GPS points had an accuracy of +/- 2m. Final SAV delineations were adjusted using the ground truth data (GPS points). Polygons were coded with a habitat type (eelgrass or widgeon grass), ground–truth information ('2012' – the polygon was ground truthed for this study, 'no' – polygon hasn't been ground-truthed, and 'historical' – the polygon has had recent ground truth information) and site names (e.g. Jamestown).

Change Analysis

Three sets of GIS data (and corresponding orthophotography) were used for the change analysis of SAV (Table 2). In addition comparing the overall extent of eelgrass in Narragansett Bay between 2006 and 2012, the following smaller sites were chosen for the analysis because they were thought to be the most comparable: Greenwich Bay, Conanicut Island (Jamestown), Prudence Island, Quonochontaug, Green Hill, Potters, and Point Judith. For each site, all data (ground truth points, individual delineations, and digital signatures) were reviewed for any inconsistencies and comparability. In a few cases, small errors of omission, digitization, or polygons that were not ground truthed, were omitted from the site change analysis.

RESULTS

Over 800 ground truth locations were collected during the fall of 2012 (including 110 courtesy of the Narragansett Bay National Estuarine Research Reserve) and 235 polygons of SAV were delineated totaling 1,382.6 acres (Table 1). A web map was created of all the delineations which can be found by clicking HERE or the URL is http://tinyurl.com/aff8fcw if you want to copy – paste into browser[1]. Most of the SAV is the study area (89.4%) was eelgrass with 146.5 acres of widgeon grass occurring in Greenwich Bay, Ninigret and Green Hill Ponds, and Briggs Marsh in Little Compton. Most of the largest SAV beds (1319.6 acres or 95.5%) have been field-visited (historically or in 2012) and the presence of SAV confirmed. The majority (38%) of SAV acreage in the study area occurred in the coastal ponds found along the south shore of Rhode Island. The least amount of SAV occurs along the west shore of the west passage of Narragansett Bay (2.8%). The site with the largest overall increase in SAV acres was

[1.] Helpful hints on the web map: 1) it works best with Firefox or Chrome as a web browser and 2) one left click on the polygon brings the table with more information.

Conanicut Island (59.8 acres) (Figure 2). The site with the largest overall decline in SAV was Green Hill Pond (-47.2 acres). Due to new 28.5 acre widgeon grass bed, the site with largest overall change was Greenwich Bay with a 100% increase (Table 2). The site with the smallest overall change was Potters Pond with a 10.4% decrease. Interestingly, both Prudence and Conanicut Islands had almost identical change percentages (36.6% and 36.8%, respectively). Overall, we calculated a 23.6% increase in eelgrass acreage for Narragansett Bay (essentially the 2006 study area minus Block Island) when comparing the totals in 2006 and 2012 (408 acres and 504.2, respectively) (Figure 2; Table 2).

SUMMARY and DISCUSSION

Two of the main Tier 1 recommendations put forth by the RI Eelgrass Mapping Task Force were to include all Rhode Island coastal waters and widgeon grass in future mapping efforts (Raposa and Bradley, 2009). With the inclusion of the coastal ponds, the Narrow River, and Little Narragansett Bay, the mapping conducted in 2012 represents the most comprehensive mapping of SAV to date for Rhode Island. A total of 1382.6 acres of SAV were delineated. Almost 800 ground truth locations were collected using GPS to support this mapping. Most of the largest SAV beds (95.5%) have been field visited to confirm the existence of SAV.

When comparing the total eelgrass between 2006 and 2012, we calculated a 23.6% increase in eelgrass acreage for Narragansett Bay. When comparing the total SAV between 2009 and 2012, we calculated an average decrease of 23.6% for three coastal ponds. However, these changes should be interpreted with caution since 1) more than two data points are needed to discern an overall trend; and 2) we also did not have time to accurately field map every SAV bed and therefore we mostly relied on the photography to delineate bed edges. In a few cases where the photography wasn't clear due to solar glint, isolated areas of poor water quality, or difficult photo signatures associated with rocks and macro-algae, we relied on our best professional judgment to delineate bed edges.

The 1996 SAV data (Huber, 1996) were not used for the change analysis in this report because the mapping methods and techniques differ enough so that a comparison is not warranted. However, when looking at the smaller sites that were used for the change analysis in Bradley et al. 2007, the upward trend of eelgrass acreage continues between 1996 and 2012 for Narragansett Bay.

The quality of the 2012 photography was better than in 2006 which add confidence to the current data. For one ground truth location in Narragansett Bay we were in 30ft of water, indicating that a photo signature was visible on the photography at that water depth. No such signature was visible in the 2006 photography. In addition we identified six new small beds in Narragansett Bay that while present in 2006, where difficult to accurately map using the 2006 photography.

One of the most challenging parts of Tier 1 mapping of SAV can be aerial photo acquisition. We began assessing flight windows in June of 2011. The photos for this project were taken June 28 and 30th 2012. It took a summer and a month to find an optimal flight window with the right combination of peak SAV biomass, low tide, wind, sun angle etc. However once the photos are taken, this is an efficient method to assess the SAV in Rhode Island coastal waters. Using a good aerial photography base map, a boat, GPS, and an underwater video camera, we mapped all of the SAV statewide in less than three months.

RECOMMENDATIONS

In order to document any long-term trends in eelgrass in Rhode Island waters, we believe Tier 1 mapping should be conducted every three years, which is a slightly shorter time frame than the 3-5 years the RI Eelgrass Mapping Taskforce recommended in 2009. This time frame seems reasonable given the dynamic nature of the beds and the logistics associated with planning aerial photography acquisition and field work. Additionally, we need to do better quantify errors associated with our mapping methods. For example, a comparison using different mapping techniques (e.g., acoustic methods) could help us understand how accurate our current mapping efforts are.

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TABLES

Table 1. Calculations of SAV acreage were done by site.

SITE	EELGRASS ACRES
Block Island	90.5
*Briggs Marsh and Greenwich Bay (widgeon grass)	43.7
Dutch, Gould, and Rose Islands	24.9
Coastal Ponds	522.7
Little Compton	55.8
Jamestown	222.4
**Little Narr. Bay (RI only)	197.6
Middletown	9.2
Narragansett	1.8
**Narrow River	24.2
Navy	25.4
Newport – Ocean Road	49.4
Newport Harbor	19.0
Newport Neck	1.4
**North Kingstown	8.2
Prudence Island	37.4
Sachuest	49.1
TOTAL	1382.7

*Most of the acreage is in Greenwich Bay
**Areas not mapped in 2006

Table 2. Percentage change in SAV acreage (change in acres / 2006 total) for each of the eight sites based on two years of data.

SITE	PERCENT SAV CHANGE
Greenwich Bay[1]	100
Conanicut Island (Jamestown)[1]	36.8
Prudence Island[1]	36.6
Green Hill Pond[2]	-34.2
Point Judith Pond[2]	28.2
Quonochontaug Pond[2]	-26.2
Narragansett Bay[1]	23.6
Potters Pond[2]	-10.4

1. 2006, 2012
2. 2009, 2012

FIGURES

A B

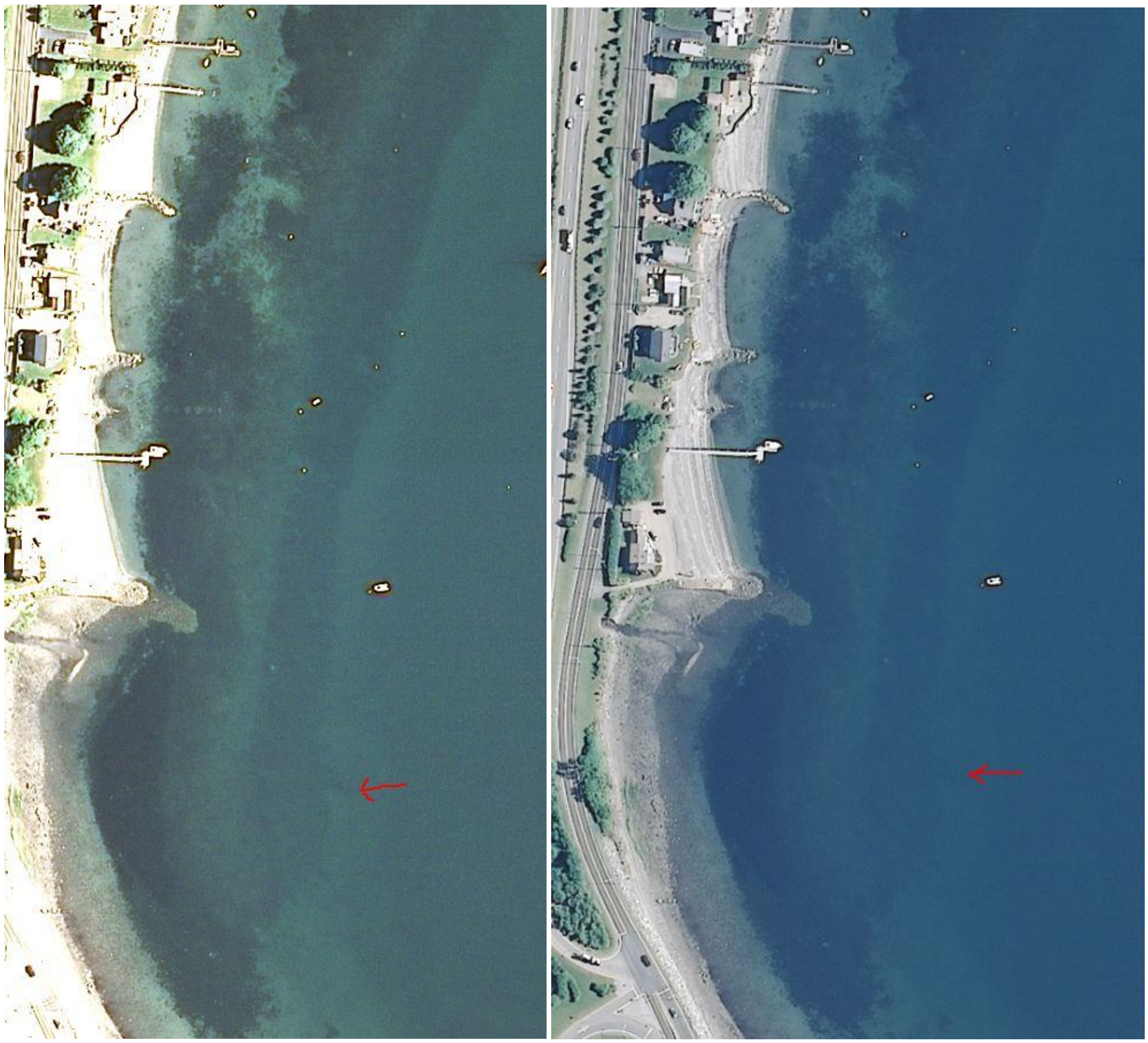

Figure 1. A) The orthophotography spectral statistics were manipulated to enhance the photo signature of SAV beds. B) The orthophotography without the spectial statistics manipulation. The red arrow points to the same bed edge in both images, which is easily viewable on the left image. The scale of both images is 1:2000.

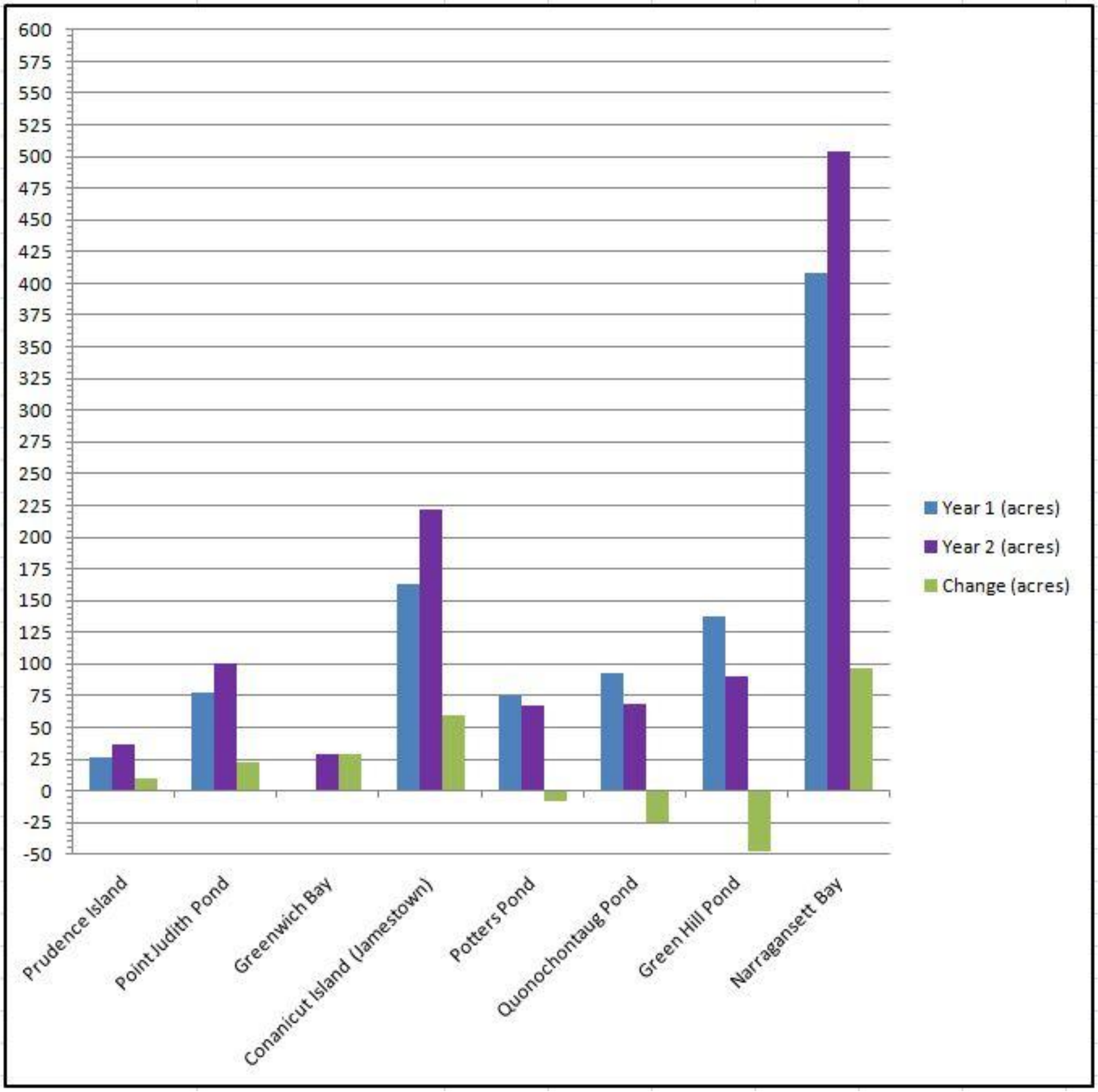

Figure 2. SAV acreage was compared for eight different sites. Year 1 corresponds to the mapping done in 2006 for the sites in Narragansett Bay. Year 1 mapping was done for Point Judith, Potters, Quonochontaug, and Green Hill ponds in 2009. Year 2 corresponds to the mapping done for this study (2012). An increase was calculated for five sites including Narragansett Bay and a decrease was calculated three coastal ponds.