SUBMERGED AQUATIC VEGETATION MAPPING IN MOBILE BAY AND ADJACENT WATERS OF COASTAL ALABAMA IN 2008 AND 2009

Prepared for

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EXECUTIVE SUMMARY

This document is the technical report for 2008 and 2009 mapping of submerged aquatic vegetation (SAV) in coastal Alabama, for the Mobile Bay National Estuary Program (MBNEP). This report documents the GIS mapping effort that provides detailed information on the distributions of SAV in the MBNEP study area during 2008 and 2009. The results are compared with the 2002 baseline survey. This information fulfills the MBNEP living resources goal of identifying the current status and trends of SAV resources in coastal Alabama.

For this SAV mapping project a digital database was developed using aerial imagery and complementary surface-level verification. Digital orthophotographs were created from native aerial imagery acquired with a digital mapping camera. Two seasonal surveys were performed based on aerial imagery obtained October 1, 2008 and July 20 and August 26, 2009. An Airborne Global Positioning System (ABGPS) and inertial measurement unit (IMU) were used to accurately position each aerial photo center (principal point). Processed ABGPS/IMU data were used in an aerotriangulation procedure to produce a digital elevation model (DEM) surface for imagery rectification. Outlines of SAV signatures in the ortho imagery were digitized in a GIS environment. Digitized areas were field-verified to document habitat characteristics at the surface level.

A total of 5,248.7 acres of SAV was mapped in 2009 (Table ES-1). The lower Delta contained most of the total 5,248.7 acres mapped particularly in the Bridgehead Quadrangle, which contained 66% of the total 2009 acreage. Other areas of substantial acreage included the Mobile Quadrangle (509.8 ac) in the Delta and the Grand Bay Quadrangle (364.2 ac) in Mississippi Sound. Fifty-seven percent of the total SAV acreage (2,981.6 acres) was mapped as continuous (>50%) coverage. Overall, there were 1,371.3 fewer acres mapped in 2009 than in the 2002 survey, primarily due to substantially less SAV in the Delta and Mobile Bay in 2009.

The southern portion of the study area had more SAV acreage mapped in 2009 and 2008 compared to 2002. There were 234.8 more acres of SAV mapped in 2009 overall in the Mississippi Sound and Perdido Key areas. Areas with greater acreage in 2009 compared to 2002 included the Orange Beach (+90.8 ac) and Perdido Bay (+20.8 ac) quadrangles in southern Baldwin County, and the Grand Bay (+67.8 ac), Petit Bois Pass (+82.7 ac), Isle aux Herbes (+41.6 ac), and Ft Morgan NW (+25.2) quadrangles in southern Mobile County.

There were large changes in SAV acreage between the 2008 and 2009 surveys, with 438.8 fewer acres mapped in 2009 (Table ES-2). The difference between surveys was primarily due to less acreage of widgeon grass (*Ruppia maritima*) in Mississippi Sound in 2009, particularly in the Grand Bay and Isle aux Herbes Quadrangles.

EXECUTIVE SUMMARY (continued)

Table ES-1. Difference in total SAV acreage by U.S.G.S. 7.5-Minute Quadrangle, comparing 2009 with the 2002 baseline survey.

USGS QUADRANGLE[1]	2009 ACREAGE[2]	2002 ACREAGE[2]	DIFFERENCE
Bridgehead	3,450.3	3,641.0	- 190.7
Chickasaw	21.2	26.9	- 5.7
Daphne	35.1	9.5	+ 25.6
Fort Morgan NW	25.2	0.0	+ 25.2
Grand Bay	364.2	296.4	+ 67.8
Grand Bay SW	61.8	79.9	- 18.1
Gulf Shores	1.5	1.2	+ 0.3
Hollinger's Island	0.0	126.7	-126.7
Hurricane	1.9	517.3	- 515.4
Isle aux Herbes	129.2	87.6	+ 41.6
Kreole	218.8	295.9	- 77.1
Mobile	509.8	1,007.0	- 497.2
Orange Beach	150.8	60.0	+ 90.8
Perdido Bay	135.4	114.6	+ 20.8
Petit Bois Pass	142.3	59.6	+ 82.7
Pine Beach	1.2	0.1	+ 1.1
The Basin	0.0	265.2	- 265.2
TOTAL	5,248.7	6,588.9	-1,340.2

Table ES-2. Difference in total SAV acreage by U.S.G.S. 7.5-Minute Quadrangle, comparing 2009 with 2008.

USGS QUADRANGLE[1]	2009 ACREAGE[2]	2008 ACREAGE[2]	DIFFERENCE
Fort Morgan	0.0	6.8	- 6.8
Fort Morgan NW	25.2	31.4	- 6.2
Grand Bay	364.2	548.1	- 183.9
Grand Bay SW	61.8	86.8	- 25.0
Gulf Shores	1.5	1.4	+ 0.1
Isle aux Herbes	129.2	355.7	- 226.5
Kreole	218.8	230.1	- 11.3
Orange Beach	150.8	147.0	+ 3.8
Perdido Bay	135.4	135.1	+ 0.3
Petit Bois Pass	142.3	142.1	- 30.9
Pine Beach	1.2	1.2	--
TOTAL	1,230.4	1,685.7	- 455.3

[1]Quadrangles not listed did not have mapped SAV; [2]Includes continuous and patchy SAV

EXECUTIVE SUMMARY (continued)

Twenty-one vascular plant species representing eleven taxonomic families were recorded during the 2008 and 2009 field surveys. Eight species not encountered in the 2002 baseline survey were documented in 2008 and 2009. Most of the identified species were minor components of the SAV community and were not included in the broad classification of species categories in the mapping process. Only sago pondweed (*Stuckenia pectinata*) occurred in significant densities and locations in 2009 to be mapped as a monospecific category in the GIS.

As in 2002, most habitats in 2009 contained mixtures of species typically found in northern Mobile Bay and the Delta. Table ES-3 lists the habitat categories resolved for the 2009 survey. The most extensive habitat was a mixture of Eurasian watermilfoil (*Myriophyllum spicatum*), southern naiad (*Najas guadelupensis*), and wild celery (*Vallinsneria neotropicalis*). Eurasian watermilfoil and wild celery were the most prevalent species. Other common fresh and brackish water species included coon's tail, southern naiad, and water stargrass.

Table ES-3. Total 2009 acreage by species (habitat) category[1].

SAV HABITAT CATEGORY	ACREAGE
Eurasian watermilfoil, southern naiad, wild celery	1005.9
Wild celery	978.6
Eurasian watermilfoil	804.3
Shoal grass	467.3
Shoal grass, widgeon grass	436.6
Eurasian watermilfoil, southern naiad	365.9
Widgeon grass	313.1
Eurasian watermilfoil, southern naiad, widgeon grass, wild celery	201.7
Eurasian watermilfoil, water stargrass	187.6
Eurasian watermilfoil, wild celery	155.8
Sago pondweed	78.7
Coon's tail, Eurasian watermilfoil, southern naiad, wild celery	76.9
Sago pondweed, wild celery	63.6
Coon's tail, Eurasian watermilfoil, water stargrass, wild celery	35.1
Eurasian watermilfoil, water stargrass, wild celery	13.7
Southern naiad	12.8
Brittle waternymph southern naiad	10.5
Coon's tail, small pondweed, southern naiad	3.3
Water stargrass	3.1
Eurasian watermilfoil, leafy bladderwort	1.7
Twoleaf watermilfoil	1.1
Turtle grass	0.04
TOTAL	**5,217.5**

[1]Multiple species indicates co-dominance

In Mississippi Sound, SAV occurred as pure or mixed stands of shoal grass and widgeon grass. SAV mapped in Mississippi Sound in 2002 was entirely shoal grass. In 2008 and 2009, mixed beds of widgeon grass and shoal grass were mapped in the Grand Bay, Isle aux Herbes, and Kreole quads.

Table ES-4 lists the acreage for each species category in the 2008 polygonal database. The most extensive habitats were a mixture of shoal grass and widgeon grass (601.6 ac) and widgeon grass (599.1). These habitats occurred in Mississippi Sound. Most of the pure shoal grass beds (425.4 ac; 88%) occurred in the Perdido area of southern Baldwin County.

Table ES-4. Total 2008 acreage by species (habitat) category[1].

SAV HABITAT CATEGORY	ACREAGE
Shoal grass	485.0
Shoal grass, widgeon grass	601.6
Widgeon grass	599.1
Turtle grass	0.04
TOTAL	**1,685.7**

Several areas of the Delta that had supported large SAV beds in 2002 were devoid of submerged vegetation in 2008 and 2009, in particular the northernmost part of the study area. The dynamics of SAV occurrence in the Delta are poorly known, and reasons for the decline of SAV in these areas are not clear.

The species composition and distribution of SAV in northern Mississippi Sound is also different compared to the 2002 baseline survey. SAV mapped in the Sound in 2002 was entirely shoal grass. During the 2008 and 2009 study, widgeon grass, shoal grass, and mixed beds of widgeon grass and shoal grass occurred in the Grand Bay, Isle aux Herbes, and Kreole quadrangles. SAV composition has changed through time in the northern Sound, likely due to exposure to wave-generated turbulence and scour, and freshwater outflow from the Mobile Bay watershed. SAV in this portion of the study area likely remains in some degree of flux due to highly variable physical environmental conditions, unlike the relatively sheltered locations containing SAV in southeastern Baldwin County.

Widgeon grass beds that occurred in Mobile Bay and in portions of northern Mississippi Sound in 2008 did not re-emerge in 2009. The early spring of 2009 was characterized by persistent strong southerly winds, and elevated turbidity was present for much of the first half of the year in open waters of Mobile Bay and Mississippi Sound, potentially limiting vegetative growth of widgeon grass in those areas.

As in 2002, SAV mapped in southeastern Baldwin County was predominantly shoal grass. Shoal grass has expanded into areas that were non-vegetated in 2002, including southern Little Lagoon, Terry Cove, and Bayou St. John.

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1.0 INTRODUCTION

The Mobile Bay National Estuary Program (MBNEP), Alabama Department of Natural Resources State Lands Division, and National Oceanic and Atmospheric Administration funded the project entitled "Mapping of Submerged Aquatic Vegetation in Mobile Bay and Adjacent Waters of Coastal Alabama in 2008 and 2009" (contract # DISL/NEP 2007-01). This report documents the mapping effort that provides detailed information on the distributions of submerged aquatic vegetation (SAV) species in the MBNEP area during 2008 and 2009.

1.1 MBNEP BACKGROUND

Mobile Bay was designated a National Estuary in 1995 through the National Estuary Program, which was established by the Clean Water Act of 1987. The charge of the MBNEP is to develop a blueprint for conserving the resources of the Mobile Bay estuary. The MBNEP has developed a Comprehensive Conservation and Management Plan (CCMP) to accomplish this conservation goal. The CCMP identifies MBNEP goals, objectives, and action plans aimed at rehabilitating and maintaining the various resources in the estuary.

1.2 STUDY PURPOSE AND OBJECTIVES

This environmental study contributes to the fulfillment of the CCMP natural resource objective to preserve and restore SAV resources in the MBNEP area. Habitat loss is a high priority area of environmental concern for the MBNEP, and the extent of SAV in coastal Alabama has declined from historic levels. SAV is an important natural resource in freshwater, brackish water, and marine ecosystems that provides food for waterfowl and other animals, and habitat for ecologically and economically important species. The information in this report fulfills the MBNEP living resources priority to identify the current status and trends of SAV in the study area. The objective of this project was to gather accurate digital data to identify the current status of SAV and changes in its distribution compared to the MBNEP 2002 baseline SAV survey (Barry A. Vittor & Associates, Inc., 2004).

1.3 PROJECT AREA

The geographic focus of this project was near-shore estuarine and marine systems in coastal Alabama (Figure 1-1). The project area encompassed the entire coastline of Alabama from its border with Mississippi east to Florida. The landward boundary was the Louisville and Nashville (L & N) Railroad north of Mobile Bay, except for the streams and bays of the waterway north of the L&N Railroad commonly known as McReynolds Lake (The Basin).

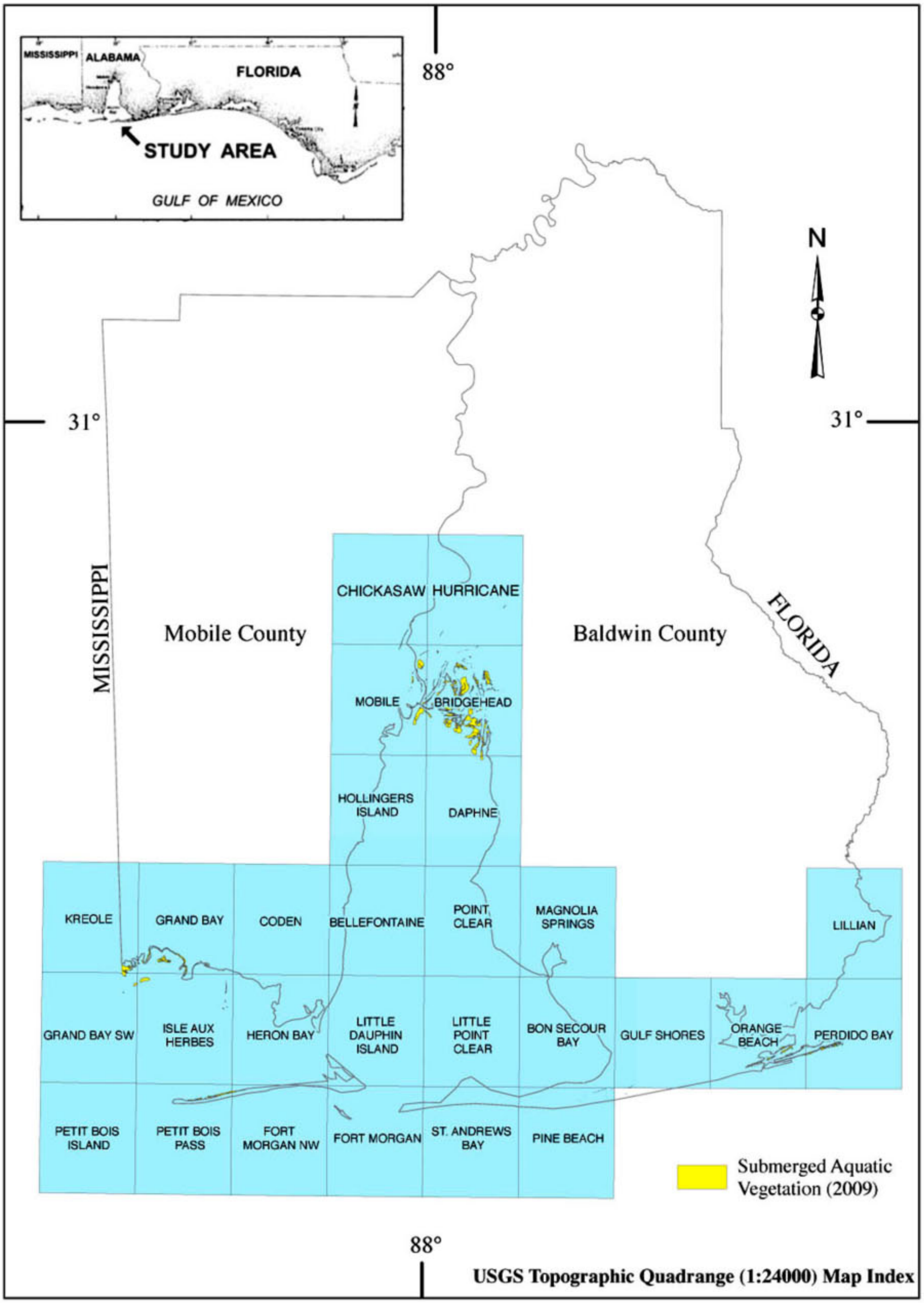

Figure 1-1. Study area for the 2008 and 2009 survey of SAV in coastal Alabama.

1.4 PROJECT APPROACH

In 1995 the U.S. Department of Commerce published benthic habitat mapping methods in a document entitled *NOAA Coastal Change Analysis Program* (C-CAP). The C-CAP is a nationally standardized database of land cover and land change information in coastal areas, developed using remotely sensed imagery. The C-CAP outlines methods and provides technical guidance for digital feature mapping using aerial photography and complementary surface-level verification.

This SAV mapping project was conducted within the technical framework established by the C-CAP. The aerial mapping technology used was airborne Global Positioning System (ABGPS) and an inertial measurement unit (IMU) to accurately position each aerial photo center (principal point). The processed GPS/ABGPS/IMU data were used in an aerotriangulation procedure to produce a digital elevation model (DEM) surface for imagery rectification. The DEM removed imagery displacements inherent in the aerial photography, such as distortions resulting from camera tilt and ground relief, to create digital orthophotographs with uniform scale and a high degree of accuracy.

Outlines of SAV signatures in the ortho imagery were digitized in a GIS environment. Digitized areas were field-verified to document habitat characteristics at the surface level. Field data on SAV species composition and density were collected to provide detailed descriptions of habitat characteristics.

1.5 PROJECT BACKGROUND AND TIMING

This project is an update on the status and trends of SAV resources in the MBNEP study area. The 2002 baseline survey (Barry A. Vittor & Associates, Inc., 2004) mapped SAV throughout upper Mobile Bay and the Mobile-Tensaw Delta, in northern and southern Mississippi Sound, and in the Perdido Key area. The Delta in 2002 contained most of the overall acreage (85%) and species (88%). Seagrasses are limited in distribution to the southern portion of the study area.

C-CAP recommends a maximum 5-year interval between updating benthic resource data. This project was intended for 2007, but poor water clarity throughout the summer prevented acquisition of aerial imagery suitable for remote sensing of SAV. In 2008, poor environmental conditions throughout the spring and summer prevented photo acquisition until early October. Because October generally is not concurrent with seasonal peak growth of SAV, particularly in upper Mobile Bay and the Delta, aerial photography was acquired only for the southern potion of the study area. The entire study area was surveyed in 2009.

2.0 METHODS

2.1 ORTHOPHOTOGRAPHY PRODUCTION

Photo Science of St Petersburg, FL acquired the aerial imagery and produced the ortho imagery for this mapping project. The orthorectification process relied on digital aerial imagery, ground control/aerotriangulation data, and a digital elevation model (DEM).

Digital Aerial Imagery

For the 2008 survey, ortho imagery was produced using aerial photographs acquired on October 1, 2008. Due to poor visibility in some portions of the study area, ortho imagery produced by USGS from native aerial imagery acquired October 28, 2008 was used to supplement the assessment of photographic signatures.

For the full 2009 survey, imagery was acquired July 20 for most of the study area. Imagery for a portion of Perdido Bay and the southernmost flight line along the immediate coast was acquired August 26, 2009.

The primary environmental constraints on remote sensing of submerged features are water clarity, wave action, and clouds. Aerial imagery for this project was acquired during a period of relatively low turbidity across most of the study area, and during morning hours with sun angles between 30 and 45 degrees to avoid glare.

A Z/I Imaging Digital Mapping Camera (DMC) was used to acquire aerial imagery. The DMC was equipped with eight (8) cameras heads, four (4) for panchromatic and one (1) each for red, blue, green and NIR (near-infrared).

Flight Mission

A computerized flight-management system was utilized during imagery acquisition. GPS-supported aircraft navigation interfaced with the DMC control software. After initial flight planning, digitized mission data were fed into the flight-management system. The start and stop points of each flight line were processed by the aircraft's onboard navigation system.

Dual-frequency GPS observation data were collected on-board the aircraft at a one second epoch. Additionally, inertial data was collected at a rate of 0.005 seconds during all periods of flight. The midpoint of each photo exposure was precisely captured by the GPS receiver. All ABGPS and Inertial data was then post-processed using Applanix MMS version 5.2 software to provide accurate positional and rotation data of the camera for each exposure. Effectively, the three dimensional position (x, y, and z) of each exposure was determined from the ABGPS data while the three-dimensional rotation (omega, phi, and kappa) of each exposure was determined from the inertial data.

An Applanix (Ontario, Canada) POS/AV-DG IMU system was used during all photo collection to measure the position of the camera perspective center and orientation angles of each photograph at the midpoint of exposure, to an accuracy of 5-10 cm and 20-30 arc seconds, respectively. For this project the position SD in Meters was as follows: Easting: 0.034m, Northing: 0.021m, Elevation: 0.021m

During imagery acquisition the aircraft flew at 27,000 feet AMT to render a native pixel resolution of 1 meter for the entire study area. The Applanix Inertial Measurement Unit (IMU) ensured that tip, tilt, and swing of the camera for each frame was less than 3 degrees. Resolution loss due to blurring was avoided by a forward image motion compensation (FMC) system. Image motion did not exceed 0.002 inches. Each individual frame was formatted for 60% endlap and 30% sidelap.

<u>Positional Accuracy</u>

Airborne Global Positioning System (ABGPS) coordinates were automatically collected for the principal point for each photographic frame during imagery acquisition. The ABGPS/IMU recorded the position and orientation of the camera platform during all flight missions. Exact measurements obtained from the ABGPS and IMU provided positional accuracy of the resultant imagery suitable to support generation of ortho imagery.

<u>Orthorectification</u>

A 30-m DEM provided by the USGS was used for the orthorectification process. Cubic convolution re-sampling was used during the rectification process. The rectification methodology sharpened the edges of linear features and sampled 16 of the closest pixels and performed a weighted adjustment.

Orthophotos were produced as individual rectified image frames. Color balancing was performed on the digital images to provide a consistent tone, brightness and contrast throughout the project area. Digital orthophotos are projected to NAD 1983, UTM, meters. A low-resolution mosaic was created in a MrSID format.

2.2 SAV DATA DEVELOPMENT

<u>Creation of Polygonal and GIS Database</u>

SAV presence was determined through examination of the aerial photography and complementary field surveys. The ortho imagery was observed in ArcView GIS, and SAV boundaries were digitally delineated on a computer screen display. ESRI polygon coverage was created in ArcView version 9.3. Once the preliminary line work was completed, polygon vector coverage was created using building, editing, cleaning, and labeling the polygonal line work. Overlapping photographs were used for verification and comparison when delineating areas of interest. The minimum mapping unit (MMU) for this project was 0.03 hectares (0.1 acres).

Polygons were visually assessed for vegetation density on a screen display and categorized as continuous (>50%) or patchy (<50%). SAV density was also recorded during field surveys. Polygons were categorized for species composition based on data collected in the field.

SAV signatures were distinguishable in the photography for most of the study area (Figure 2-1). Ambiguous signatures included tree shadow, leaf litter, and bathymetric depressions. Questionable areas were visited in the field to verify initial assumptions regarding identification of photographic signatures.

Field Surveys

Field surveys were conducted to document SAV presence and habitat characteristics. Locations of interest identified through review of the aerial imagery were pre-plotted in GPS. Opportunistic field data were also collected and recorded with GPS. Field locations were logged using a Trimble Pro XR differential GPS unit, and followed common GPS practices. An elevation mask of 6 was used to avoid degraded signals from satellites. A Positional Dilution of Precision (PDOP) threshold of 6, data logging at 2-second intervals, and real-time differential correction/post-processing of the field data collected data accurate to within 1 meter.

Information on species composition and bed density was recorded at field points. SAV species identifications were collected either by *in-situ* observation or taxonomic assessment of hand-collected specimens. Data were collected at a total of 1,326 field points in 2009 and 182 points in 2008.

There were some locations where SAV was observed in the field but was not readily apparent in the photography due to occurrence in small, scattered patches. Field points were logged in these areas, which were re-scrutinized in the imagery.

QA/QC

Two analysts identified potential SAV signatures using screen displays and hard prints of the orthophotography. Analysts visually reviewed the polygons superimposed on the digital imagery to check completeness and edges. The analysts also reviewed the attribute classification for each delineated area and made determinations of accuracy of the habitat categories based of the field species and bed density data. Analysts consulted regarding questionable areas, and the entire polygonal data set was reviewed after completion.

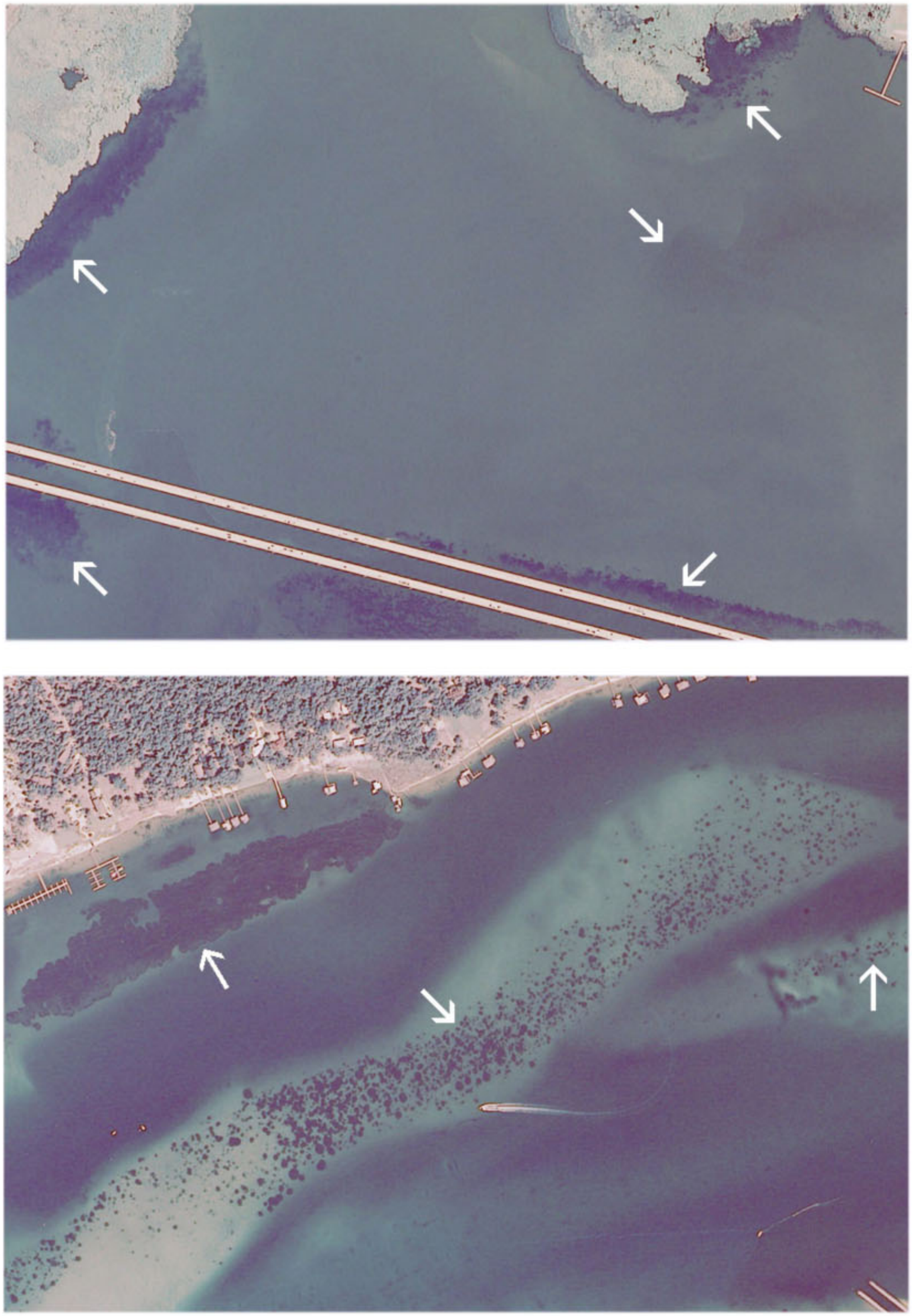

Figure 2-1. 2009 aerial imagery showing SAV in the Mobile-Tensaw Delta (top) and Bayou St. John in Southern Baldwin County (bottom).

A quality control assessment was performed to test spatial and thematic accuracy of the completed polygonal data set. The spatial test was performed to assess the horizontal spatial error of SAV polygon boundaries, based on comparison with actual SAV boundaries in the field. The thematic test was performed to assess the correctness of habitat attributes, such as species composition. An independent data set was randomly selected from the completed polygonal data set to measure and calculate spatial and thematic accuracies.

Spatial accuracy was calculated using the National Standard for Spatial Data Accuracy (NSSDA) (LMIC, 1999), using a horizontal positional accuracy statistic. A total of 76 test point measurements was used for determining horizontal accuracy. At vegetated test points in the field the locations of the actual bed edges were recorded with GPS. The collected field edge points were imported into ArcGIS and compared with the location of the corresponding random test points. An average of the distance errors was calculated to determine the average spatial error. The average spatial error was 10.4 feet (3.17 meters).

To test thematic accuracy, the random sample points were visited to verify actual cover type (recorded as reference data) for comparison with the corresponding polygon attributes. An error matrix was created using 361 random locations visited in the field. The error matrix compared the actual "ground truth" data with the predicted classes for the random sample points. The overall classification accuracy was computed as the total number of correct class predictions divided by the total number of cells in the matrix. The thematic accuracy was determined to be 90%.

<u>Metadata</u>

Metadata for the project meet Federal Geographic Data Committee (FGDC) standards and guidelines (FGDC, 1998). The objectives of FGDC standards are to provide a common set of terminology and definitions for the documentation of digital geospatial data. FGDC standards establish names of data elements and compound elements (groups of data elements) to be used for these purposes, the definitions of these compound elements and data elements, and information about the values that are to be provided for the data elements.

3.0 RESULTS

Table 3-1 lists the 2009 SAV acreage by USGS Quadrangle area (see Figure 1). As in 2002, SAV was concentrated in upper Mobile Bay and the Mobile-Tensaw Delta, Mississippi Sound, and the Perdido Key area of southeast Baldwin County.

Most of the 2009 SAV acreage occurred in the lower Delta, particularly in the Bridgehead Quadrangle, which contained 66% (3,450.3 ac) of the total 5,248.7 acres mapped. Other areas of substantial acreage included the Mobile Quadrangle (509.8 ac) in the Delta and the Grand Bay Quadrangle (364.2 ac) in Mississippi Sound. Fifty-seven percent of the total SAV acreage (2,981.6 acres) was mapped as continuous (>50%) coverage.

Table 3-1. Difference in total SAV acreage by U.S.G.S. 7.5-Minute Quadrangle, comparing 2009 with the 2002 baseline survey.

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Grand Bay SW	61.8	79.9	- 18.1
Gulf Shores	1.5	1.2	+ 0.3
Hollinger's Island	0.0	126.7	-126.7
Hurricane	1.9	517.3	- 515.4
Isle aux Herbes	129.2	87.6	+ 41.6
Kreole	218.8	295.9	- 77.1
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Pine Beach	1.2	0.1	+ 1.1
The Basin	0.0	265.2	- 265.2
TOTAL	5,248.7	6,588.9	-1,340.2

[1]Quadrangles not listed did not have mapped SAV; [2]Includes continuous and patchy SAV

Overall, there were 1,371.3 fewer acres mapped in 2009 than in the 2002 survey. The between-survey difference in acreage was primarily due to substantially less SAV in the Delta and Mobile Bay in 2009. In 2009 there was less acreage compared to 2002 in the Hurricane (-515.4 ac), Mobile (-497.2 ac), The Basin (-265.2 ac), Bridgehead (-190.7 ac), and Hollinger's Island (-126.7 ac) quadrangles. Figure 3-1 shows a comparison of SAV coverage between 2009 and 2002 in the Mobile quadrangle.

The southern portion of the study area had more SAV acreage mapped in both 2009 (Table 3-1) and 2008 (Table 3-2) compared to 2002. There were 234.8 more acres of SAV mapped in 2009 overall compared to 2002 in the Mississippi Sound and Perdido Key areas. Areas with greater acreage in 2009 compared to 2002 included the Orange Beach (+90.8 ac) and Perdido Bay (+20.8 ac) quadrangles in southern Baldwin County, and the Grand Bay (+67.8 ac), Petit Bois Pass (+82.7 ac), Isle aux Herbes (+41.6 ac), and Ft Morgan NW (+25.2) quadrangles in southern Mobile County.

Changes since 2002 were even more pronounced for the 2008 mapping in the Grand Bay (+251.7 acres) and Isle aux Herbes (+268.1 acres) quadrangles. Grand Bay Quadrangle contained the greatest overall areal coverage in 2008, with 548.1 acres (Table 3-2), which was an increase of 251.7 acres compared to 2002.

Figure 3-1. SAV coverage (shaded yellow) in the Mobile Quadrangle comparing the 2009 and 2002 surveys.

The increase in acreage in the Isle aux Herbes Quadrangle for both 2008 and 2009 was due to SAV beds adjacent to Isle aux Herbes that were not present in 2002. Other locations with SAV in 2008 and 2009 that did not occur in 2002 include portions of Little Lagoon, Perdido Key, and Terry Cove in southern Baldwin County. Since 2002, shoal grass beds on the north side of Dauphin Island have expanded to the east and west.

There were 455.3 fewer acres mapped in 2009 compared to 2008 (Table 3-2). The difference between surveys was primarily due to less acreage of widgeon grass (*Ruppia maritima*) in Mississippi Sound in 2009, particularly in the Grand Bay and Isle aux Herbes Quadrangles. And example of the between-survey change is shown in Figure 3-2, which illustrates the species' distributions of SAV near Isle aux Herbes for the 2008 and 2009 surveys. Other between-survey changes included the occurrence of patchy shoal grass on the lee side of Sand Island in 2008 that was not present in 2009. Shoal grass beds in Little Lagoon and the Perdido Key area exhibited little change across surveys.

Table 3-2. Difference in total SAV acreage by U.S.G.S. 7.5-Minute Quadrangle, comparing 2009 with 2008.

USGS QUADRANGLE[1]	2009 ACREAGE[2]	2008 ACREAGE[2]	DIFFERENCE
Fort Morgan	0.0	6.8	- 6.8
Fort Morgan NW	25.2	31.4	- 6.2
Grand Bay	364.2	548.1	- 183.9
Grand Bay SW	61.8	86.8	- 25.0
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Pine Beach	1.2	1.2	--
TOTAL	1,230.4	1,685.7	- 455.3

[1]Quadrangles not listed did not have mapped SAV; [2]Includes continuous and patchy SAV

Twenty-one vascular plant species representing eleven taxonomic families were recorded during the 2009 field surveys (Table 3-3). Most of these species typically occur in the study area as submerged plants. Eight species not encountered in the 2002 baseline survey were documented in 2008 and 2009, including curly pondweed (*Potamogeton crispus*), Illinois pondweed (*Potamogeton illinoensis*), sago pondweed (*Stuckenia pectinata*), brittle waternymph (*Najas minor*), southern watergrass (*Luziola fluitans*), slim spikerush (*Eleocharis elongata*) and horned pondweed (*Zannichellia palustris*). Species encountered in 2002 but not 2009 included longleaf pondweed (*Potamogeton nodosus*) and exotic Brazilian waterweed (*Egeria densa*).

Most of the species identified were minor components of the SAV community in the Delta and were not included in the broad classification of species categories in the polygonal database. Of the newly documented species only sago pondweed occurred in significant densities and locations in 2009 to be mapped as a monospecific category.

Brittle waternymph and curly pondweed are non-native, introduced taxa. Brittle waternymph is native of Eurasia and northern Africa (Haynes, 2000). This species is commonly cited as occurring in the Chesapeake watershed. Brittle waternymph was infrequently encountered in mixed beds of SAV, though in one area south of the Highway 90 Causeway in Shellbank Creek had a large area mixed with southern naiad. Although the USDA distribution map (2009a) does not indicate brittle waternymph occurring in Baldwin County, it has been known to occur at least since the early 1990s (Horne, personal observation). Curly pondweed is native to Europe (Godfrey and Wooten, 1979).

Table 3-3. SAV species* identified during 2009 field surveys.

FAMILY	SPECIES	COMMON NAME
Cabombaceae		
	Cabomba caroliniana A. Gray	Carolina fanwort
Ceratophyllaceae		
	Ceratophyllum demersum L.	coon's tail
Cymodoceaceae		
	Halodule wrightii Asch.	shoal grass
Cyperaceae		
	Eleocharis elongata Chapm	slim spikerush
Haloragaceae		
	Myriophyllum heterophyllum Michx.	twoleaf watermilfoil
	Myriophyllum spicatum L.	Eurasian watermilfoil †
Hydrocharitaceae		
	Hydrilla verticillata (L.f.) Royle	hydrilla †
	Najas guadelupensis (Spreng.) Magnus	southern naiad
	Najas minor All.	brittle waternymph †
	Thalassia testudinum Banks & Sol. ex J. König	turtle grass
	Vallisneria neotropicalis Marie-Victorin.	wild celery
Lentibulariaceae		
	Utricularia foliosa L.	leafy bladderwort
	Utricularia gibba L.	humped bladderwort
Poaceae		
	Luziola fluitans (Michx.) Terrell & H. Rob	southern watergrass
Pontederiaceae		
	Heteranthera dubia (Jacq.) MacMill.	water stargrass
Potamogetonaceae		
	Potamogeton crispus L.	curly pondweed †
	Potamogeton illinoensis Morong	Illinois pondweed
	Potamogeton pusillus L.	small pondweed
	Stuckenia pectinata (L.) Böerner	sago pondweed
	Zannichellia palustris L.	horned pondweed
Ruppiaceae		
	Ruppia maritima L.	widgeon grass

*Taxonomy of families follows Angiosperm Phylogeny Group III (APG III) (2009); Common names follow USDA, NRCS (2009). † = non-native, invasive taxa

Figure 3-2. SAV coverage near Isle aux Herbes in Mississippi Sound comparing the 2008 and 2009 surveys.

Table 3-4 lists the acreage for each species category in the 2009 polygonal database. As in 2002, most 2009 habitats contained mixtures of species typically found in the northern portion of Mobile Bay and the Delta. The most extensive habitat (1005.9 ac) was a mixture of Eurasian watermilfoil, southern naiad, and wild celery. Eurasian watermilfoil, an invasive SAV, was also mapped in an additional 1,038.4 acres of mixed beds, and in pure (categorical) stands totaling 804.3 acres. Wild celery likely represents the most important freshwater SAV species from a wildlife standpoint in the Mobile Bay area, and was mapped in an additional 546.8 acres of mixed beds and in pure stands totaling 978.6 acres. Southern naiad was observed mostly in mixed beds. Other common species in the Delta included coon's tail and water stargrass.

Table 3-4. Total 2009 acreage by species (habitat) category[1].

SAV HABITAT CATEGORY	ACREAGE
Eurasian watermilfoil, southern naiad, wild celery	1005.9
Wild celery	978.6
Eurasian watermilfoil	804.3
Shoal grass	467.3
Shoal grass, widgeon grass	436.6
Eurasian watermilfoil, southern naiad	365.9
Widgeon grass	313.1
Eurasian watermilfoil, southern naiad, widgeon grass, wild celery	201.7
Eurasian watermilfoil, water stargrass	187.6
Eurasian watermilfoil, wild celery	155.8
Sago pondweed	78.7
Coon's tail, Eurasian watermilfoil, southern naiad, wild celery	76.9
Sago pondweed, wild celery	63.6
Coon's tail, Eurasian watermilfoil, water stargrass, wild celery	35.1
Eurasian watermilfoil, water stargrass, wild celery	13.7
Southern naiad	12.8
Brittle waternymph southern naiad	10.5
Coon's tail, small pondweed, southern naiad	3.3
Water stargrass	3.1
Eurasian watermilfoil, leafy bladderwort	1.7
Twoleaf watermilfoil	1.1
Turtle grass	0.04
TOTAL	**5,217.5**

[1]Multiple species indicates co-dominance

Table 3-5 lists the acreage for each species category in the 2008 polygonal database. The most extensive habitats were a mixture of shoal grass and widgeon grass (601.6 ac) and widgeon grass (599.1). These habitats occurred in Mississippi Sound. Most of the pure shoal grass beds (425.4 ac) occurred in the Perdido area of southern Baldwin County.

Table 3-5. Total 2008 acreage by species (habitat) category[1].

SAV HABITAT CATEGORY	ACREAGE
Shoal grass	485.0
Shoal grass, widgeon grass	601.6
Widgeon grass	599.1
Turtle grass	0.04
TOTAL	**1,685.7**

[1]Multiple species indicates co-dominance

4.0 DISCUSSION

Several areas of the Mobile-Tensaw Delta that had supported large SAV beds in 2002 were devoid of submerged vegetation in 2008 and 2009, in particular the northernmost part of the study area. The dynamics of SAV occurrence in the Delta are poorly known, and reasons for the recent decline of SAV in some locations are not clear.

Since 2002 there have been two major storm events in Hurricanes Ivan (2004) and Katrina (2005) that potentially may have influenced the distribution of SAV in the Delta. Hurricanes can adversely affect SAV through increased salinity, turbidity, scouring, and sedimentation associated with storm surges, and may have lingering effects on submerged vegetation (Edmiston et al., 2008). However, SAV community distribution and composition are highly variable across multiple temporal scales, and are greatly affected by both interannual and seasonal variability in physical parameters (salinity, light and nutrient availability), and short-term environmental change. Identification of the primary factors contributing to temporal variability in SAV abundance and diversity in a dynamic system like the Delta likely would require detailed, species-specific assessments over several years.

The species composition and distribution of SAV in northern Mississippi Sound is also different compared to the 2002 baseline survey. SAV mapped in the Sound in 2002 was entirely shoal grass. During the 2008 and 2009 study, widgeon grass, shoal grass, and mixed beds of widgeon grass and shoal grass occurred in the Grand Bay, Isle aux Herbes, and Kreole quadrangles. SAV composition has changed through time in the northern Sound, likely due to exposure to wave-generated turbulence and scour, and freshwater outflow from the Mobile Bay watershed. Crance (1971) reported shoal grass in Portersville Bay, but by 1980 the northern Sound supported only widgeon grass (Stout and Lelong, 1981). SAV in this portion of the study area likely remains in some degree of flux due to highly variable physical environmental conditions, unlike the relatively sheltered locations containing SAV in southeastern Baldwin County.

Widgeon grass beds that in 2008 occurred in Mobile Bay and in portions of northern Mississippi Sound did not re-emerge in 2009. Spring shoot growth of widgeon grass from seeds, roots, and rhizomes is rapid (Cho and Poirrier. 2005); however, during early spring growth of canopy-forming SAV such as widgeon grass, insufficient light availability may be a critical constraint on initial growth (Chesapeake Bay Program, 2000). The early spring of 2009 was characterized by persistent strong southerly winds, and elevated turbidity was present for much of the first half of the year in open waters of Mobile Bay and Mississippi Sound, potentially limiting vegetative growth of widgeon grass in those areas.

As in 2002, SAV mapped in southeastern Baldwin County was predominantly shoal grass. Shoal grass has expanded into areas that were non-vegetated in 2002, including southern Little Lagoon, Terry Cove, and a large shoal in the middle of Bayou St. John (see Figure 2-1). According to McGovern and Blankenhorn (2007), seed production of shoal grass in the study area appears to be uncommon, with most vegetative expansion due to asexual growth. However, the population examined in their study occurred in Mississippi Sound. The Bayou St. John shoal currently supports patchy, circular beds characteristic of growth initiated after settlement of numerous propagules, suggesting recent large-scale seed production, presumably at a local source.

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