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 19pp

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Narragansett Bay Estuary Program
The Narragansett Bay Estuary Program Report

Report on the
Analysis of True Color Aerial Photographs to
Map Submerged Aquatic Vegetation and Coastal Resource Areas
In
Narragansett Bay Tidal Waters and Nearshore Areas
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A. Introduction

The University of Massachusetts, Natural Resources Assessment Group (NRAG) contracted in 1996 with the Rhode Island Department of Environmental Management, Narragansett Bay Estuary Program (RIDEM) and with Save the Bay, Inc. (STB) to provide original air photointerpretation of submerged aquatic vegetation (SAV), primarily eelgrass (Zostera marina), coastal wetlands and coastal deepwater habitats, the shoreline and selected coastal features in Narragansett Bay and nearshore waters in Rhode Island and Massachusetts. For purposes of this report, areas inventoried other than SAV are referred to as "estuarine and marine habitats."

Z. marina is recognized as a vital resource for estuarine food chain support and as a indicator of estuarine productivity and function. An inventory of Z. marina beds provides coastal resource managers and marine scientists with means to assess the extent and locations of this resource. Additionally, an updated inventory provides managers with a reasonably accurate acreage coverage of present coastal wetland habitats, and gives an overview for regulatory applications. The data base can be further developed with specialized photoanalyses. Examples are photoanalysis of potential coastal wetland restoration sites and trend analysis of estuarine and marine resources.

The SAV, coastal wetlands and coastal deepwater habitats were classified according to U.S. Fish & Wildlife Service's Classification of Wetlands and Deepwater Habitats of the United States (Cowardin et al. 1979; reprinted 1992).

This report describes methods and materials employed by NRAG to produce the inventory and details field findings. Appendix A is a plant list for the project area derived from field work conducted by NRAG. Appendix B contains field data sheets for 109 field sites documented with the project. Additionally, results of the field work and photointerpretation are summarized, and acreage statistics by wetland type were obtained from RIDEM's Geographic Information System (RIGIS).

No freshwater wetlands or watercourses were included with this mapping project.

B. Description of Project Area

Narragansett Bay and its nearshore waters occupy the eastern portion of Rhode Island and the upper Mount Hope Bay/Taunton River portions of Massachusetts. Limits of the project area were defined by geography (state lines), brackish classification breaks and bay hydrogeomorphology. (See Section C.3.) Figure 1 is a map depiction of the project area.

Approximately 540 miles of shoreline was covered with the project, located on portions of the following 13 U.S. Geological Survey (USGS) 1:24,000 scale topographic
quadrangles: Providence, East Providence, Somerset, Assonet, East Greenwich, Bristol, Fall River, Wickford, Prudence Island, Tiverton, Narragansett Pier, Newport and Sakonnet Point.

C. Methods and Materials

1. Aerial Photography Acquisition

Aerial photography was ordered by RIDEM with reference to NOAA Coastal Change Analysis Program (C-CAP): Guidance for Regional Implementation (Dobson, et al., 1995) for obtaining optimal SAV visibility.

Two overflights were used: 1:12,000 (1:12K) true color transparencies for SAV photointerpretation, and 1:40,000 (1:40K) true color transparencies for photointerpretation of estuarine and marine habitats.

The 1:12K overflight was undertaken to maximize visibility of SAV, primarily Z. marina, under conditions approaching peak biomass, low haze, low wind, no cloud cover, low tide and low turbidity.

The 1:40K photographs used for the estuarine and marine habitat mapping allowed reasonably accurate mapping with respect to production/cost output, efficiency in transfer, and the desired minimum mapping units for GIS map display purposes.

The 1:12K overflight was on July 6, 1996 and the 1:40K overflight on August 11, 1996. The James W. Sewell Company of Old Town, Maine was the aerial photography contractor. Photography was inspected by NRAG and determined suitable for purposes of the project with respect to time constraints, seasonality and project start up.

2. Data Preparation

NRAG prepared the aerial photography for photodelineation in the following manner:
- Each model was mounted with a Grafic Wet Media Dura-Lar .004 gauge 9 inch by 9 inch mylar, affixed with drafting tape at each corner.
- Each work area mylar was pin-registered to each photo model at four corners.
- Identifying notations in permanent black ink were made on each work area mylar (photo number, adjoining photo numbers and edge lines) and labels identifying photo number and quadrangle name were affixed on the upper edge of the sleeves.
- Project limits were drawn directly onto the work area overlays.
- Photography was indexed and organized into separate folders by flight lines and by quadrangles.
3. Determination of Project Limits and System Breaks

The landward limits of the Narragansett Bay project area were determined in the field and/or on the photography as the limits of estuarine brackish vegetative indicator species, with respect to definitions in Cowardin et al., 1979:

The estuarine system extends (1) upstream and landward to where ocean-derived salts measure less than 0.5 parts per thousand during the period of average annual flow; (2) an imaginary line closing the mouth of a river, bay or sound; and (3) to the seaward limit of wetland emergents, shrubs or trees where they are not included in (2).

Seaward project limits were established by defining the mouth of Narragansett Bay, represented by a line drawn from Point Judith Point on the west and Sakonnet Point to the east. (See Figure 1.)

System breaks between Marine and Estuarine environments within the Narragansett Bay project area were established with respect to Cowardin et al., 1979:

The Marine System extends from the outer edge of the continental shelf shoreward to one of three lines: (1) the landward limit of tidal inundation (extreme high water of spring tides), including the splash zone from breaking waves; (2) the seaward limit of wetland emergents, trees, or shrubs; or (3) the seaward limit of the Estuarine System, where this limit is determined by factors other than vegetation.

It is noted that freshwater wetlands and deepwater habitats, including those classified in Cowardin, et al. (1979) as “tidally-influenced” are not included in this inventory. Users are advised to refer to the Classification of Wetlands and Deepwater Habitats of the United States for further explanation of the tidally-influenced freshwater system. Some wetland areas noted during the project appear to be former estuarine wetlands. Apparent alterations changed their classification from estuarine to tidally-influenced freshwater and therefore were not included with the inventory.

4. Minimum Mapping Units

Minimum polygonal mapping units (MMU) were 0.5 acre for eelgrass beds and .25 acre for isolated polygonal coastal wetlands. The internal polygonal MMU (that is, map units of distinct wetland types within other wetland types) was contracted to be 3.0-to-5.0 acres. Smaller internal polygons (approximately 0.5-to-1.0 acre) were mapped for habitat types of particular ecological significance. Examples are most pannes and pools within high salt marshes. Inclusion of small significant habitat types was dependent on photo interpreter's judgment.

It is noted that excessive internal mapping can create difficulties for project production costs and GIS map display. The level of mapping detail is dictated by the scope of the project and the scale of photography used.
The MMU for linear estuarine and marine habitats was pen width (approximately 35 feet on the ground using 1:40K scale photography). Collateral use of the 1:12K photography for verification of fringe marsh and beaches resulted in linears slightly less than pen width, except where shadowed on either source photography. Therefore, an estimated average of 27.5 feet wide was used to calculate acreage statistics. The linear foot (LF) MMU for line segments was 1/8 inch or about 250 LF at 1:24 K base map scale.

With regards to SAV, only aquatic beds containing eelgrass were mapped as polygonal data. Dots were used to locate centers of all other field-checked SAV beds, as per direction from STB and RIDEM. No linear or dot SAV was photointerpretable on the 1:12K. Some narrow polygons of eelgrass were reduced to linear size during transfer from the 1:12K photography to the 1:24K base map.

5. Field Work

Prior to photointerpretation, NRAG staff previewed aerial photos, selected field sites, and noted them on USGS 1:24K topographic maps for in-field orientation.

Field data was collected for two purposes: 1) to discriminate photosignatures unique to various habitat types as workable with the type and scale of source photography, and 2) to provide an ecological profile of habitat types representative of the project area.

Site selection criteria included the following: a) areas representative of project area ecology; b) areas disturbed and potentially requiring NWI modifiers in classification; c) areas used to establish system and sub-system breaks; d) areas affected by haze, shadow, emulsion or other photography quality concerns; e) areas accessible with respect to trespassing and time constraints.

SAV field work included verification of aquatic bed photosignatures having varied tones and textures. Depth drop-offs were noted, particularly where mimicking or abutting a potential eelgrass signature. SAV field work took place on August 19-21, and on September 11 and 12, 1996 using boats provided by RIDEM Shellfisheries Division and STB. Depth permitting, beds were identified visually. Sampling also took place utilizing rake devices provided by STB, or by dive inspections. A total of 67 SAV field sites were inspected and documented. Volunteers from STB provided some additional SAV data for sites in the Jamestown and Newport area.

Estuarine and marine habitat sites were accessed by vehicle and by foot. A total of 42 coastal wetland sites were field-documented. Documentation of other habitats such as beaches was made in conjunction with SAV and coastal wetland site inspections.

Field data sheets were developed by NRAG specifically for the project.
6. Aerial Photointerpretation and Quality Control (QC):

Photodelination utilized Cartographic Engineering mirrored stereoscopes and rapidographs at 4x0 line weight with permanent black India ink.

For mapping SAV, use of Cowardin et al. (1979) permits description of the beds to life form and water regime (see Tables 2 and 3). Z. marina was differentiated from other SAV species. Additionally, a percent cover modifier for eelgrass was developed by NRAG for this project, as follows:

- a = <10%
- b = 10 - 39%
- c = 40 - 69%
- d = 70 - 100%
- e = unknown

Map classification and delineation techniques for the SAV, coastal wetlands and deepwater habitats were based on Cowardin et al. (1979) and the accompanying Photointerpretation Conventions for the National Wetlands Inventory (National Wetlands Inventory, 1995).

Coastal features included in the inventory were dunes and coastal banks. Photointerpretation of these features was as best determined on the 1:40K photography according to definitions in the Rhode Island Coastal Resources Management Program, As Amended, (RICRMP) Sections 210. Codes for labeling these features were designated by NRAG as “D” for dunes and “CB” for coastal banks.

The shoreline delineation was photointerpreted to be the “inland edge of coastal feature” described in the RICRMP. This delineation is inclusive with the landward limits of linework (polygon and linear). To avoid multiple labeling, the shoreline was not separately annotated as “SL.” From project data, the seaward limits of the upland have been calculated on GIS to obtain a shoreline of 539.7 miles (Paul Jordan, RIDEM, pers. comm. 11/23/99).

It is noted that the shoreline is dynamic along beaches, banks and bluffs, where erosion can rapidly change shoreline locations.

For quality control of the photointerpretation, each completed annotated mylar was examined by a photointerpreter other than the one producing the original photodelinations and classifications. Corrections were made as needed to maintain accuracy and consistency throughout the map product.

Photointerpretation and QC progressed in a south to north, quad by quad basis to maintain delivery for rectification and digitizing.

7. Transfer, Rectification and Base Map Preparation:

Transfer of SAV data from the 1:12K to the 1:40K photography took place using a Bausch & Lomb Stereo Integrated System (SIS) or by use of a Zoom Transfer Scope (ZTS).
Data on the 1:40K photography were rectified using a Bausch & Lomb Zoom transfer Scope (ZTS) or with an Ottico Meccanica Italiana stereofacet plotter (OMI). Data were transferred from the aerial photograph overlays to USGS 1:24K stable base mylars affixed with registered frosted mylar overlays. Frosted mylars containing the rectified data were first quality controlled by NRAG staff, then delivered to the GIS contractor for digitizing. QC of rectified data addressed alignment, labeling and linework completion prior to delivery for digitizing. Some rectification difficulty was encountered on the Tiverton quadrangle when attempting to triangulate across the Sakonnet River.

8. Habitat Type Classification

Within estuarine and marine habitats (or “systems”), subtidal and intertidal subsytems were applied according to the following definitions from Cowardin et al.(1979):

Subtidal (1). - The substrate is continuously submerged.
Intertidal (2). - The substrate is exposed and flooded by tides; includes the associated splash zone.

Tables 2 and 3 are provided with reference to Cowardin et al. (1979) defining particular habitat types inventoried with this project. Table 2 describes tidal water regimes and Table 3 summarizes the classification of habitat types inventoried.

Table 2. Tidal Water Regimes and Special Modifiers for Habitat Types in the Narragansett Bay Project Area

Tidal Water Regimes
Subtidal(T). The substrate is permanently flooded with tidal water.
Irregularly Exposed(M). The land surface is exposed by tides less often than daily.
Regularly Flooded(N). Tidal water alternately floods and exposes the land surface at least once daily.
Irregularly Flooded(P). Tidal water floods the land surface less often than daily.

Special Modifiers
Excavated (x): Lies within a basin or channel excavated by man.
Impounded (h): Created or modified by a barrier or dam which purposefully or unintentionally obstructs the outflow of water. Includes man-made dams and beaver dams.
Diked (d): Created or modified by a man-made barrier or dike designed to obstruct the inflow of water.
Ditched/Partly-Drained (d): The water level has been artificially lowered, but the area is still classified as wetland because soil moisture is sufficient to support hydrophytes.
Artificial (a): Refers to substrates classified as Rock Bottom, Unconsolidated Bottom, Rocky Shore and Unconsolidated Shore that were emplaced by man, using either natural materials such as dredge spoil or synthetic materials such as...concrete. Jetties and breakwaters are examples of Artificial Rocky Shores.
Oligohaline (o): Term to characterize water with salinity of 0.5 to 5.0 parts per thousand, due to ocean-derived salts.
<table>
<thead>
<tr>
<th>NWI Code &amp; Modifiers</th>
<th>Cowardin et al. (1979) Description</th>
<th>Common Description</th>
<th>Examples of Vegetation or Cover</th>
</tr>
</thead>
<tbody>
<tr>
<td>EIUB, MlUB (L, Lh, Lx)</td>
<td>Estuarine, Marine Subtidal, Unconsolidated Bottom</td>
<td>Estuarine, or Marine Open Water</td>
<td>cobble, sand, mud or organic</td>
</tr>
<tr>
<td>E1AB3L, M1AB3L</td>
<td>Estuarine or Marine, Subtidal Rooted Vascular Aquatic Bed</td>
<td>Eelgrass Bed</td>
<td>Zostera marina</td>
</tr>
<tr>
<td>E1ABL</td>
<td>Estuarine, Subtidal Algal, Aquatic Bed</td>
<td>Algal Beds</td>
<td>Ulva lactuca, Fucus spp., Chondrus crispus, Enteromorpha sp.</td>
</tr>
<tr>
<td>E1UB4L</td>
<td>Estuarine, Subtidal, Unconsolidated Bottom, Organic</td>
<td>Pools</td>
<td>Ruppia sp. or other algae</td>
</tr>
<tr>
<td>E2US(1,2,3)(M,N)</td>
<td>Estuarine, Intertidal Unconsolidated Shores</td>
<td>Tide Flats</td>
<td>cobble, gravel, sand or mud; patches of algae</td>
</tr>
<tr>
<td>E2RS(1,2)(N,P); M2RS(1,2)(N,P)</td>
<td>Estuarine or Marine, Intertidal Rocky Shores</td>
<td>Rocky Shores</td>
<td>bedrock or rubble; patches of Fucus spp</td>
</tr>
<tr>
<td>E2RF2N</td>
<td>Estuarine, Intertidal, Mollusc Reef</td>
<td>Oyster Bed</td>
<td>Crassostrea virginica</td>
</tr>
<tr>
<td>E2SB(2,3)(N)</td>
<td>Estuarine, Intertidal Streambed</td>
<td>Tidal Creek</td>
<td>sand or mud</td>
</tr>
<tr>
<td>E2EM(1,5*)P</td>
<td>Estuarine, Intertidal Persistent Emergents, Irregularly Flooded</td>
<td>High Marsh</td>
<td>Spartina patens, Juncus gerardii, Distichlis spicata (*note: 5 = Phragmites australis)</td>
</tr>
<tr>
<td>E2SS1P</td>
<td>Estuarine, Intertidal Scrub-Shrub, Broad-leaved Deciduous, Irregularly Flooded</td>
<td>High Marsh</td>
<td>Iva frutescens, Baccharis halimifolia</td>
</tr>
<tr>
<td>E2EM1N</td>
<td>Estuarine, Intertidal Persistent Emergents Regularly Flooded</td>
<td>Low Marsh</td>
<td>Spartina alterniflora</td>
</tr>
<tr>
<td>E2EM(1,5*)P6</td>
<td>Estuarine, Intertidal Persistent Emergents Irregularly Flooded, Oligohaline</td>
<td>Brackish Marsh</td>
<td>Typha angustifolia, Spartina pectinata (*note: 5 = Phragmites australis)</td>
</tr>
</tbody>
</table>
D. Results: Descriptions and Acreages of Habitat Types

The acreages described below were compiled from RIGIS for linear and polygonal data. Table 4 is an acreage summary of habitats types inventoried with this project.

1. Aquatic Beds
Aquatic beds (SAV) were found dominated by one of the following species: eelgrass (Z. marina), Irish moss (Chondrus crispus), Deadman’s fingers (Codium fragile), barrell weed (Champia parvula), graceful red weed (Gracilaria sp.), rough tangleweed (Stilophora rhizodes), hollow green weeds (Enteromorpha spp.), rockweed (Fucus vesiculosus), and sea lettuce (Ulva lactuca).


Pure stands of Z. marina were found in about 30% of the sites inspected. Remaining Z. marina beds inspected were mixed in composition, and included subordinate species such as Enteromorpha sp., C. crispus, Gracilaria sp. and C. fragile.

A total of 99.5 acres of Z. marina were inventoried. Most Z. marina beds were found in south, southwest and west central portions of the project area.

2. Dunes
Forty-three acres of dune were inventoried with the project. There are likely additional acres of this habitat not mapped due to erosion exposure and crests indetetable on the source photography.

3. Open Water
A total of 124,222.4 acres of open water habitat was inventoried. Estuarine open water accounted for 89,284.9 acres (72%). An additional 148.4 acres of estuarine brackish open water was inventoried. Marine open water amounted to 34,789.1 (28%) acres.

4. Pannes and Pools
Estuarine pannes and pools totalled 46.3 acres. Pools field checked were vegetated with widgeon grass (Ruppia maritima). Pannes were either unvegetated or colonized by common glasswort (Salicornia europaea).

5. Tidal flats
Tidal flats totalled 568.6 acres. Of these, 99% (566.3 acres) were estuarine and 1% (2.3 acres) were marine.

Marine flats were represented by 2.3 acres of irregularly-exposed sand flats.

Of estuarine tidal flats, 80% (453.6 acres) were irregularly-exposed sand or mud bottoms and 20% (112.7 acres) were regularly-flooded mud bottoms.
6. Beaches
A total of 1,450.5 acres of beaches were inventoried. Eighty-seven percent (1,257.0 acres) were in the estuarine environment and 13% (193.5 acres) were marine. Of all beach habitat inventoried, irregularly-flooded cobble beach accounted for 5% (72.0 acres), and irregularly-flooded sand beach accounted for 47% or 678.3 acres. Regularly-flooded beach (sand and/or cobble material) accounted for 48% or 700.2 acres.

7. Artificial Habitats
A total of 23.1 acres of artificially placed habitat was inventoried. Rock jetties or groins amounted to 35% (8.1 acres) and unconsolidated breakwater totalled 65% or 15 acres. Of this total, 5% (1.1 acres) was in the marine environment and 95% (22.0 acres) in the estuarine environment.
It is noted that there are other man-made coastal features not classifiable under Cowardin et al. (1979). Those inventoried are photointerpretable as providing habitats for biota such as rockweeds (Fucus spp.), periwinkles (Littorina littorea) and barnacles (Balanus spp.)

8. Rocky Shores
Rocky shores totalled 573.3 acres, with 61% (346.9 acres) in the marine system and 39% (226.4 acres) in the estuarine system. Of all rocky shores inventoried, irregularly-flooded bedrock or rubble rocky shore amounted to 56% or 321.0 acres, and regularly flooded bedrock or rubble rocky shore was 44% or 252.3 acres of this habitat type. Seaweeds such as Ascophyllum nodosum and Fucus vesiculosus commonly colonize the regularly-flooded zone of rocky shores.

9. Reefs
Nine acres of oyster reef (Crassostrea virginica) was inventoried in the estuarine system. (The reef is located in Mill Gut on the Bristol quadrangle.)

10. Stream Beds
There were 3.5 acres of estuarine mud or sand bottom stream bed inventoried.

11. Estuarine Emergent High Salt Marsh
A total of 2,708.7 acres of estuarine emergent high salt marsh (irregularly-flooded) was mapped. Typical high marsh emergent species occupied 92% or 2,480.1 acres of this habitat type, represented by species such as salt meadow cordgrass (Spartina patens), black grass (Juncus gerardii), spike grass (Distichlis spicata), marsh orach (Atriplex patula), sea blite (Suaeda linearis), seaside arrow grass (Triglochin maritimum), annual salt marsh aster (Aster subulatus), perennial salt marsh aster (A. tenuifolius), seaside goldenrod (Solidago sempervirens) and sea lavender (Limonium nashii). Of this acreage, 53% or 1,314.5 acres was ditched emergent high salt marsh.
Common reed (*Phragmites australis*) dominated 8% (228.6 acres) of high salt marsh inventoried, and 17% or 38.6 acres of this *P. australis*-dominated high salt marsh was ditched.

Impounded high salt marsh accounted for 1% or 34.4 acres of the total high salt marsh; 13.0 acres of this area was dominated by *P. australis*.

12. **Estuarine Scrub-Shrub Wetland**

Estuarine high salt marsh (irregularly-flooded) dominated by shrubs accounted for 159.3 acres. Of this, 11% or 17.2 acres was ditched. Species representative of this habitat type are high tide bush (*Iva frutescens*) and groundsel tree (*Baccharis halimifolia*).

13. **Estuarine Emergent Low Salt Marsh**

A total of 443.2 acres of estuarine low salt marsh (regularly-flooded) dominated by salt marsh cordgrass (*Spartina alterniflora*) was inventoried. Of this, 0.8% (3.5 acres) is impounded and 0.2% (0.7 acres) is ditched.

14. **Estuarine Brackish Marshes**

Brackish estuarine emergent marsh totalled 427.6 acres. Of this area, 54% or 232.2 acres was represented by brackish marsh species such as narrow-leaf cattail (*Typha angustifolia*), river bulrush (*Scirpus fluviatilis*), Olney’s three square (*S. americanus*), Common three-square rush (*S. pungens*), salt marsh bulrush (*S. robustus*), marsh orchid, Halberd-leaf tearthumb (*Polygonum arifolium*), rose mallow (*Hibiscus moscheutos*), rice cutgrass (*Leersia oryzae*), spike rush (*Eleocharis sp.*), slough grass (*Spartina pectinata*) and seaside goldenrod.

Forty-six percent (195.4 acres) of brackish estuarine high marsh was dominated by *P. australis*. Of this area, 25% or 49.4 acres consisted of *P. australis*, co-dominated by *T. angustifolia*.

15. **Upland**

Within project area limits, 371,730.9 acres of upland have been inventoried.
Table 4. Acreage Summary of Estuarine and Marine Habitats Inventoried for Narragansett Bay Project Area.

<table>
<thead>
<tr>
<th>Habitat Type</th>
<th>Area in Acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eelgrass Beds</td>
<td>99.5</td>
</tr>
<tr>
<td>Dunes</td>
<td>43.0</td>
</tr>
<tr>
<td>Open Water</td>
<td>124,222.4</td>
</tr>
<tr>
<td>Pannes &amp; Pools</td>
<td>46.3</td>
</tr>
<tr>
<td>Tidal Flats</td>
<td>568.6</td>
</tr>
<tr>
<td>Beaches</td>
<td>1450.5</td>
</tr>
<tr>
<td>Artificial Jetties &amp; Breakwaters</td>
<td>23.1</td>
</tr>
<tr>
<td>Rocky Shores</td>
<td>573.3</td>
</tr>
<tr>
<td>Oyster Reefs</td>
<td>9.0</td>
</tr>
<tr>
<td>Stream Beds</td>
<td>3.5</td>
</tr>
<tr>
<td>High Salt Marsh</td>
<td>2,708.7</td>
</tr>
<tr>
<td>High Scrub-Shrub Marsh</td>
<td>159.3</td>
</tr>
<tr>
<td>Low Salt Marsh</td>
<td>443.2</td>
</tr>
<tr>
<td>Brackish Marsh</td>
<td>427.6</td>
</tr>
<tr>
<td><strong>SUBTOTAL</strong></td>
<td><strong>130,778.0</strong></td>
</tr>
<tr>
<td>Upland</td>
<td>371,730.9</td>
</tr>
<tr>
<td><strong>GRAND TOTAL</strong></td>
<td><strong>502,508.9</strong></td>
</tr>
</tbody>
</table>

E. Photointerpretation Problems and Problem Resolution

1.) Detection of *Z. marina* Beds
The overflight for capture of SAV was slightly later in the season than optimum. As a result, turbidity potentially limited photointerpretation of small *Z. marina* beds and of the outer limits of larger beds where reflectance contrast was reduced. Positive depth change appears to affect photodelination of the outer limits of eelgrass beds independent of turbidity conditions.

It is suggested that small *Z. marina* beds verified by field personnel may be added as points to the data base using location aids such as the Global Positioning System (GPS). Area measurements of selected *Z. marina* polygons may be obtained by dives or other methods (e.g., hydroacoustic detection) to refine delineations at outer limits. Bathymetry data might be a helpful correlation with as-mapped *Z. marina* polygons to estimate the outer portions of beds within limits of light penetration required for survival. It is noted that maps produced with this inventory are based on 1996 conditions.
2.) Shadowing
Shadows from relatively tall upland features such as conifer tree stands, banks and tall buildings were present on portions of the 1:12K and the 1:40K overflights. This condition is not expected to have significantly affected photointerpretation within established minimum map units. Areas subject to shadowing from the upland would be narrow habitats along the shore and those at upper limits of high marshes. Problems with shadowing were reduced by use of collateral data and by interpolating between non-shadowed areas.

3.) Haze and Cloud Cover
These conditions were not prevalent in the overflights, but we do note isolated encounters in portions of the 1:40K overflight (i.e., Assonet quadrangle). Where this condition compromised visibility significantly, we consulted the 1:12K imagery to reduce effects on map accuracy.

4.) Minimum Mapping Units:
Detection of relatively small eelgrass beds (that is, .25 to about 3.0 acres) was restricted by turbidity and/or lack of reflectance contrast. We recommend supplementing the data base with point locations of Z. marina confirmed by field personnel. (See Section E.1.) Inventory of estuarine and marine habitats was based on photointerpretation of the 1:40K imagery. We found use of this imagery successful within, and in cases, exceeding the minimum mapping units. Users may be interested in additional detail on wetland plant communities, for example, small (less than 1.0 acre) internal communities of P. australis or I. frutescens. Large scale photointerpretation would enable this, with caution that proper rectification methods may be costly. A draft map review was undertaken after the transfer and digitizing to verify addition of smaller habitat areas, verify classification, and to proof linework and labels.

F. Summary
Using the 1:12K imagery provided for this project, a photosignature unique to Z. marina was established for interpretation. Various field-to-photo signature correlations from other kinds of algal beds further defined photosignature characteristics of Z. marina.

Beds were either purely Z. marina or dominated by the species. The “e” (unknown) density class was used for beds identified by other field personnel but not field-verified by NRAG.

We acknowledge that numerous small sized Z. marina beds are not likely mapped with this inventory. This may be attributed to turbidity conditions on the July 1:12K imagery. It is suggested that point locations of small Z. marina beds be added to the data base using field personnel and location aids such as GPS.
We advise that the outer limits of *Z. marina* beds may not be accurately represented. As beds drop off with depth, reflectance contrast between the vegetation and the open water is reduced. Turbidity can further confound accurate interpretation of outer boundaries.

*Z. marina* (about 100 acres) was not found abundant in estuarine waters of the project area. We recommend a trends analysis of coastal wetlands and of land use/land cover to obtain information on potential contributing factors to decline of this species in the Bay.

The locations, extent, and acreages of estuarine and marine habitats may be used to perform analysis of potential wetland restoration sites; for example, tidally-restricted wetlands, filled wetlands, wetlands colonized by *Phragmites australis*. A trends analysis may be helpful to determine acreages and possible causes of coastal habitat loss and degradation over selected time intervals.

Increased map detail on the extent and locations of *Phragmites australis* or other small plant communities of special interest is possible by photointerpreting the 1:12K imagery and transferring the information to the data base.
ACKNOWLEDGMENTS

NRAG gratefully acknowledges Save the Bay, Inc. and the Rhode Island Department of Environmental Management (RIDEM) for funding this project. Helen Cottrell of RIDEM Narragansett Bay Estuary Program was particularly helpful in the development and management of this project. Dr. Peter Veneman of the University of Massachusetts, Department of Plant and Soil Sciences acted as Principal Investigator. Special acknowledgment is extended to Dr. Robert Orth of the Virginia Institute of Marine Science for his guidance early in the development of the project.

We acknowledge the following individuals for their help in project coordination and/or in the field: Nicole Cromwell, Andy Lipsky, Gwynne Holcombe and John Torgan of Save the Bay, Inc.; Chris Powell and Chris D’Acutis of RIDEM. We also acknowledge the field data supplied by volunteers under Andy Lipsky of Save the Bay.

Lynn Carlson of RIDEM is acknowledged for performing the GIS work on this project. Paul Jordan of RIDEM is also acknowledged for additional GIS information.

The author acknowledges Todd Nuerminger, David Foulis and Christine Nichols of NRAG for their diligent field work and photointerpretation. Mr. Foulis and Mr. Nuerminger also assisted with quality control.

Special thanks to Mr. Nuerminger for assistance with report table layouts and with the compilation of acreage statistics.

The James W. Sewell Company of Old Town, Maine is acknowledged for obtaining the overflights used in photointerpretation.
REFERENCES


APPENDIX A.

Plant Species Observed at Field Sites
Narragansett Bay Project Area
August - October, 1996

1. Vegetated Wetlands:

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amaranthus cannabinus</td>
<td>Water Hemp</td>
</tr>
<tr>
<td>Agalinis maritima</td>
<td>Saltmarsh False-Foxglove</td>
</tr>
<tr>
<td>Agropyron punctiformis</td>
<td>Stiff-Leaf Quackgrass</td>
</tr>
<tr>
<td>Agrostis stolonifera</td>
<td>Creeping Bent Grass</td>
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<tr>
<td>Alnus rugosa</td>
<td>Speckled Alder</td>
</tr>
<tr>
<td>Aster novae-angliae</td>
<td>New England Aster</td>
</tr>
<tr>
<td>Aster novi-belgii</td>
<td>New York Aster</td>
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<tr>
<td>Aster punicus</td>
<td>Annual Salt Marsh Aster</td>
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<tr>
<td>Atriplex patula</td>
<td>Halberd-Leaf Saltbush</td>
</tr>
<tr>
<td>Atriplex sp.</td>
<td>Saltbush</td>
</tr>
<tr>
<td>Baccharis halimifolia</td>
<td>Sea Myrtle</td>
</tr>
<tr>
<td>Bidens connuta</td>
<td>Purple-stem Beggar-Ticks</td>
</tr>
<tr>
<td>Bidens frondosa</td>
<td>Devil's Beggar-Ticks</td>
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<tr>
<td>Cephalanthus occidentalis</td>
<td>Common Buttonbush</td>
</tr>
<tr>
<td>Ceratophyllum sp.</td>
<td>Hornwort</td>
</tr>
<tr>
<td>Convolvulus septum</td>
<td>Hedge Bindweed</td>
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<tr>
<td>Cuscuta sp.</td>
<td>Dodder</td>
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<tr>
<td>Cyperus filicinus</td>
<td>Slender Flatsedge</td>
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<tr>
<td>Distichlis spicata</td>
<td>Seashore Saltgrass</td>
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<tr>
<td>Eleocharis sp.</td>
<td>Spike Rush</td>
</tr>
<tr>
<td>Elymus riparius</td>
<td>Riverbank Wild Rye</td>
</tr>
<tr>
<td>Elymus virginicus</td>
<td>Virginia Wild Rye</td>
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<tr>
<td>Hibiscus moscheutos</td>
<td>Swamp Rose Mallow</td>
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<tr>
<td>Impatiens capensis</td>
<td>Spotted Touch-Me-Not</td>
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<tr>
<td>Iva frutescens</td>
<td>Marsh Elder</td>
</tr>
<tr>
<td>Juncus canadensis</td>
<td>Canada Rush</td>
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<tr>
<td>Juncus gerardii</td>
<td>Saltmeadow Rush</td>
</tr>
<tr>
<td>Juniperus virginiana</td>
<td>Eastern Red Cedar</td>
</tr>
<tr>
<td>Leersia oryzoides</td>
<td>Rice cutgrass</td>
</tr>
<tr>
<td>Lilaeopsis chinensis</td>
<td>Eastern Lilaeopsis</td>
</tr>
<tr>
<td>Limonium nashii</td>
<td>Northern Sea Lavender</td>
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</table>
Lycopus virginicus
Lythrum salicaria
Myrica pensylvanica
Panicum virgatum
Parthenocissus quinquefolia
Phalaris arundinacea
Phragmites australis
Pluchea purpurascens
Polygonum arifolium
Poncetaria cordata
Potamogeton sp.
Pttilimnium capillaceum
Ramunculus sp.
Rosa palustris
Rosa rugosa
Rumex sp.
Rumex verticillatus
Ruppia maritima
Sagittaria latifolia
Salicornia europea
Salicornia virginica
Samolus parviflorus
Scirpus americanus
Scirpus fluviatilis
Scirpus pungens
Scirpus robustus
Solanum dulcamara
Solidago sempervirens
Sparganium sp.
Spartina alterniflora
Spartina patens
Spartina pectinata
Suaeda linearis
Suaeda maritima
Teucrium canadense
Toxicodendron radicans
Triglochin maritimum
Typha angustifolia
Typha latifolia
Vitis labrusca
Zizania aquatica
Virginia Bugleweed
Purple Loosestrife
Northern Bayberry
Switchgrass
Virginia Creeper
Reed Canary Grass
Common Reed
Saltmarsh Camphor-Weed
Halberd-Leaf Tearthumb
Pickerel Weed
Pondweed
Mock Bishop-Weed
Buttercup
Swamp Rose
Saltspray Rose
Dock
Swamp Dock
Widgeon Grass
Broad-Leaf Arrowhead
Slender Glasswort
Virginia Glasswort
Water Pimpernel
Olney’s Bulrush
River Bulrush
Three-Square Bulrush
Saltmarsh Bulrush
Bittersweet Nightshade
Seaside Goldenrod
Bur-Reed
Saltmarsh Cordgrass
Saltmeadow Cordgrass
Slough Grass
Annual Seepweed
White Seepweed
American Germander
Poison Ivy
Seaside Arrow Grass
Narrow-leaved Cattail
Broad-leaved Cattail
Fox Grape
Annual Wild Rice
2. Submerged Aquatic Vegetation (SAV):

<table>
<thead>
<tr>
<th>Scientific Name</th>
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<tbody>
<tr>
<td>Agardhiella sp.</td>
<td>Red Weed</td>
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<tr>
<td>Ascophyllum nodosum</td>
<td>Knotted Wrack</td>
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<tr>
<td>Champia parvula</td>
<td>Barrel Weed</td>
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<tr>
<td>Chondrus crispus</td>
<td>Irish Moss</td>
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<td>Codium fragile</td>
<td>Deadman's Fingers</td>
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<tr>
<td>Enteromorpha sp.</td>
<td>Hollow Green Weeds</td>
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<tr>
<td>Eudesme virescens</td>
<td>Brown Slime Weed</td>
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<tr>
<td>Fucus vesiculosus</td>
<td>Rockweed</td>
</tr>
<tr>
<td>Fucus sp.</td>
<td>Rockweed</td>
</tr>
<tr>
<td>Gracilaria tikvahiae</td>
<td>Graceful Red Weed</td>
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<tr>
<td>Phycodrys rubens</td>
<td>Sea Oak</td>
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<tr>
<td>Polysiphonia sp.</td>
<td>Tubed Weeds</td>
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<tr>
<td>Sargassum filipendula</td>
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<tr>
<td>Sphaerotrichia divaricata</td>
<td>Slippery Tangle Weed</td>
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<tr>
<td>Stilophora rhizoides</td>
<td>Rough Tangle Weed</td>
</tr>
<tr>
<td>Ulva lactuca</td>
<td>Sea Lettuce</td>
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<tr>
<td>Zostera maritima</td>
<td>Eelgrass</td>
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