Use of GIS for Estuarine Seagrass Surveys and Restoration Planning

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ABSTRACT

Proper site selection for seagrass habitat restoration requires landscape level research and planning. We have mapped existing seagrass beds; surveyed seasonal depth distribution at selected sites; and monitored surface and underwater light; and collected spatial turbidity data at Grand Bay National Estuarine Research Reserve (GBNERR), Mississippi. The surveyed information was saved in text files; imported into ArcGIS 9.1; converted to vector formats; and analyzed. The seagrass distribution data surveyed along transects at three sites in Summer 2005, Fall 2005, Summer 2006, and Fall 2006 indicate that there are discrete seasonal changes in the seagrass abundance and species composition in the Reserve. The current seagrass bed locations, daily wind direction analysis, and water clarity data suggest that wind-driven waves and the associated reduced light penetration are the limiting factors for seagrass growth on certain shores. The areas with gradual shoreface slopes and protected from waves are the most feasible restoration sites.

INTRODUCTION

Seagrass communities are keystones of shallow coastal habitats. They are essential fisheries habitat, providing nursery grounds and food sources for communities of nekton, aquatic invertebrates, and waterfowl (Orth and Moore, 1984, Larkum et al. 2006). Their shoots help reduce wave energy while roots and rhizomes bind and stabilize sediment. Therefore, healthy growing seagrass beds provide shore protection, reduce effects of storm surges, and reduce sediment suspension.

These valuable natural resources have been in global decline (Short et al. 2001) largely due to increases in human disturbances that either directly destroy seagrass habitats or make them more vulnerable to natural and anthropogenic stresses. In Mississippi Sound, seagrass beds and their potential habitat have reportedly declined up to 75% during the past four decades (Eleuterius 1973, Montcreiff et al. 1998). However, little is known about local seagrass phenology, seasonal changes in their abundance, or factors that limit the distribution and growth of seagrasses.

We have transect surveyed the SAV depth distributions at selected sites in Grand Bay National Estuarine Research Reserve (GBNERR), Mississippi, twice a year since the summer of 2005. To store and display our surveyed data, we used the ArcGIS9.1 suite; this allows us to gain a better understanding of the seasonal variations of seagrass communities and provides a baseline for habitat restoration projects. We will continue our monitoring and surveying of the GBNERR seagrasses and update acquired data to ArcGIS in order to further understand the long-term trends and ecological drivers of seagrass systems. This information will be crucial for selection and implementation of proper management strategies.

METHODS

Study Area

Grand Bay National Estuarine Research Reserve (GBNERR) is the 24th NERR among the 27 Reserves in the nation (http://nerrs.noaa.gov/Background_Chart.html). It is located in southeast Mississippi (30.41° N 88.53° W) encompassing 74.5 square km (Fig.1). We have selected permanent transect survey sites for seagrass (Fig. 1) based on previous bay-wide surveys (Cho and May 2006).

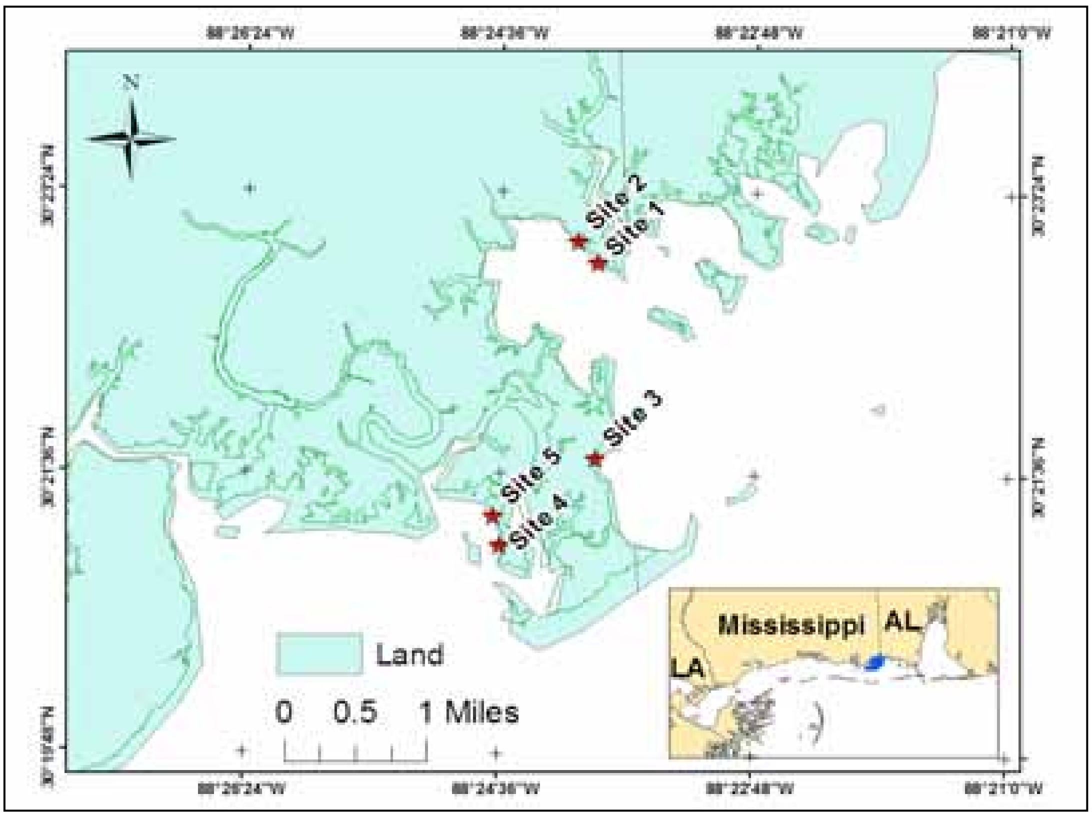

Figure 1. The map of Grand Bay National Estuarine Research Reserve (GBNERR), Mississippi. The blue area in the inset indicates the location of GBNERR in the State. The red stars represent our seagrass transect survey sites.

Transect Surveyed Seagrass Distribution

Three replicates of 200-meter-transects were used at each survey site (Fig. 2). A base line was laid parallel to shore; then the three surveyed transects were extended perpendicular from the shore at 0m, 10m, and 28m along the base line. We recorded the seagrass patches that were intercepted by the transects (Fig. 3) while snorkeling along transect lines.

Figure 2. Christina Watters of GBNERR and Melissa Larmer of Jackson State University (JSU) are assisting transect setting at Site 1 in July 2006.

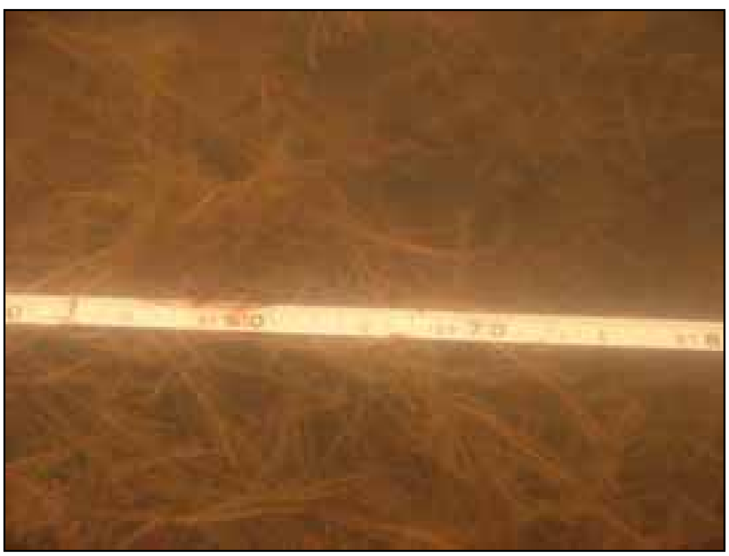

Figure 3. Transect line over a *Halodule wrightii* bed

Vegetation survey data along the transects were stored as text files (Fig. 4). Three 200-m-long lines were drawn to simulate the survey transects in ArcMap 9.1 (using Universal Transverse Mercator projection). The seagrass depth distribution was visualized using the dynamic segmentation feature of ArcGIS; the seagrass patches were used as linear feature events and transect lines were used as routes as described in Cho et al. (2006).

Figure 4. An example of seagrass survey text file.

Mapping of Existing Seagrass Beds

Existing seagrass beds were mapped using a Trimble GeoXT GPS unit. The perimeters of existing beds were determined by conducting raking surveys from a boat. The perimeters were recorded using the GPS, and differential correction was used during post-processing to increase the accuracy of field data. Data were imported into ArcMap as shapefiles.

Monitoring of Photosynthetically Active Radiation (PAR)

Measurements of PAR were made at water depths of either 0 m and 0.5m or at a water depth of 1.0 m at three locations near the survey sites twice a month from September 2005 to February 2007. The PAR measurements collected at the water surface and subsurface were used to calculate the site mean vertical absorption coefficient (K_d) (Cho and May 2006).

Analysis of Wind Direction

Hourly wind direction, measured in degrees at the Grand Bay NERR meteorological station located on Crooked Bayou, was classified into general wind direction (N, NE, E, SE, S, SW, W, and NW) in order to determine seasonal shifts in predominant wind direction.

Middle Bay-wide Turbidity Measurements

Turbidity was measured at 38 sites along four transects (Fig. 5) that ran across Middle Bay on March 13th, 2007. At each site, water depth was measured using a wooden stick marked in one-foot increments; geographic coordinates were recorded using a GARMIN *etrex* handheld GPS; and turbidity was measured using HACH Colorimeter/Turbidimeter (Figs. 6 and 7). Latitudes, Longitudes, and turbidity values at the sites were saved in a text file and added into ArcMap; point features were then created from this file. The point turbidity data were interpolated using the Kriging method (the linear semivariogram model, using variable search radius) in Spatial Analyst.

Figure 5. Turbidity measurement sites in Middle Bay, GBNERR.

Figure 6. Martha Ragwa of JSU is taking turbidity measurement using a HACH colorimeter.

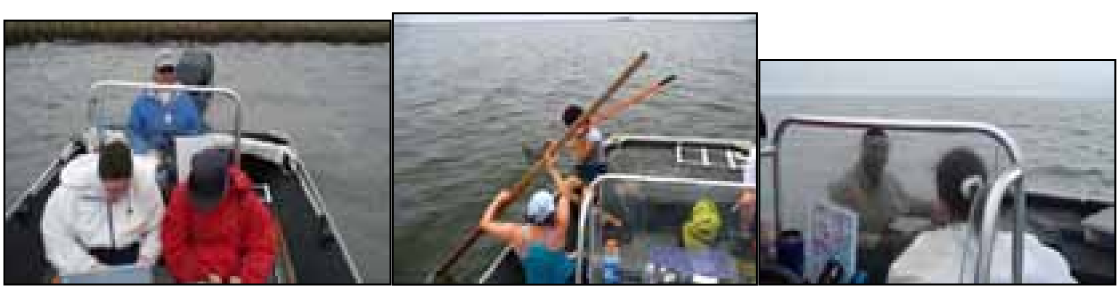

Figure 7. The research team consisting of JSU and GBNERR people are recording the data, measuring the water depth, raking for seagrass patches from a boat.

Bay-wide water depth data

Water depth data were downloaded from the National Geophysical Data Center website and converted to meters. Point features were created in ArcGIS using the data; and they were interpolated using the Kriging method (the linear semivariogram model, using variable search radius) within the Spatial Analyst. The interpolated turbidity was reclassified into 9 classes.

RESULTS and DISCUSSION

Transect Surveyed Seagrass Distribution

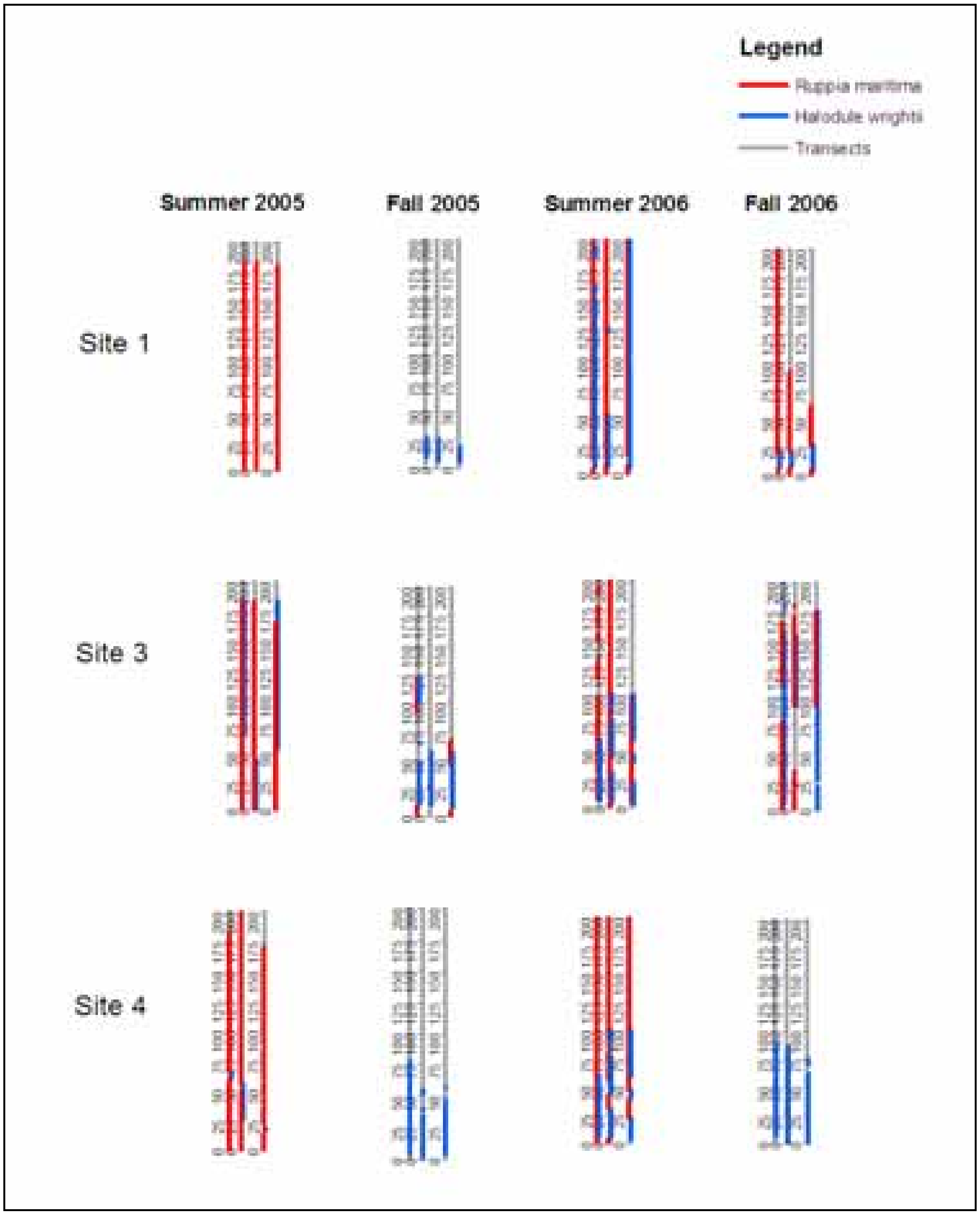

Figure 8. Transect distributions of *Ruppia maritima* and *Halodule wrightii* surveyed in July 2005, October 2005, July 2006, and October 2006 at three sites of GBNERR.

There were two seagrass species occurring at the GBNERR sites, *Ruppia maritima* and *Halodule wrightii*. As shown in Figure 8, there were distinct seasonal changes in the seagrass abundance and the species dominance. Based on three-way ANOVA we conducted for an on-going study, the total seagrass cover was higher in summer than in fall (July and October surveys) in both 2005 and 2006. During the summer months, the transects were nearly 100% covered by vegetation. Except for Site 1, located in Middle Bay, the seasonal changes in seagrass coverage were mainly due to decline of *R. maritima* in the fall. The total seagrass abundance was significantly lower in fall 2005 when compared to fall 2006, due to the sedimentation that buried the existing beds after the passages of Hurricanes Katrina and Rita in 2005.

Mapping of Existing Seagrass Beds

The largest seagrass beds were located in the northeastern shores of Middle Bay and Point aux Chenes Bay at GBNERR. Monospecific *Halodule* beds occurred during the summer on sandy shoals in Point aux Chenes Bay (a Figure will be available for the conference presentation).

Monitoring of Photosynthetically Active Radiation (PAR)

The estimated annual mean light extinction coefficient (K_d) values ranged from 1.8 (Site 3) to 2.3 (Site 4) based on our monitoring data and estimated information from the maximum depth of seagrass growth. Areas with sandy substrate had statistically higher water clarity (low K_d values) than areas in Middle Bay (i.e. Site 1).

Analysis on Daily Wind Direction

Dominant wind direction in the GBNERR region was south in August and north in December. Easterly winds were overriding compared to westerly winds during the time period of August-December 2004 (Fig. 9).

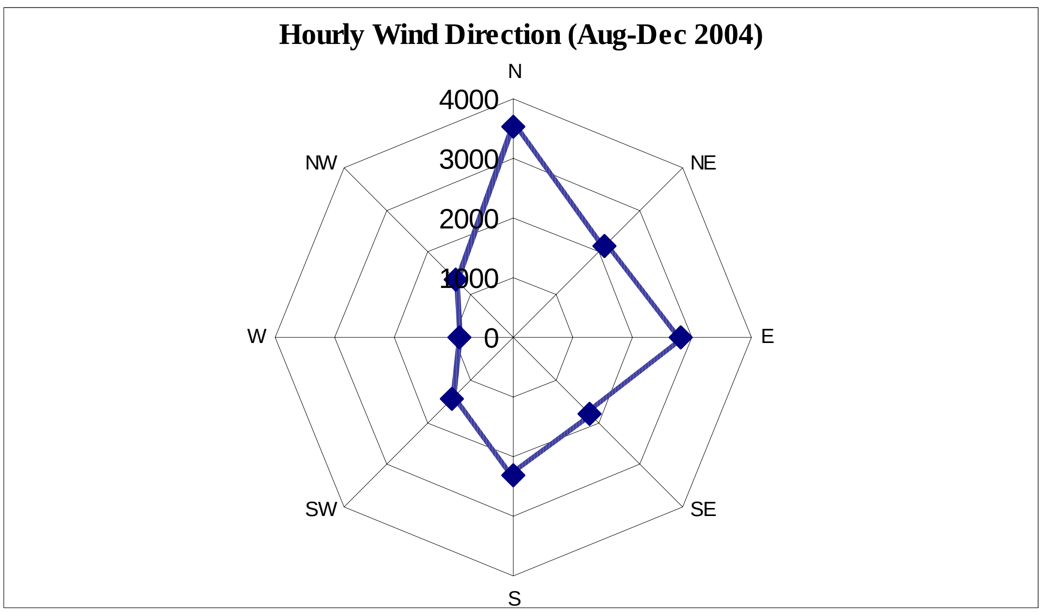

Figure 9. Hourly wind direction, classified into general wind direction (N, NE, E, SE, S, SW, W, and NW). The data were collected in degrees at the Grand Bay NERR meteorological station located on Crooked Bayou.

Middle Bay-wide Turbidity Measurements

Since the data were collected on a single day in Middle Bay, the interpolated map cannot be used to interpret the general turbidity pattern of the bay. On our sampling day, March 13th, 2007, turbidity was higher near southwestern shores of Middle Bay where seagrasses do not occur (Fig. 10)

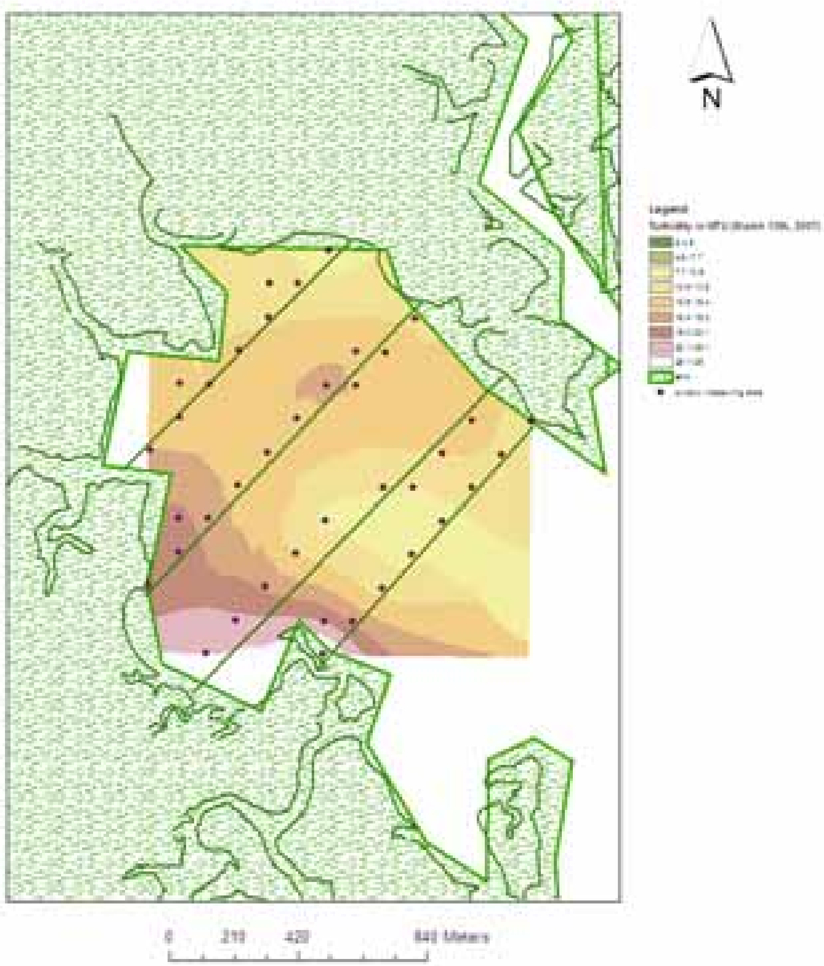

Figure 10. Interpolated using the Kriging method and classified turbidity data collected on March 13th, 2007 at 38 sites in Middle Bay, GBNERR. MS.

<u>Bay-wide water depth data</u>

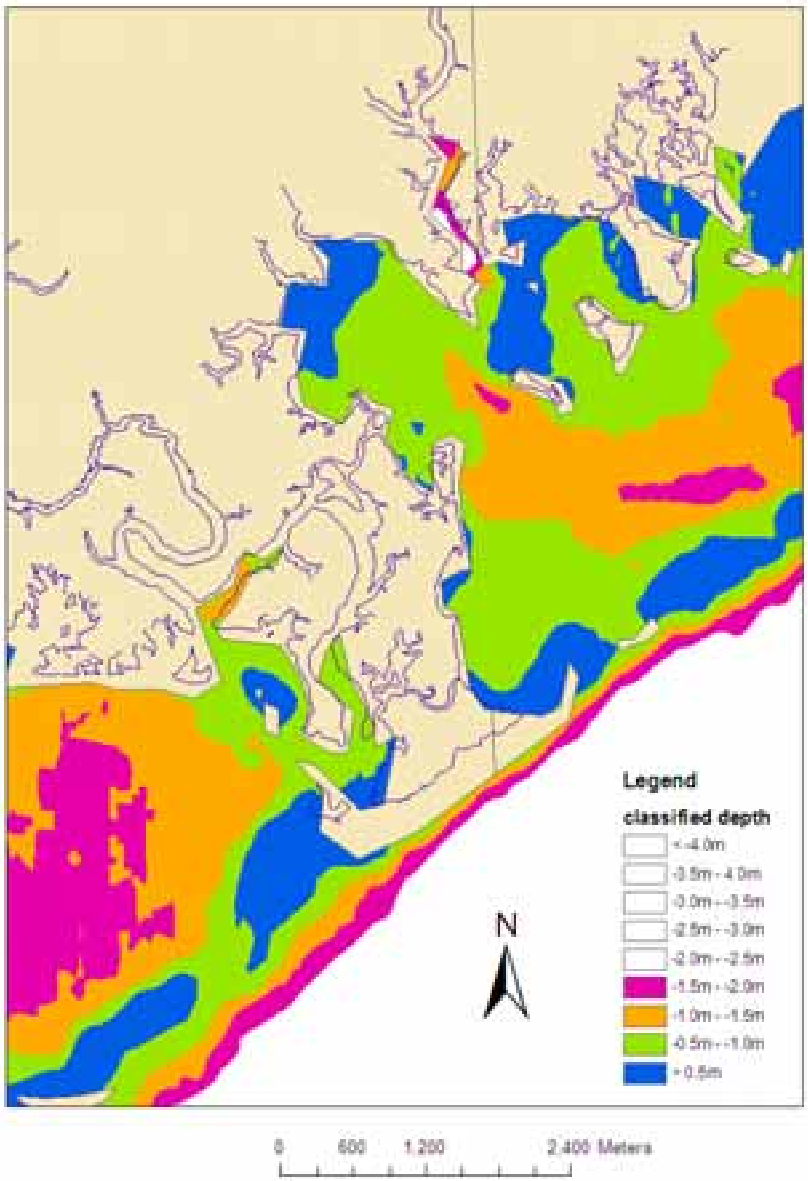

Figure 11. Water depth at Grand Bay NERR

Most of the GBNERR area is shallow with depths less than 2 meters below the mean sea level (Fig. 12). The areas that support seagrass beds have mean depths less than 1 meter. Sand shoals that extend from both sides of Grand Batture indicate the dominant south-east winds and the resultant long shore drifts are important in sediment transport in the area.

MAJOR FINDINGS AND FUTURE IMPLICATION

1. The seagrass shoreline distribution at Grand Bay NERR suggests the shores that are relatively protected from (south) easterly winds and the resultant long-shore currents support abundant vegetation. Landscape level habitat assessment is required to provide information on wave stresses on SAV in the ecosystem. This information will be critical in planning restoration strategies.
2. The immediate impacts of Hurricanes Katrina and Rita were seen in the form of sedimentation that partially buried SAV beds, but the delayed negative impacts of the hurricanes on the seagrass beds were not shown in the study sites (Fig. 8).
3. The coverage of *Halodule wrightii* is more stable than *Ruppia maritima*, especially in the areas with higher sand content. *R. maritima* grows rapidly after winter senescence (Fig. 8). Therefore, the areas that support both *Halodule wrightti* and *Ruppia maritima* may have higher resistance to periodic disturbances.
4. Assuming light absorption is the prevailing limiting factor, we have estimated a 20% decrease of the annual mean K_d through watershed restoration or improved community stewardship would result in a 35% increase in the potential SAV habitat, from approximately 1700 ha to about 2300 ha (Cho et al. 2006). The relative PAR extinction caused by phytoplankton chlorophyll *a*, suspended sediment, dissolved organic carbon, and epiphytes will be determined through future studies.

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