Mobile Bay

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Background

Mobile Bay is the largest bay found in Alabama's coastal area (Handley et al., 2007). It was named an Estuary of National Significance in 1995 under the U.S. Environmental Protection Agency's (EPA) National Estuary Program (NEP), and its Comprehensive Conservation Management Plan was completed in 2002. Mobile Bay is 1,070 km^2 (413 $miles^2$) in area and 51 km (32 miles) long, making it the sixth largest estuary in the continental United States (Mobile Bay NEP, 2008). Its ecosystem provides habitat for more than 300 species of birds, 310 species of fish, 68 species of reptiles, 57 species of mammals, 40 species of amphibians, and 15 species of shrimp (Mobile Bay NEP, 1997). Mobile Bay lies between the Mississippi and Atlantic Flyways (Mobile Bay NEP, 2003). Commercial and residential development and industrial use is heavy in the Mobile Bay area. Although local growth and industrial markets support the Mobile Bay area economy, the resulting environmental damage to the very ecosystem upon which they depend remains a threat to the environment, economy, and population.

The Mobile Bay ecosystem boasts high biological diversity and productivity and supports many freshwater and saltwater species of recreational and commercial importance. The great diversity of Mobile Bay reflects the diversity of Alabama, which is home to the largest number of different plant and animal species of all states east of the Mississippi River (Stein, 2002), and is bolstered by the unique climate and geographic

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conditions surrounding the bay. Freshwater inflow from the Mobile-Tensaw River Delta, ranging from 60,000 to 3,700,000 gallons per second (Wallace, 1996), mixes with saltwater from the Gulf of Mexico, which enters Mobile Bay via wind and tides (Burgan and Engle, 2006). Because of the unique conditions surrounding Mobile Bay, including shallow waters, a dynamic climate, and artificial hydrologic modifications—such as the construction of the Mobile Bay Causeway in the 1920s, which serves as an unintentional barrier between Delta waters north of the Causeway and saline waters south of the Causeway, the salinity of Mobile Bay is highly variable. Mobile Bay receives an average of 165 cm (65 inches) of rain per year from tropical storms, summer thunderstorms, and winter cold fronts (Stout et al., 1998).

The climate and geography that have made Mobile Bay so rich in resources have also contributed to the threats surrounding its ecosystem. The extensive amount of rain in Mobile Bay creates large amounts of runoff, polluting the waters with fertilizers, chemicals, sediment, oil, trash, and sewage (Mobile Bay NEP, 1997). Tourism, ecotourism, recreational and commercial fishing, recreational boating, shipping, and chemical, pulp, and paper production are significant industries in Mobile Bay and the surrounding areas. Despite the approximate $3 billion and 55,000 jobs these industries bring into the community (Alabama Tourism Department, 2010), the growth, development, and environmental stress they create are major threats to the Mobile Bay ecosystem.

Among the nation's states, Alabama ranks fifth in number of different species (144 endemic species), second in number of extinctions that have already occurred (90 extinct species) and fourth in number of species at risk for extinction (14.8% at risk out

of 4,533 total species; Stein, 2002). Twenty-one of these threatened and endangered species are found in Mobile Bay, whose brackish waters provide a nursery area for many species of vertebrates and invertebrates. Some of these species include the Alabama sturgeon, Gulf sturgeon, heavy pigtoe mussel, inflated heel-splitter mussel, West Indian manatee, Alabama beach mouse, Perdido beach mouse, Alabama red-bellied turtle, gopher tortoise, Kemp's ridley sea turtle, green sea turtle, loggerhead sea turtle, eastern indigo snake, flatwoods salamander, piping plover, red-cockaded woodpecker, and wood stork. Habitat loss underlies the decline of some bird species in Mobile Bay, and large mammals such as the red wolf, Florida panther, and Florida black bear are no longer found in the area. However, some rare species, such as the swallow-tailed kite, sandhill crane, and gopher tortoise can still be found (Duke and Kruczynski, 1992).The value of wetlands in Mobile Bay and the rest of the Gulf of Mexico is still being investigated. Although various monetary valuations of wetlands exist, critics remark that undervaluation of wetlands is inevitable (Mobile Bay NEP, 2008) and that estimates often do not place appropriate value on ecological services (Mitsch and Gosselink, 2000). Additionally, many estimates account only for anthropogenic values. One estimate concludes that one acre of wetlands performs $3,000 worth of water purification each year (Mobile Bay NEP, 1997). With more than 76,890 hectares (190,000 acres) of wetlands in the Mobile Bay area, that equates to a value exceeding one-half billion dollars every year. Tourism, fishing, boating, production, and shipping are significant industries in the Mobile Bay area. More than 90% of fish landed in recreational and commercial fishing in the bay depend on bay habitat, including wetlands, for life requirements (Mobile Bay NEP, 1997). The Port of Mobile is Alabama's only ocean-ship

port (Mobile Bay NEP, 2008). Baldwin County, on the eastern side of the bay, experienced a population increase of 75% from 1990 to 2007, with an 89% increase in housing units (Mobile Bay NEP, 2008). Development and industry support the Mobile Bay economy, but they depend on the continued health, sustainability, and production of the water and living resources of the Mobile Bay ecosystem. Wetland loss, along with other forms of environmental degradation, remains a threat to the Mobile Bay ecosystem and Mobile Bay's socioeconomic foundation.

Scope of Area

Mobile Bay is where the freshwater Mobile-Tensaw River Delta mixes with salt water from the Gulf of Mexico. The Bay lies between the two coastal Counties of Alabama – Mobile and Baldwin. The city of Mobile is found along the northwestern shore of Mobile Bay. Mobile Bay is 37 km (23 miles) wide at its maximum width, near the opening to the Gulf of Mexico, and 16 km (10 miles) wide at the city of Mobile (Mobile Bay NEP, 2003; Mobile Bay NEP, 2008). The Main Pass is the primary opening into the Gulf of Mexico (Burgan and Engle, 2006). The Main Pass lies between Dauphin Island and the Fort Morgan Peninsula. Mobile Bay is remarkably shallow, with an average depth of approximately 3 m (10 ft), yet it discharges approximately 1,756 m^3 (62,000 ft^3) of water every second (Mobile Bay NEP, 2008). The Mobile Bay watershed is the sixth largest watershed in the continental U. S., draining a total land area of approximately 111,370 km^2 (43,000 $miles^2$) across Alabama and portions of Mississippi, Georgia, and Tennessee (Figure 1; Handley et al., 2007). There are several sub-watersheds around Mobile Bay, including the Magnolia River, Fish River, Three Mile Creek, Dog River, Fowl River, and the Lower Tensaw River (Mobile Bay NEP, 2008).

Together, Mobile Bay and the Mobile-Tensaw River Delta contain 115,335 hectares (285,000 acres) of open water (Mobile Bay NEP, 2003).

Methodology Employed to Determine and Document Current Status

Black and white and natural color aerial photography was acquired, ranging in scale from 1:20,000 to 1:65,000. The 1950s data were derived from 1:20,000 scale, black and white aerial photography (National Wetlands Research Center, 2007). The 1979 and 1988 data were derived from NASA 1:65,000 scale, color infrared aerial photography. The 2001 Baldwin County data were derived from 1:36,000 scale, color infrared aerial photography. The 2002 Mobile County data were derived from USGS NAPP 1:40,000 scale, color infrared aerial photography. The mapping protocol consisted of stereoscopic photointerpretation, cartographic transfer, and digitization in accordance with strict mapping standards and conventions. Other important aspects of the protocol included the use of the Cowardin Classification System (Cowardin et al., 1979), ground truthing, quality control, and peer review. Land, water, and all wetland habitats were delineated on the maps. The information derived from the photography was subsequently transferred using a zoom transfer scope onto a stable medium overlaying U.S. Geological Survey (USGS) 7.5-minute,1:24,000-scale quadrangle basemaps. The ground truthing phase included the participation of field staff from the USGS National Wetlands Research Center. Draft maps were sent to USGS staff for review and comments. All comments received were incorporated into the final maps that were subsequently prepared and delivered.

Methodology Employed to Analyze Historical Trends

Historical emergent wetland trends were analyzed by comparing changes in total areal coverage of emergent wetland habitat along a time sequence. Comparisons were made among data sums of emergent wetland coverage for the mid-1950s, 1979, 1988, and 2001/2002. Maps of emergent wetland distribution for these years were studied to determine the location of major changes of coverage.

Status and Trends

Emergent wetland monitoring during 1955, 1979, 1988, and 2001/2002 (Figures 2-5) confirm the loss and decline of emergent wetland habitat in Mobile Bay (Table 1). Mobile Bay lost 3,318 hectares (8,198 acres), or 17.2%, of its emergent wetlands between 1955 and 1979; an additional 4,631 hectares (11,444 acres), or 24.0%, of its emergent wetlands between 1979 and 1988; and an additional 1,963 hectares (4,850 acres), or 10.2%, of its emergent wetlands between 1988 and 2001/2002. During the complete 47-yr time period this study encompasses, Mobile Bay lost 9,912 hectares (24,492 acres), or 51.3%, of emergent wetland habitat.

Table 1. Emergent wetland acreage in Mobile Bay for 1955, 1979, 1988, and 2001/2002.

Emergent Wetland Type	**1955**		**1979**		**1988**		**2001/2002**		**Total Change 1955-2001/2002**	
	Hectares	Acres	Hectares	Acres	Hectares	Acres	Hectares	Acres	Hectares	Acres
Estuarine	11,829	29,231	9,596	23,712	8,991	22,218	8,191	20,241	-3,638	-8,990
Palustrine	7,501	18,537	6,417	15,857	2,391	5,907	1,228	3,034	-6,274	-15,502
Total	19,331	47,767	16,013	39,570	11,382	28,125	9,419	23,275	-9,912	-24,492

Between 1955 and 1979, Mobile Bay lost 2,233 hectares (5,519 acres), or 18.9%, of salt marsh. A loss of 605 hectares (1,494 acres), or 5.1%, of salt marsh occurred

between 1979 and 1988, and another 800 hectares (1,977 acres), or 6.8%, of salt marsh were lost between 1988 and 2001/2002. A total of 3,638 hectares (8,990 acres), or 30.8%, of salt marsh was lost during the entire 47-yr study period.

Mobile Bay lost 1,084 hectares (2,679 acres), or 14.5%, of coastal fresh marsh between 1955 and 1979. A loss of 4,027 hectares (9,950 acres), or 53.7%, of fresh marsh occurred between 1979 and 1988. Another 1,163 hectares (2,873 acres), or 15.5%, of fresh marsh were lost between 1988 and 2001/2002. A total of 6,274 hectares (15,502 acres), or 83.6%, of coastal fresh marsh was lost in Mobile Bay throughout the entire 47-yr study period.

Causes of Change

Mobile Bay lost over 4,049 hectares (10,000 acres) of emergent wetlands between the 1940's and 1979 (Duke and Kruczynski, 1992). Urban and silvicultural developments were the primary cause of palustrine wetland loss between 1955 and 1979 (Roach et al., 1987). Natural succession; industrial, navigational, and urban development; and erosion were the primary causes of estuarine wetland loss. The hydrology of Mobile Bay has been affected by the deep, man-made shipping channel—first dredged in 1830, and 45 ft deep and 400 ft wide today—along with many dredge disposal areas (Duke and Kruczynski, 1992; Mobile Bay NEP, 2003). Different studies have concluded dredging has had the biggest impact on wetland loss in Mobile Bay, with 2,428 hectares (6,000 acres) of marsh destroyed and 890 hectares (2,200 acres) of marsh created (Duke and Kruczynski, 1992). Sea-level rise and erosion caused by waves, tides, and currents are expected to continue to contribute to more wetland habitat loss. Some shoreline recession has already occurred in Mobile Bay (Mobile Bay NEP, 2008).

Other factors affecting the general health of the Bay are outlined in the State of the Bay Report (Mobile Bay NEP, 2008), periodically published by the Mobile Bay National Estuary Program (MBNEP). The State of the Bay Report includes useful information about Mobile Bay, current issues and threats, and suggested courses of action to continually improve the health of the Bay ecosystem. Although many of these threats encompass a broad range of categories, they all affect or are affected by wetland health and existence. Addressing all of these problems will improve the ecological health of Mobile Bay, including the status of its emergent wetlands.

Threats to Mobile Bay related to human use include population growth, changing and conflicting land and water use, recreational access restriction, public health concerns, fishing interest, increasing tourism, and commercial and industrial development. Threats to habitat include overdevelopment and wetland loss, which create concerns for bird habitats, bank buffers, sea grass beds, marshes, and other wetlands. The Mobile Bay estuary provides stopover and "first landfall" habitat and renourishment opportunities during migration, as well as critical habitat for colonial nesting birds (Mobile Bay NEP, 2003). The presence of wading birds is an indicator of wetland habitat quality, because they require extensive salt and fresh water habitat. Loss of avian nesting habitat to increasing development is a problem in the estuary.

Threats affecting living resources in Mobile Bay include heavy fishing pressure, threats to endangered species, ignorance about factors impacting living resources, a general lack of available data and information coordination, and lack of monitoring to determine abundance, status, and trends. The Alabama-Mississippi Rapid Assessment Team conducted rapid assessment surveys of living resources in Mobile Bay in 2003 and

discovered many non-native species, including ones not previously observed in Alabama (Burgan and Engle, 2006). Estimates indicate that 10-20% of Alabama's species are threatened by exotic species (Mobile Bay NEP, 2008). More than 80 of these exotic, invasive species are found in waterways and on the coast of Alabama. Invasive aquatic weeds such as hydrilla (*Hydrilla verticillata*), water hyacinth (*Eichhornia crassipes*), Eurasian milfoil (*Myriophyllum spicatum*), and water lettuce (*Pistia straiotes*) have choked waterways, reduced recreational value, and affected nutrient cycles and other species' populations in the bay.

Water quality is degraded by toxins such as heavy metals, pesticides, and chemicals; pathogens such as bacteria like *E. coli*; erosion and sedimentation, caused by development, agriculture, and other factors; nutrient and organic material over-enrichment; and the modification of wetlands and waterways. The first paper mill in the Bay area began production in 1856 and commenced point source pollution of the Bay (Mobile Bay NEP, 2003). Sewage and pathogen loads became a significant problem around 1940, and depleted oxygen levels probably caused high fish kills in the 1970s (depleted oxygen levels also cause the famous "jubilee" events, where large numbers of fish are forced toward the shore) (Mobile Bay NEP, 2003). With regulation of point source pollution today through the Clean Water Act, nonpoint source pollution has become the biggest problem. The National Coastal Assessment rated Mobile Bay with an overall condition of "fair," based on 2000/2001 data, with a "good" score for the Fish Tissue Contaminants Index, "fair" scores for the Water Quality Index and Sediment Quality Index, and a "poor" score for the Benthic Index (Burgan and Engle, 2006). However, the 2004 National Sediment Quality Survey found that Mobile Bay had "areas

of probable concern" caused by the presence of mercury and hydrocarbons such as fuels, solvents, and pesticides (Mobile Bay NEP, 2008). Mobile Bay's natural, heavy rainfall increases mercury deposition into the Bay from the increased runoff that it creates. Atmospheric deposition does not require runoff to deliver mercury to the Bay.

Mapping and Monitoring Needs

In 2009, in support of Section 309 of the Coastal Zone Management Act of 1972, the Geological Survey of Alabama began an in-depth investigation to map detailed shoreline protection, generalized shoreline type, and boat ramps, and further, quantify short-term erosion within Mobile Bay. Currently, no inventory of geographic information system (GIS) thematic layers representing shoreline protection, shoreline type, and comprehensive compilation of public and private boat ramps for coastal Alabama exists. This project was warranted, in part, due to the inherent relationship between the type and geospatial position of shoreline protection and the proximity of shoreline and marsh habitat loss in relation to the protection.

According to Jones and others (2009), approximately 220 km (136.7 miles) were mapped in Mobile Bay for shore protection (from Cedar Point in Mobile County to the western terminus of the Fort Morgan Peninsula, excluding tributaries and areas north of U.S. I-10). Baldwin County has the longer portion of Mobile Bay shoreline with approximately 139 km (86.6 miles) compared to Mobile County with approximately 81 km (50.1 miles). "Natural, unretained" defines most of the shoreline with a total of approximately 134 km (83.4 miles) or 61.0 percent. The main engineered shore protection in Mobile Bay is from bulkheads, totaling 58 km (36.1 miles) or 26.4 percent of the total engineered shore protection. The second longest shore protection in Mobile

Bay is rubble/riprap totaling 17 km (10.7 miles) or 7.8 percent of the total engineered shore protection. An estimated 84 km (52.5 miles) or 38.4 percent of Mobile Bay shoreline is protected by hard armoring. Mobile Bay had 215 km (133.5 miles) of mapped shoreline type classified into three major types: vegetated with 91 km (56.8 miles) or 42.6 percent, organic having 81 km (50.2 miles) or 37.6 percent, and sediment having 28 km (17.2 miles) or 12.9 percent of the total. Organic includes marsh, fringe, and forested.

In order to further our understanding of the relationship between shoreline protection and erosion, it would be appropriate to incorporate and maintain the GIS data developed above in a comprehensive geodatabase supported by emergent wetland delineations, installation of living shorelines, dredging, wetland restoration areas, and indications of shorelines-receding-or-accreting trend.

It is likely that essential geology and hydrodynamics background information is not well documented and characterized before emergent restoration projects are planned and designed. Types of supplemental data should include, but not be limited to, an investigation of historical shoreline change trends, potential causes and effects, the characterization of substrate and geomorphology, effects of currents and tides on the water-bottoms and adjoining shorelines, and pre-existing assessment and future monitoring of the horizontal and vertical position (geospatially) of shoreline, bottom and surface topography, marsh edge, etc.

Results from Digital Shoreline Analysis System (DSAS; Figure 6) show a clear erosional trend in Mobile Bay from 1996 to 2008 (Jones and others, 2009). Of the 2,268 transects that showed good regression values (R2 >=0.75) and a low Standard Error of

the Estimate (LSE) (5.0 or less), 92.7 percent indicated shoreline erosion. Limited amounts of accretion were measured in northern areas of the bay and along the tip of Fort Morgan Peninsula. Western Mobile Bay exhibited high erosional trends in the vicinity of Deer River and Point Judith (Figure 6). A mean shoreline change rate of -2.5 ± 1.4 m per year (-8.2 ± 4.5 ft per year) is indicated near the mouth of Deer River. Moderate erosion is indicated at other locations along western Mobile Bay, such as Point Judith, Alabama Port, Delchamps Bayou, and Brookley. Significant erosion was quantified in Mobile Bay on Fort Morgan Peninsula in the vicinity of St. Andrews Bay, Little Point Clear, and Three Rivers. Near St. Andrews Bay, rates of shoreline erosion range from -1.5 ± 0.4 m (-5.0 ± 1.3 ft) to -8.9 ± 1.4 m (-29.3 ± 4.5 ft) on the western approach, and -0.7 ± 2.6 m (-2.4 ± 8.6 ft) and -2.0 ± 1.8 m (-6.6 ± 6.0 ft) on the eastern approach. The stretch of shoreline extending from Little Point Clear to Edith Hammock displayed similar trends, with a mean shoreline change rate of -1.6 ± 0.7 m per year (-5.4 ± 2.3 ft per year). The predominance of naturally vegetated shoreline in this region is a contributing factor to this erosional trend. Eastern Mobile Bay exhibited slight erosional trends south of Ragged Point, with a mean shoreline change rate of -0.9 ± 0.6 m per year (-2.9 ± 2.0 ft per year). Locations along Bon Secour Bay showed similar trends. From Fish River Point to Seymour Bluff a mean shoreline change rate of -1.2 ± 0.8 m per year (-3.9 ± 2.7 ft per year) is indicated.

Restoration and Enhancement Opportunities

Established monitoring programs for emergent wetlands in coastal Alabama include the Alabama Department of Conservation and Natural Resources – Dauphin Island Sea Lab Emergency Disaster Relief Program Partnership and the Weeks Bay

National Estuarine Research Reserve. A review of the Mobile Bay National Estuary Program's Mississippi-Alabama Habitats Tool (http://habitats.disl.org/), National Estuaries Restoration Inventory (https://neri.noaa.gov/neri/), and Gulf of Mexico Foundation (http://www.gulfmex.org/conservation-restoration/gulf-conservation-restoration-and-preservation/) databases show that, with respect to previous emergent vegetation restoration or conservation, restoration projects have mainly been a function of land acquisitions for conservation and protection via the effects of hard shoreline armoring and the removal of invasive species. A very limited amount of emergent vegetation restoration projects have been undertaken.

The Mobile Bay National Estuary Program's Mississippi-Alabama Habitats Tool contained the most comprehensive list of emergent marsh restoration efforts. Within Mobile Bay, the Dauphin Island Causeway Aquatic Ecosystem Restoration project of 2004 resulted in the planting of about 1.6 hectares (4 acres) of wetland habitat along over 1,069 m (3,500 ft) of shoreline. Approximately 1.4 hectares (3.5 acres) of Helen Wood Park, Mobile County, was improved between 2007 and 2009 by removal of invasive phragmites and Chinese Tallow, excavation to enhance flooding, and native estuarine vegetation plantings.

The Nature Conservancy is working on the project "100-1000: Restore Coastal Alabama Partnership" to plant approximately 405 hectares (1,000 acres) of marsh. Both projects utilize breakwaters, where the latter includes the installation of about 161 km (100 miles) of oyster shell breakwaters in various locations along the Alabama coast.

During the development of the Choctaw Point Terminals in north Mobile Bay, the Alabama State Port Authority completed a mitigation project that converted

approximately 23 hectares (56 acres) of uplands into tidal fringe marsh at Arlington Cove, North Garrows Bend, and South McDuffie Island (Harris, 2009).

Although others exist, opportunities tend to be associated with funding sources such as the Coastal Impact Assistance Program, the Forever Wild Program, and Emergency Disaster Relief Programs. Possibly the greatest emergent wetland restoration areas of opportunity exist within Mississippi Sound, where much marsh habitat has been lost to erosion, as well as north Mobile Bay.

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Figure 1. Watershed for Mobile Bay.

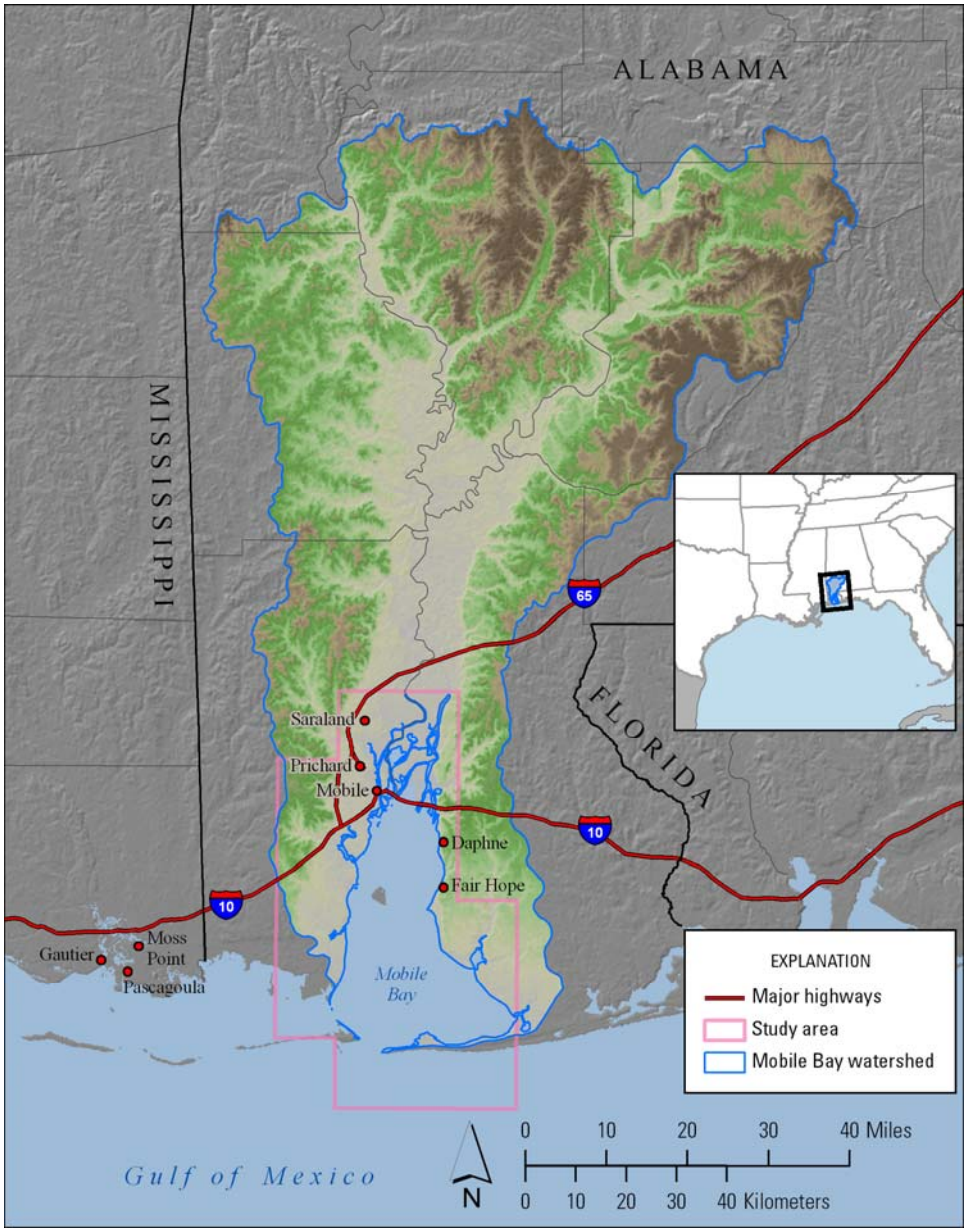

Figure 2. Distribution of emergent wetlands in Mobile Bay, 1955.

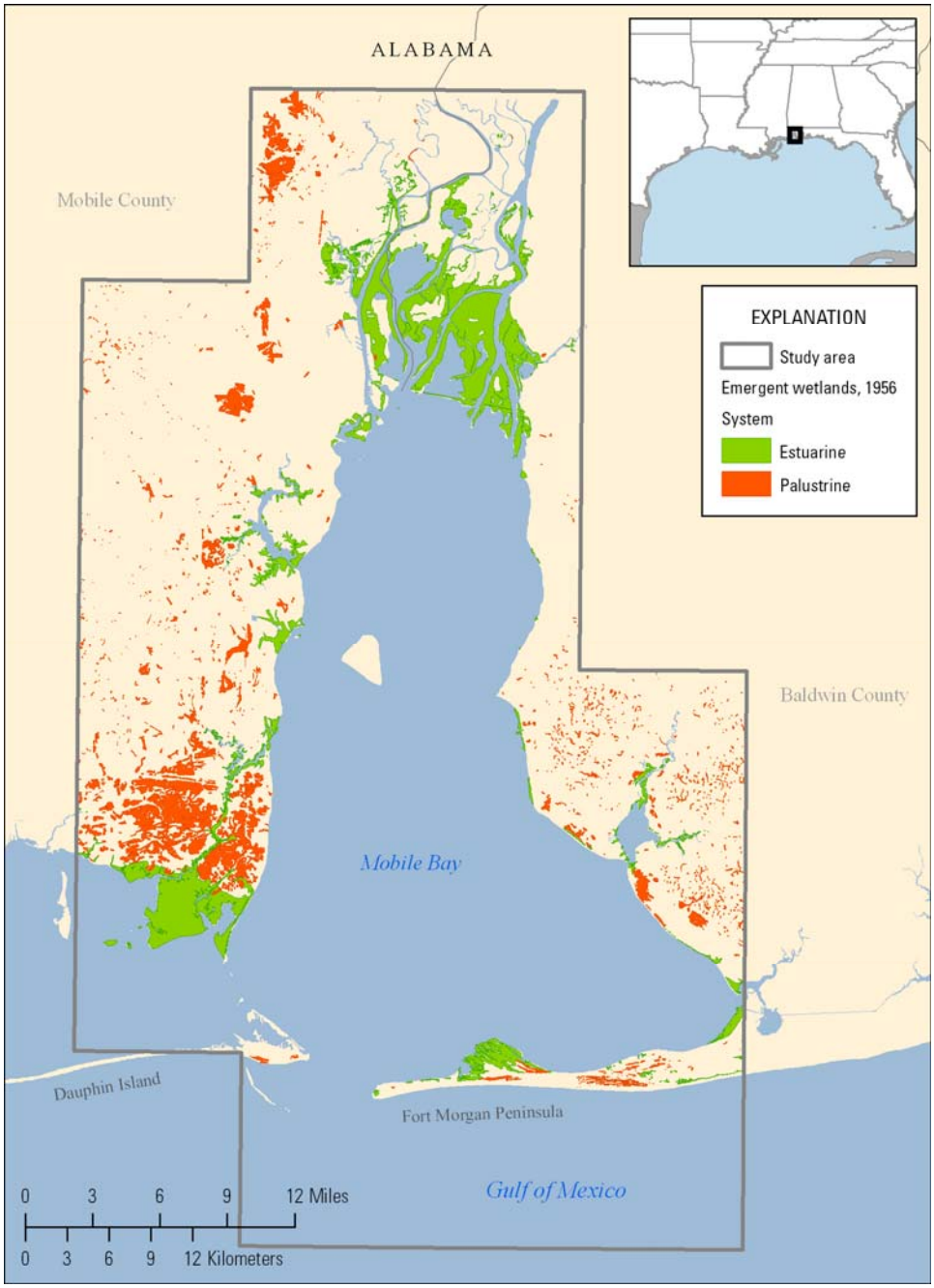

Figure 3. Distribution of emergent wetlands in Mobile Bay, 1979.

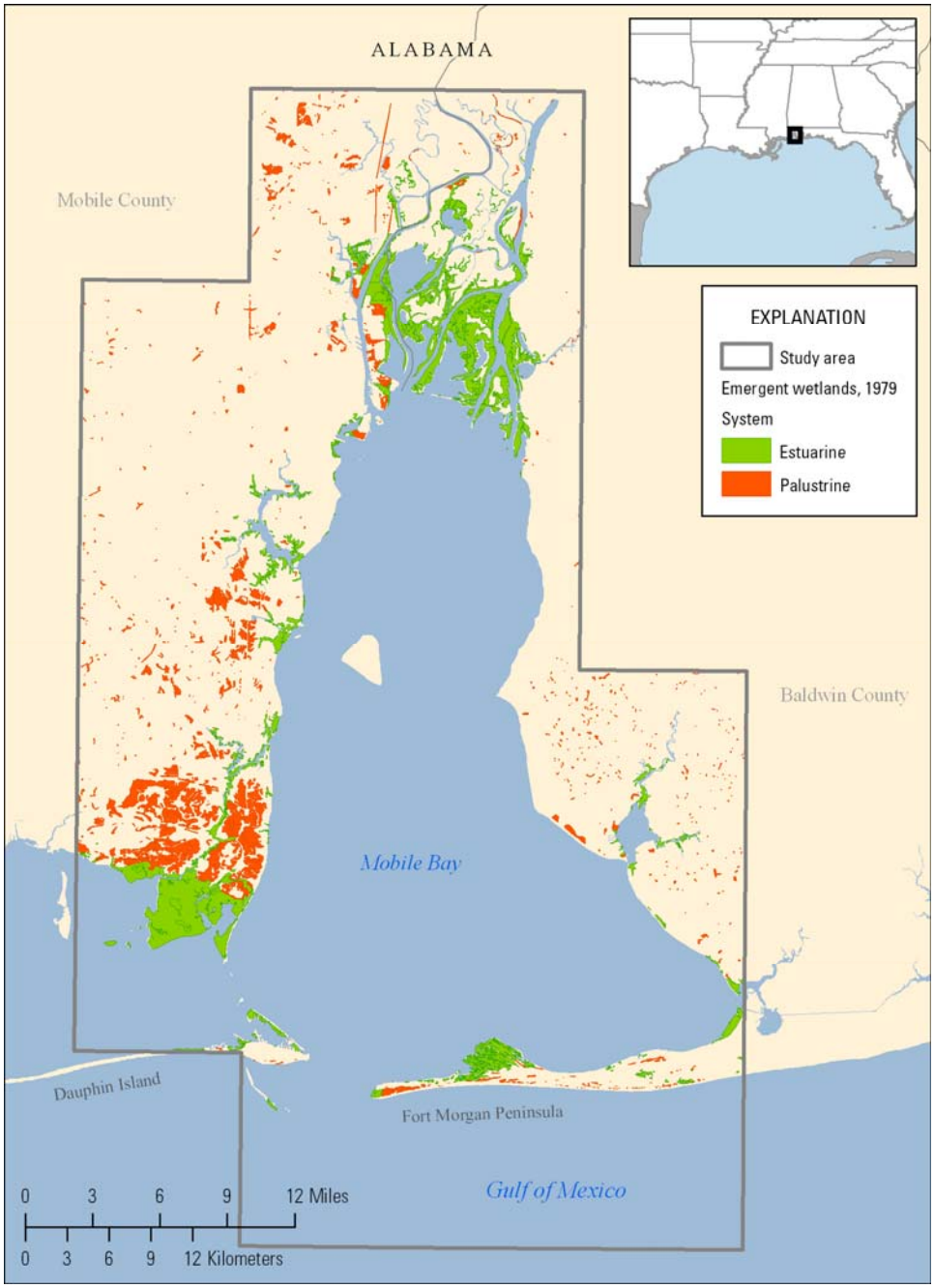

Figure 4. Distribution of emergent wetlands in Mobile Bay, 1988.

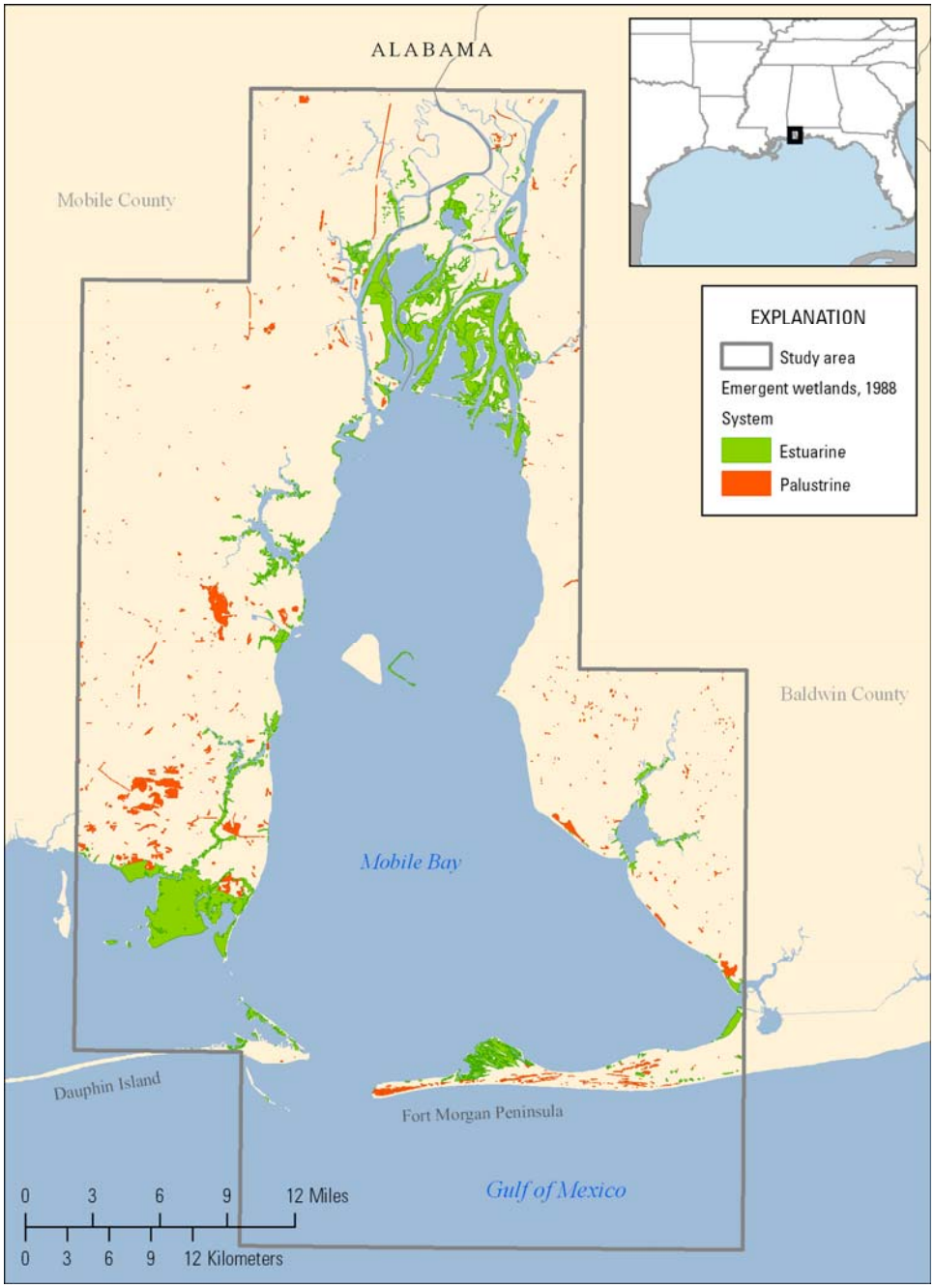

Figure 5. Distribution of emergent wetlands in Mobile Bay, 2001/2002.

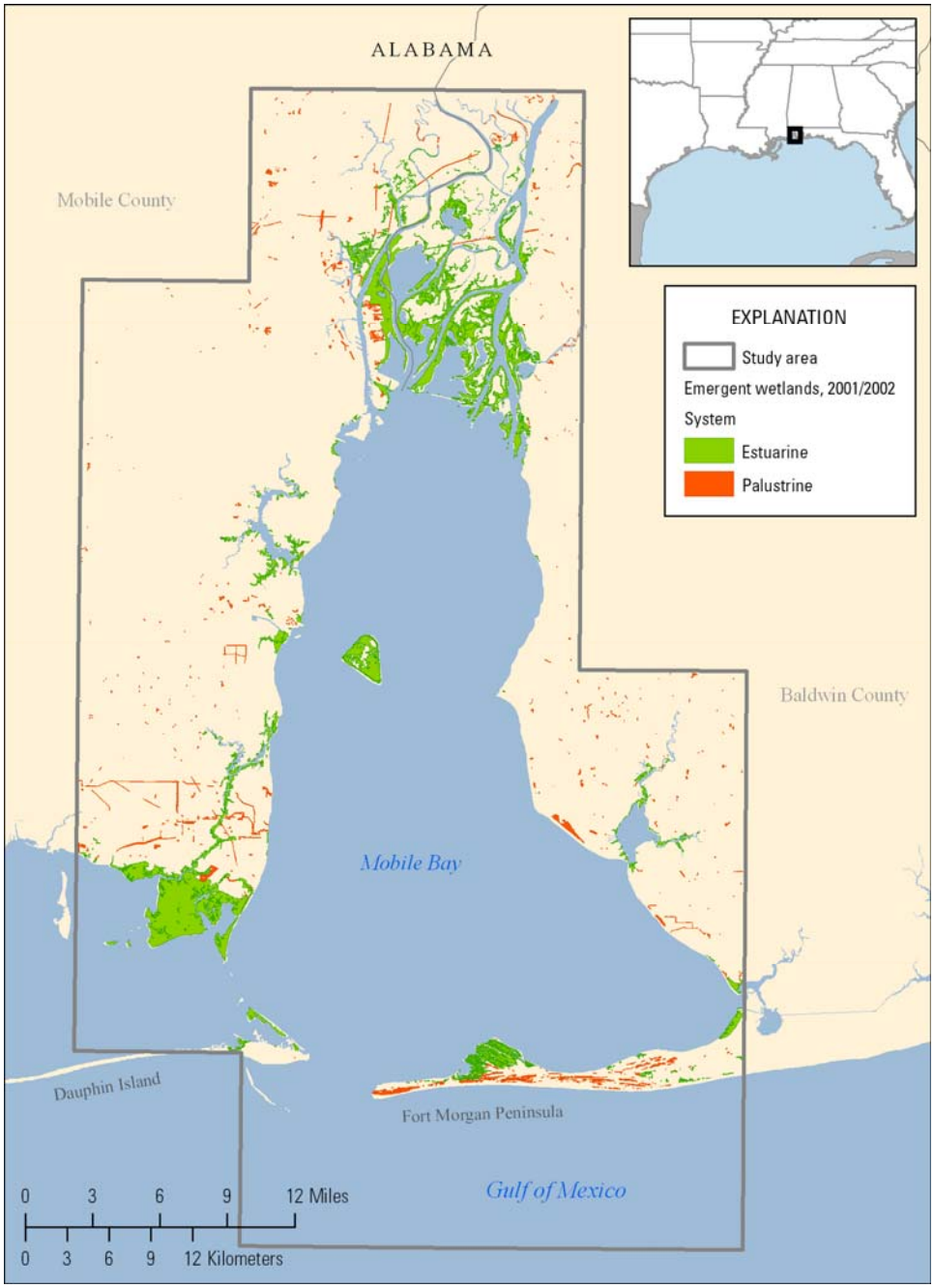
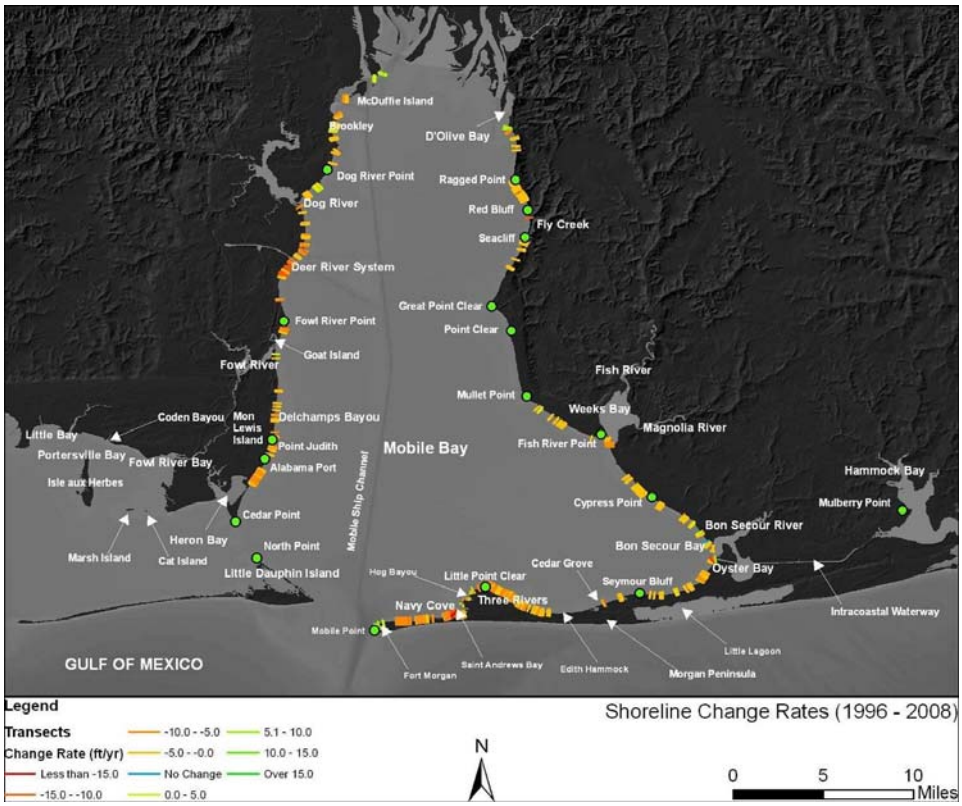
Figure 6. Results from Digital Shoreline Analysis System (1996 through 2008; Jones and others, 2009).