Mississippi Sound and the Gulf Islands

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Background

Seagrasses in Mississippi Sound were likely first documented by H.J. Humm (1956), though there are earlier descriptions of marine angiosperms associated with the barrier islands of Louisiana and Mississippi (Loyd and Tracy, 1901). Prior to Humm's work, it was believed that seagrasses, with the exception of wigeon grass (*Ruppia maritima*), occurred only very rarely between Bay County, Fla., and Aransas County, Tex. (Thorne, 1954). Humm (1956) described extensive beds of seagrasses along the northern margins of Mississippi's barrier islands, dominated by turtle grass (*Thalassia testudinum*), and indicated that turtle grass was the dominant seagrass in Mississippi Sound. He also documented the presence of manatee grass (*Syringodium filiforme*), shoal grass (*Halodule wrightii*), and star grass (*Halophila engelmannii*), in addition to the presence of previously reported beds of wigeon grass.

The location of most of Mississippi's seagrasses along the north shorelines of the State's barrier islands may be a key factor in the recruitment and survival of commercially harvested penaeid shrimp and blue crabs (*Callinectes sapidus*) and of many noncommercial species of shellfish and finfish. Seagrasses are often the closest structures to the tidal passes between the barrier islands. Studies of local food webs indicate that seagrass epiphytes are critical components of the base of the food web in the vicinity of the barrier islands (Moncreiff and Sullivan, 2001). Sampling within the seagrasses indicates that popular game fish species, such as "speckled trout" (spotted seatrout, *Cynoscion nebulosus*) and small sharks, also rely on this habitat for shelter and food.

Seagrasses were first mapped throughout the Mississippi Sound as a component of the Cooperative Gulf of Mexico Estuarine Inventory and Study, Mississippi, by L.N. Eleuterius between 1967 and 1969 (Christmas, 1973). All five previously mentioned seagrass species were again present and relatively abundant, though the beds of turtle grass described by Humm (1956) at Ship Island had disappeared as of March 1969 (Eleuterius, 1973); this period may have been the beginning of seagrass loss in Mississippi Sound. Stressors that might have caused seagrasses to become diminished or to disappear from Mississippi coastal regions likely resulted from the cumulative effects of human activities in the coastal marine environment. These activities include historical commercial uses and present-day recreational uses of seagrass habitat in addition to a number of other factors which may directly or indirectly impact seagrasses. Development may be a major factor, as it often results in higher sediment loads, introductions of contaminants, and elevated nutrient levels, which all can contribute to a loss of water quality, thus affecting seagrass communities (see watershed of area in fig. 1).

Land use and land-use changes in the eight watersheds feeding into the Mississippi Sound which may have an effect on seagrass resources include (1) a shift from the historical focus on agriculture and forestry for the paper and lumber industries to urban development related to the casino industry and (2) a shift in the State's focus to port development, plastics, and chemicals as regional industries. Land use in the region consists of silviculture and agriculture (horticultural crops and row crops) and urban development (residential and commercial) associated with a total of 11 water-based casino complexes located in Harrison and Hancock Counties. Industrial development includes commercial shipping, shipbuilding, phosphate rock refinement for phosphate fertilizer, and three electric power generating complexes; these industries are primarily located in Harrison and Jackson Counties. As of 2001, the three coastal Mississippi counties that make up most of the northern border of the sound had a total population of 366,263 within a land area of 462,315 ha (1,142,365 acres); this density constituted 12.8% of the State's population at 0.79 persons per ha (0.32 persons per acre), over three times the population density for the entire State. In addition, the region has experienced a 21.8% increase in population over the past decade, which is over twice that observed for the entire State (U.S. Census Bureau, 2002).

Weather patterns in the northern Gulf of Mexico may contribute to local patterns in the distribution of seagrasses. Mean annual precipitation is 154 cm (61 inches), resulting from an average of 75.7 days with thunderstorms (Office of Nuclear Waste Isolation, 1983); runoff associated with this rainfall contributes to the relatively high turbidity observed in coastal Mississippi waters. Hydrological changes over time within Mississippi Sound that may have a potential effect on seagrass resources involve the maintenance of two channels for port access, the Pascagoula and Gulfport ship channels, both of which have been deepened for access. The former disrupts longshore sediment transport, and the latter acts as

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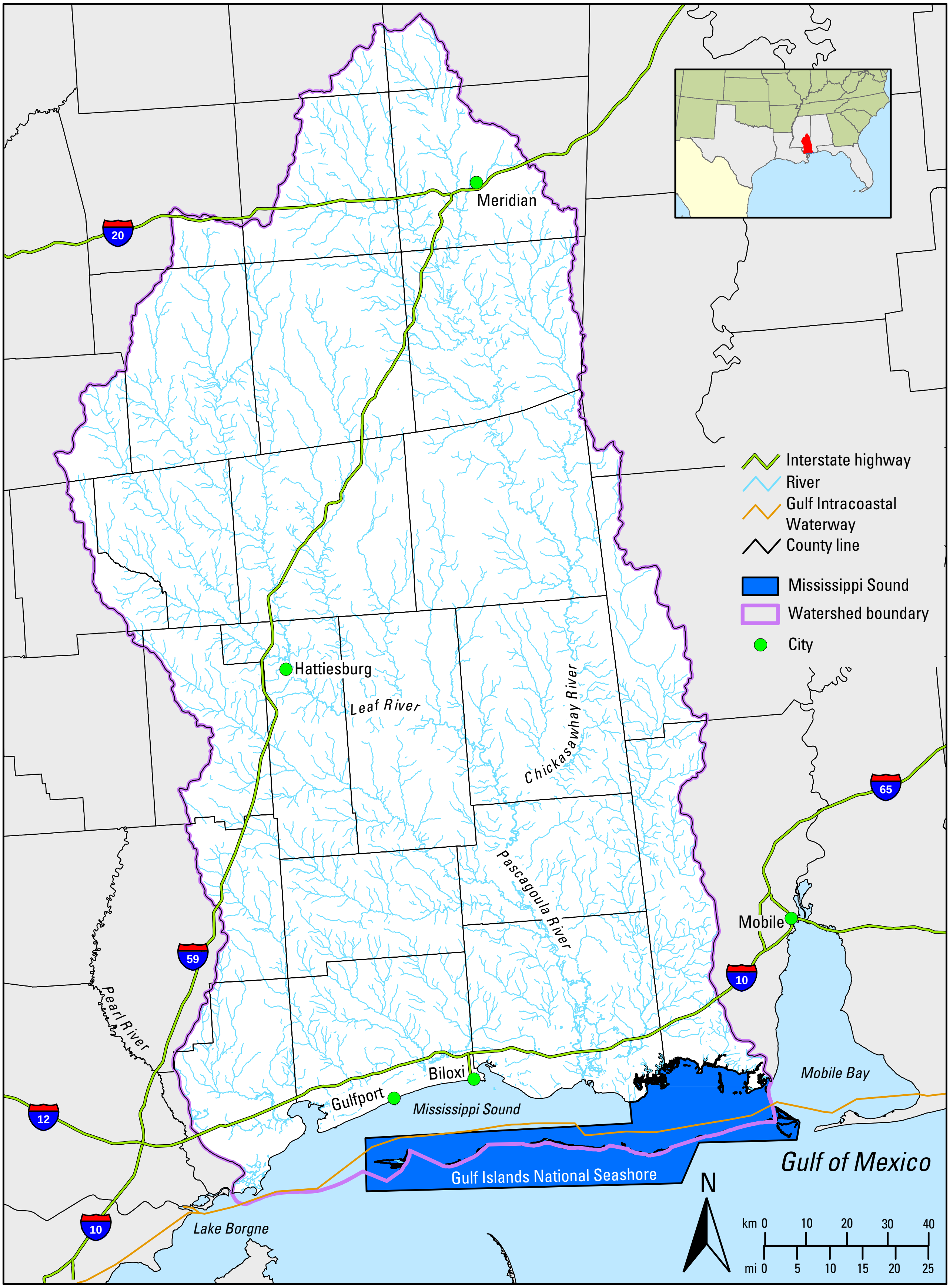

Figure 1. Watershed for Mississippi Sound.

a hydrological barrier in the observed patterns of surface circulation of water. An additional constructed feature which at times contributes tremendous amounts of fresh water to Mississippi Sound is the Bonnet Carre Spillway, a flood-control structure on the Mississippi River that is designed to protect New Orleans, La., from spring floods. Water from the Mississippi River passes over this structure into Lakes Pontchartrain and Borgne in Louisiana and then directly into Mississippi Sound. Salinities in Mississippi Sound can remain depressed for months after the spillway has been employed for flood relief and have been documented at or near zero over the western two-thirds of the sound for 2 to 3 months following opening of the spillway (H. Perry, oral commun.). Tropical storms and hurricanes are an additional feature of regional climate that can also directly affect seagrasses. Species distributions noted along the north shore of Horn Island by Sullivan in 1977 (Sullivan, 1979) suggested that the passage of Hurricane Frederick in 1979, combined with openings of the Bonnet Carre Spillway in 1979 and 1981, may have contributed to the demise of the more halophytic seagrasses in the sound.

The part of Mississippi Sound that supports the majority of the region's seagrass area lies within the boundaries of the Gulf Islands National Seashore. The barrier islands off of the Mississippi coast were incorporated into the Gulf Islands National Seashore by Congress in January 1971; Cat Island was added to the Gulf Islands National Seashore on March 28, 2002.

Important yet essentially unanswered questions about Mississippi Sound's seagrasses center around the following points, shared by seagrass ecosystems on a global scale: (1) current status of seagrasses in terms of areal coverage, species composition, standing crop, productivity, and other characteristics; (2) trends in seagrass coverage, seagrass phenology, and biology; (3) water-quality conditions needed to maintain seagrasses; and (4) conditions required to promote recovery and expansion of seagrasses.

Scope of Area

Bounded by the coast of Mississippi to the north, by Mobile Bay, Ala., to the east, by Lake Borgne, La., to the west, and by a series of barrier islands to the south that make up most of the Gulf Islands National Seashore (fig. 2), Mississippi Sound has a long history of coastal water transport by Native Americans and a series of European explorers, including Bienville and D'Iberville, who established a colony on its shores in 1699. Geologically, the entire area is similar, with most of the seagrasses occurring along the barrier islands, which are slowly migrating to the west (Otvos, 1981). Tidal amplitudes are low; average astronomical tidal range is 0.6 m (1.96 ft). The effects of wind on local hydrodynamics generally overwhelm the effects of tides and tend to dictate local water depth and surface level fluctuations. The climate is categorized as semitropical or subtropical, winds are typically from the south-southeast at 10.4 kph (6.5 mph), and October tends to be the driest month of the year (Office of Nuclear Waste Isolation, 1983). Rivers draining to the region tend to carry high sediment loads. Mississippi Sound also receives waters from the Pascagoula River, one of the last undammed rivers in the continental United States.

Methodology Employed To Determine and Document Current Status

The most current mapping study of seagrass coverage for the Mississippi Sound and the Gulf Islands area was conducted more than 10 yr ago by the U.S. Geological Survey (USGS) National Wetlands Research Center (NWRC) by using natural-color aerial photography taken in 1992 at a 1:24,000 scale as part of the northeastern Gulf of Mexico seagrass mapping project. In cases where the data were inadequate or incomplete, contemporary supplemental data were acquired from other sources (Moncreiff and others, 1998; Moncreiff, personal observation) and used to complete the photographic coverage.

Natural color, 1:24,000-scale aerial photography was acquired in June 1992; however, the primary data source was natural color, 1:24,000-scale aerial photography flown by NASA-Stennis in fall 1992. This photography was used in map generation and included stereoscopic photointerpretation, cartographic transfer, and digitization in accordance with strict mapping standards and conventions. Other important aspects of the protocol included the development of a classification system (described below), groundtruthing, quality control, and peer review. Seagrass distribution information derived from the photography was transferred by using a zoom transfer scope onto a stable medium overlaying USGS 1:24,000-scale quadrangle base maps.

The seagrass classification system used in the 1992 dataset consisted of two classes of open water—RIV (riverine, fresh water) and EST (estuarine or marine open water)—and five classes of seagrass habitats. One class of continuous seagrass (CSG) for which no density distinction was made and four classes of patchy seagrass were based on percent ground cover of patches in 5% increments: PSG1 (0%–10%, very sparse), PSG2 (15%–40%, sparse), PSG3 (45%–70%, moderate), and PSG4 (75%–95%, dense). All seagrass cover in Mississippi waters was very sparse to sparse, falling within the PSG1 and PSG2 classes.

The groundtruthing phase included the participation of field staff from Gulf Islands National Seashore, Dauphin Island Sea Lab, and Mississippi State University. Draft maps were sent out to the aforementioned agencies and staff for review and comments. All comments received were incorporated into the final maps.

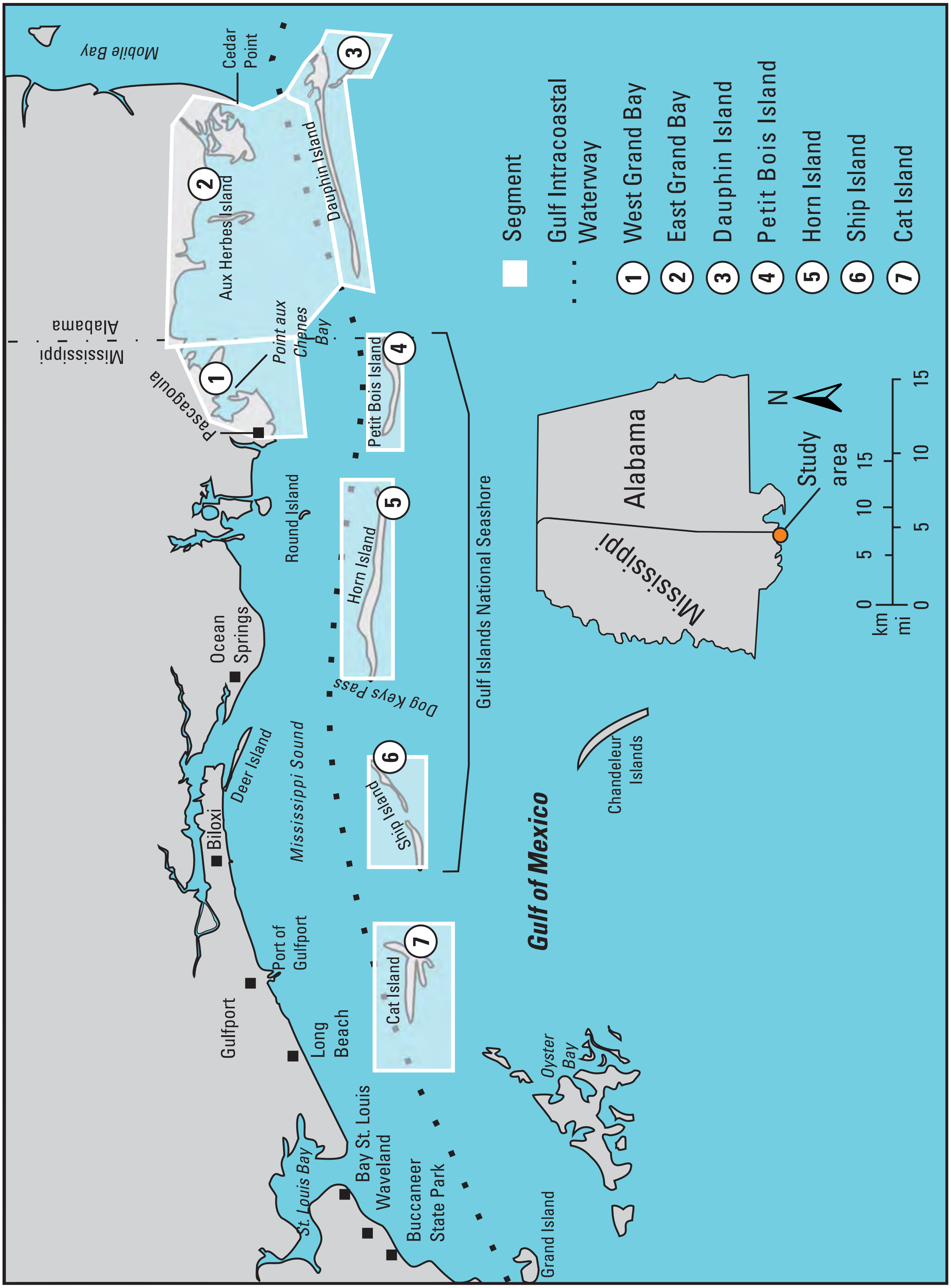

Figure 2. Scope of area for the Mississippi Sound seagrass vignette.

Methodology Employed To Analyze Historical Trends

Only one study of trends in seagrass cover over time has been conducted for Mississippi Sound. The results of this study, summarized in a report to the Mississippi Department of Marine Resources (Moncreiff and others, 1998), are limited by the lack of consistency in current and prior seagrass mapping efforts but are considered here because they constitute the sole effort in this area at this point in time. Hectares of seagrass coverage in Mississippi Sound were calculated from the Eleuterius (1973) 1967−69 dataset as well as from the data in the NWRC preliminary maps (U.S. Geological Survey, 1992) of seagrass distributions in Mississippi Sound. The area of potential seagrass habitat was also determined by using the 2-m (6.6-ft) depth contour as a criterion.

Distribution data for submerged aquatic vegetation in Mississippi Sound from Eleuterius (1973) and groundtruthed data from the 1992 NWRC aerial imagery study (described in the previous section) were plotted onto hydrographic survey maps. Potential seagrass habitat in Mississippi Sound was also identified and mapped by using a 2-m (6.6-ft) critical depth limit established by Heck and others (1994, 1996) in a previous seagrass project documenting distribution and abundance of seagrass along the Gulf Islands National Seashore. The 2-m (6.6-ft) depth contours used were taken from National Oceanic and Atmospheric Administration navigational charts (National Oceanic and Atmospheric Administration, 1996a, b).

Status and Trends

Information on seagrass distribution in Mississippi Sound is limited. Our most recent “historical” maps of seagrass beds and potential seagrass habitat are based on 1992 aerial imagery and maps prepared by NWRC (fig. 3). Aerial photographs taken in 1999 for the Gulf Islands National Seashore were photointerpreted by staff at NWRC for this report. Seagrass distributions from a 1969 Gulf of Mexico estuarine inventory were used as a source of historical documentation, while data from the 1992 NWRC aerial imagery study were used to provide more recent distribution patterns. Potential seagrass habitat was identified by using a 2-m (6.6-ft) critical depth limit which was previously established by Heck and others (1994, 1996) and described in a National Park Service seagrass monitoring project report. Hectares of seagrass in Mississippi Sound were calculated from the Eleuterius (1973) 1967–69 dataset as well as for the data from the NWRC maps (U.S. Geological Survey, 1992) of seagrass distributions in Mississippi Sound (fig. 4).

Table 1 provides the estimated historical, present, and potential areal extent of seagrass in Mississippi Sound. In 1969, about 5,254 ha (12,982 acres) of seagrasses were documented, and as of 1992, only 600 of those (1,482 acres) were vegetated. An additional 209 ha (516 acres) of seagrass were also documented in 1992 in areas that were excluded from Eleuterius’ (1973) work, for a total of 809 ha (1,999 acres) of seagrass in 1992. Imagery from 1999 suggests that seagrass coverage was slowly increasing throughout the sound, with an apparent dramatic increase in areal extent of seagrasses at Cat Island; however, 2,023 ha (4,999 acres) surrounding Cat Island were covered with several species of attached macroalgae during the 1969 survey and were not included in the seagrass cover estimates. In total, 6,024 ha (14,885 acres) of coastal Mississippi water bottoms have been identified as suitable habitat for seagrasses.

Information from the Eleuterius (1973) studies indicated that 67.6% of potential seagrass habitat was vegetated, in comparison to only 13.4% in 1992. Physical loss of seagrass habitat is assumed for areas where 1969 coverage exceeded current estimates of seagrass habitat; this total is estimated to be 19.6%. Loss of previously vegetated areas which still fall within the regions delimited as potential seagrass habitat, even when corrected for physical loss of habitat, totals 54.2%. Seagrass communities in Mississippi Sound need to be routinely mapped to determine if this roughly 50% loss of vegetated habitat is in response to natural or human-caused effects.

Causes of Change

The primary reason for the disappearance of seagrasses is thought to be an overall decline in water quality (Orth and Moore, 1983; Robblee and others, 1991). On a historical time scale, disappearance of seagrasses resulted from a combination of physical disturbances associated with tropical weather systems, depressed salinities associated with flood events, and an overall decline in water quality resulting in increased turbidity (Eleuterius, 1989), which has a deleterious effect on most if not all of the species of seagrasses that occur in the northern Gulf of Mexico (Thayer and others, 1994; Zieman and others, 1994).

In Mississippi Sound, seagrasses appear to be threatened by the cumulative effects of both natural events and human activities in the coastal marine environment. For example, extended periods of depressed salinity (Montague and Ley, 1993) and physical disturbances such as tropical storms and hurricanes can contribute. Physical loss of habitat and decreased light availability combined with declining water quality are the most visible features which directly affect seagrass communities. Some observed changes in seagrass distributions appear to be directly linked to physical loss of habitat; areas of seagrass habitat loss coincide with areas where rapid coastal erosion and massive long-term movement of sand have been well documented (Otvos, 1981; Oivanki, 1994). Loss of vegetated areas corresponds with potential loss in water clarity over time, caused by (1) human influences, (2)

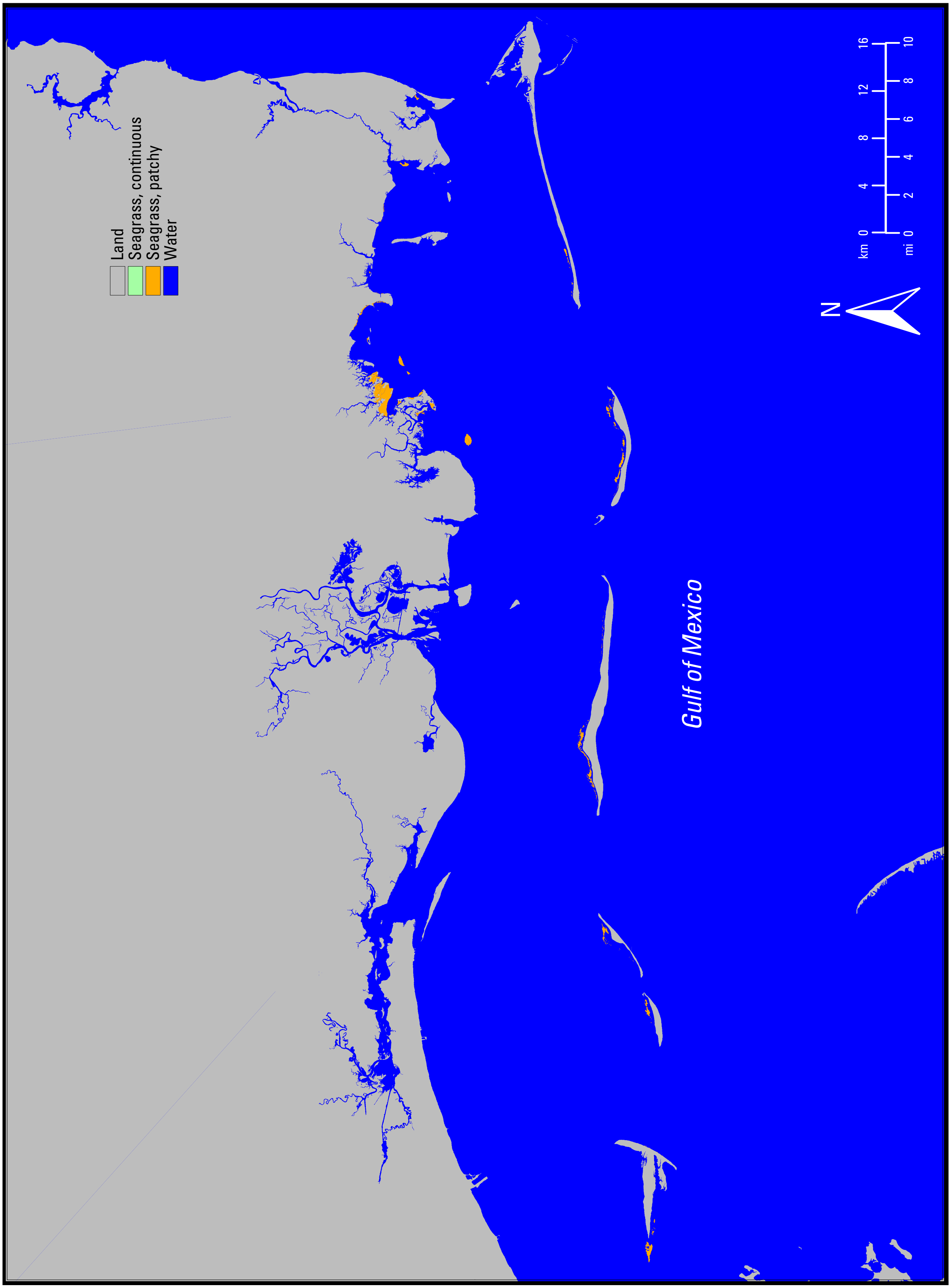

Figure 3. Distribution of seagrasses in Mississippi Sound, 1992.

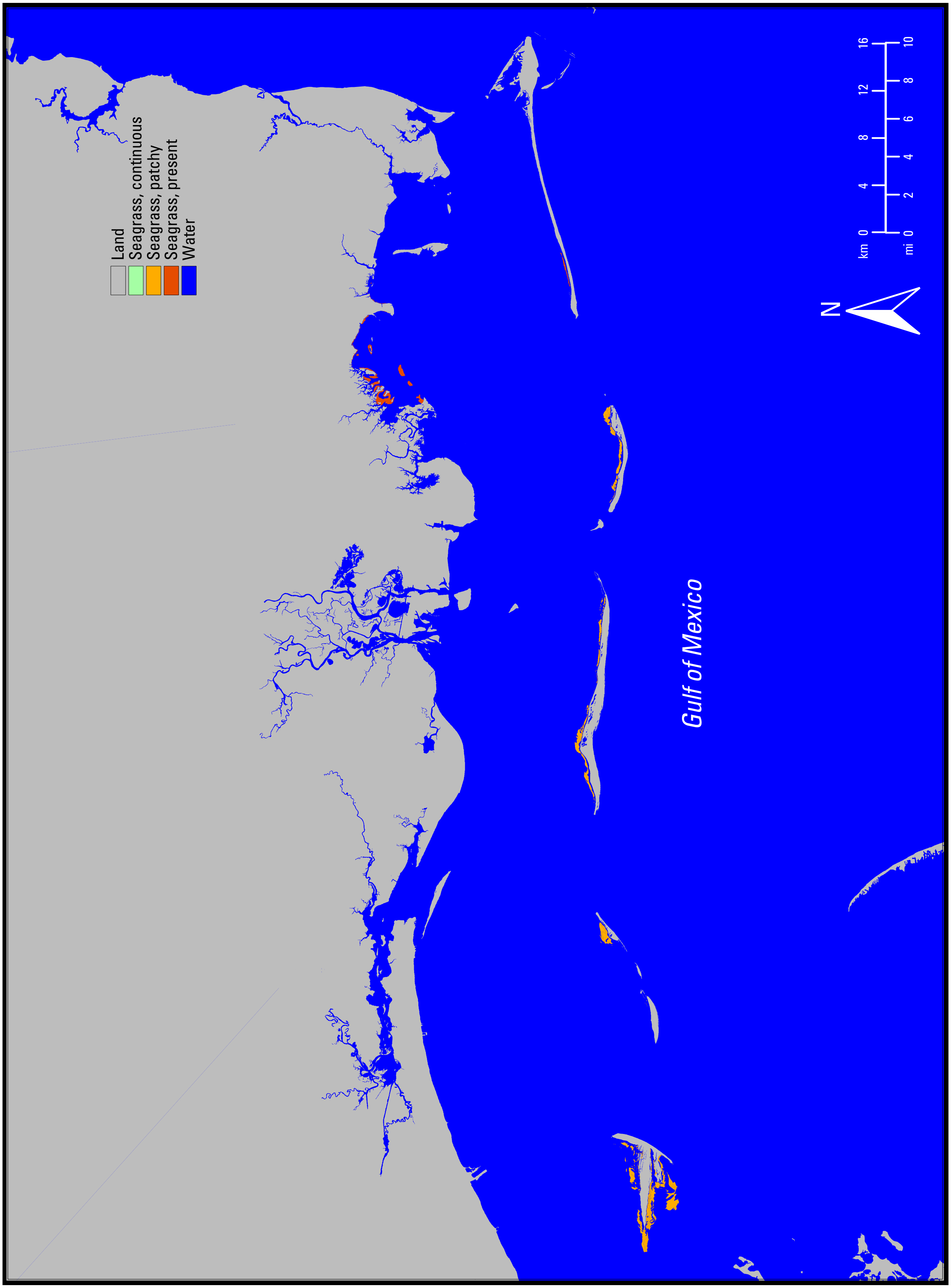

Figure 4. Distribution of seagrasses in Mississippi Sound, 1999–2001/2002.

cyclic shifts in precipitation patterns which would affect both salinity and turbidity, or (3) a combination of these factors. Some of the observed differences in coverage are also likely a result of mapping techniques; the information collected between 1967 and 1969 by Eleuterius (1973) is less precise than the detailed mapping efforts that are possible with current aerial imagery such as the photographs used to prepare the 1992 seagrass distribution maps for Mississippi Sound.

Seagrass Health

The central issue of concern in Mississippi Sound with regards to seagrass health is the genetic variation that remains in extant populations of shoal grass and wigeon grass following the dramatic losses of cover and of species between 1977 and 1987. Observations on the genetic status and implied health of populations of shoal grass are described in *2002 Annual Investigator's Report* to the National Park Service and will be published elsewhere in the near future. Studies of the phenology and genetic diversity of wigeon grass are in progress.

Critical points excerpted from the report to the National Park Service, which summarizes information collected for the thesis research of Opel (2002), are that in theory, because of the predominance of vegetative growth, shoal grass beds should be clonal in composition, and local populations of shoal grass may have little to no genetic variation caused by environmental and geographic constraints on their growth and reproduction. To test hypotheses related to the genetic composition of shoal grass, samples were collected from four populations in the northern Gulf of Mexico, including the Chandeleur Islands, La.; Petit Bois Island and central Horn Island, Miss.; and Perdido Key, Fla. DNA was extracted from these samples and used as a template for genetic analysis; genetic variation was detected at all levels within single seagrass beds, within populations, and among the four populations. Shoal grass in the northern Gulf of Mexico has a moderate amount of genetic diversity when compared to other submerged, marine angiosperms, all of which use hydrophilous pollination and have predominance towards vegetative growth. Data also indicate that shoal grass populations from Petit Bois Island may have a genetic component associated with phenotype; specifically, blade and shoot lengths may have a genetic component, as opposed to simply growing in response to environmental conditions.

The information generated from this thesis project (Opel, 2002) indicates that seagrass conservation techniques, such as transplanting, need to be done with utmost care to maintain the current ecology of the northern Gulf of Mexico. For example, certain individual genotypes exist in shoal grass populations within Mississippi Sound that have survived the reduction in seagrass distribution over the last 30 yr. If "foreign" genotypes

Table 1. Estimated areas of seagrasses in Mississippi Sound during 1969, 1992, and 1999, plus a bathymetry-based estimate of potential seagrass habitat (PSGH).

[Area is given in hectares and acres]

Location	1969	1992	Difference 1969–92	1999	Difference 1992–99	PSGH
Buccaneer State Park	83 ha 205 acres	22 ha 54 acres	61 ha 151 acres	No data	22 ha 54 acres	128 ha 316 acres
Cat Island	242 ha 598 acres	68 ha 168 acres	174 ha 430 acres	645 ha 1,594 acres	577 ha 1,426 acres	2,075 ha 5,127 acres
Ship Islands	621 ha 1,534 acres	103 ha 254 acres	518 ha 1,280 acres	98 ha 242 acres	5 ha 12 acres	648 ha 1,601 acres
Dog Keys Pass	841 ha 2,078 acres	0 ha 0 acres	841 ha 2,078 acres	No data	0 ha 0 acres	465 ha 1,149 acres
Horn Island	2,253 ha 5,567 acres	215 ha 531 acres	2,038 ha 5,036 acres	234 ha 578 acres	19 ha 47 acres	1,760 ha 4,349 acres
Petit Bois Island	684 ha 1,690 acres	147 ha 363 acres	537 ha 1,327 acres	172 ha 425 acres	25 ha 62 acres	732 ha 1,809 acres
Point-aux-Chenes Bay	528 ha 1,305 acres	45 ha 111 acres	483 ha 1,194 acres	No data	45 ha 111 acres	216 ha 534 acre
Totals	5,252 ha 12,977 acres	600 ha * 1,483 acres	4,652 ha 11,496 acres	1,149 ha 2,839 acres	693 ha 1,712 acres	6,024 ha 14,885 acres

* Areas at the northeastern margin of Mississippi Sound were omitted from the Eleuterius (1973) survey; this region supported 209 ha (516 acres) of vegetation in 1992 for a total of 809 ha (1,998 acres) of seagrasses.

are introduced, these transplants may not survive the factors that led to the seagrass decline historically observed. If these new plants do survive, they may dilute the genes and genotypes that were initially adapted to that location. Therefore, transplanting from one population to another may have no real benefit as it may be inefficient and costly in terms of money and of disruption to the gene pool at each population. Genetic information suggests that the examined shoal grass populations would benefit most from use of local plant material in conservation and restoration efforts.

Species Information

Extant seagrass populations off of the coast of Mississippi consist almost exclusively of shoal grass. Historically, populations of shoal grass, star grass, wigeon grass, manatee grass, and turtle grass were present and abundant along the northern shores of the Mississippi barrier islands (Humm, 1956; Eleuterius, 1973; Eleuterius and Miller, 1976; Sullivan, 1979). Overall, Mississippi has lost half of the seagrass area that was present in the 1967–68 time frame and has virtually lost all but one of its marine seagrass species (Heck and others, 1994; Moncreiff and others, 1998). Only shoal grass exists in any type of measurable area throughout the southern portion of Mississippi Sound. Wigeon grass occurs in isolated but well-developed patches along the immediate coastline and as a rare component in shoal grass beds along the barrier islands in Mississippi Sound (Heck and others, 1996; Moncreiff and others, 1998). Peak development of wigeon grass may be bimodal in this subtropical region; it may not coincide with time frames that are optimal for development and mapping efforts for other seagrasses. Studies of the phenology of this species in coastal Mississippi waters are in progress to better document the time frames in which wigeon grass is most abundant for accurate mapping of this essential aquatic habitat and protected resource.

Well-established populations of shoal grass, star grass, wigeon grass, manatee grass, and turtle grass exist along the western shorelines and in the small internal bayou systems of the Chandeleur Islands. Though technically part of southeastern Louisiana, these islands begin 35 km (22 mi) south of Biloxi, Miss., and are likely a source of vegetative propagules and possibly of seeds supplementing or repopulating seagrass beds in some areas of the Mississippi coast and even Grand Bay, Ala. (north of Dauphin Island) (Stout, 2004, personal commun.).

Seagrasses and potential seagrass habitat in Mississippi Sound lie mainly along the northern shorelines of Ship, Horn, and Petit Bois Islands. Round and Cat Islands have had well-developed grass beds in the past (Eleuterius, 1973); no seagrasses occur at Round Island at present. Cat Island seagrass populations occur at the north and west tips of this T-shaped island, as well as in protected areas along its southwest shoreline. Wigeon grass occurs along the mainland shoreline in Hancock County between Waveland and Clermont Harbor, in the Grand Bay National Estuarine Research Reserve south of the marshes in eastern Jackson County, and along the Mississippi-Alabama border.

Monitoring, Restoration, and Enhancement Opportunities

State, Federal, and academic programs that target the monitoring, restoration, and enhancement of the seagrasses in Mississippi Sound are limited to funding and grant-supported efforts outside of the assessment that is described in this document. It is hoped, however, that future seagrass monitoring will be undertaken by the State's Department of Marine Resources as a component of its marine resource monitoring and mapping efforts based on geographic information systems.

A community-based pilot seagrass restoration project, funded by the Gulf Restoration Network, will be initiated within the boundaries of the Gulf Islands National Seashore. Originally, lead investigator for the project was Robin K. McCall (University of Southern Mississippi Gulf Coast Research Laboratory). McCall planned to collect viable turtle grass shoots following any major storm events from wrack lines in the Perdido Key area of northwest Florida, hold them for a short period of time to ensure viability, and then plant the shoots along the north-central shore of Horn Island. The location selected is at an appropriate depth and is located where a sample of turtle grass was collected in June of 1993, in association with sampling for invertebrates conducted by R. Heard and J. McLelland, both of the Gulf Coast Research Laboratory. The project currently has Jerry McLelland as lead investigator, and monitoring of seagrass establishment and growth is ongoing.

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