Informational Report

Shoreline Change: Hancock County Marsh 1850 to Present

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Introduction

Coastal wetland loss is an ongoing concern in the United States and Mississippi. Coastal wetlands play an integral part in the health of coastal and ocean ecosystems, which, in turn, supports commercial and recreational fisheries (Gosselink, 1984; Fish and Wildlife Service, 1985). There are many natural and human (anthropogenic) reasons for wetland loss; they range from development to subsidence/sea level rise (Orson et al., 1985). Loss of coastal wetlands is offset somewhat by the conversion of upland areas to wetlands as sea level encroaches on bordering habitats. Today, however, the process of upland conversion is limited, and in many cases reversed, by development, making marsh erosion more problematic. Predictions of future acceleration of sea level rise (Houghton et al., 1996) have created further concern over coastal habitat loss.

Wetlands are both highly vulnerable and adaptable to sea level change. Coastal wetlands have the ability to aggrade (grow vertically) (Nielsen and Nielsen, 2002) when sediment is available, but in the absence of substantive sediment to counter sea level rise large areas can be lost because of the low overall elevation of the marsh surface. On marsh coasts open to wave attack, shoreline retreat is a major cause of marsh loss (Kennish, 2001). Sea level also affects shoreline retreat caused by waves; for example, on sandy shorelines, beach retreat is often 150 times the amount of sea level rise. No work has documented the wave-retreat-rate/sea-level-rise ratio on marshes, but given the fact that little or no coarse sediment (sand) is available to buffer wave attack or facilitate storm recovery, the ratio may be even higher.

Erosion of marsh shoreline in Hancock County has been occurring steadily throughout the past several thousand years, since the abandonment of the Saint Bernard delta lobe of the Mississippi River (Otvos, 1985). The Hancock County marsh is located in the southwest corner of Mississippi, adjacent to Louisiana. This natural process is driven by relative sea-level rise (combination of sea-level rise and land subsidence) (Figure 1) and wave attack. This update on shoreline position and area loss in the Hancock County marsh system is meant to highlight recent and historical trends associated with coastal erosion.

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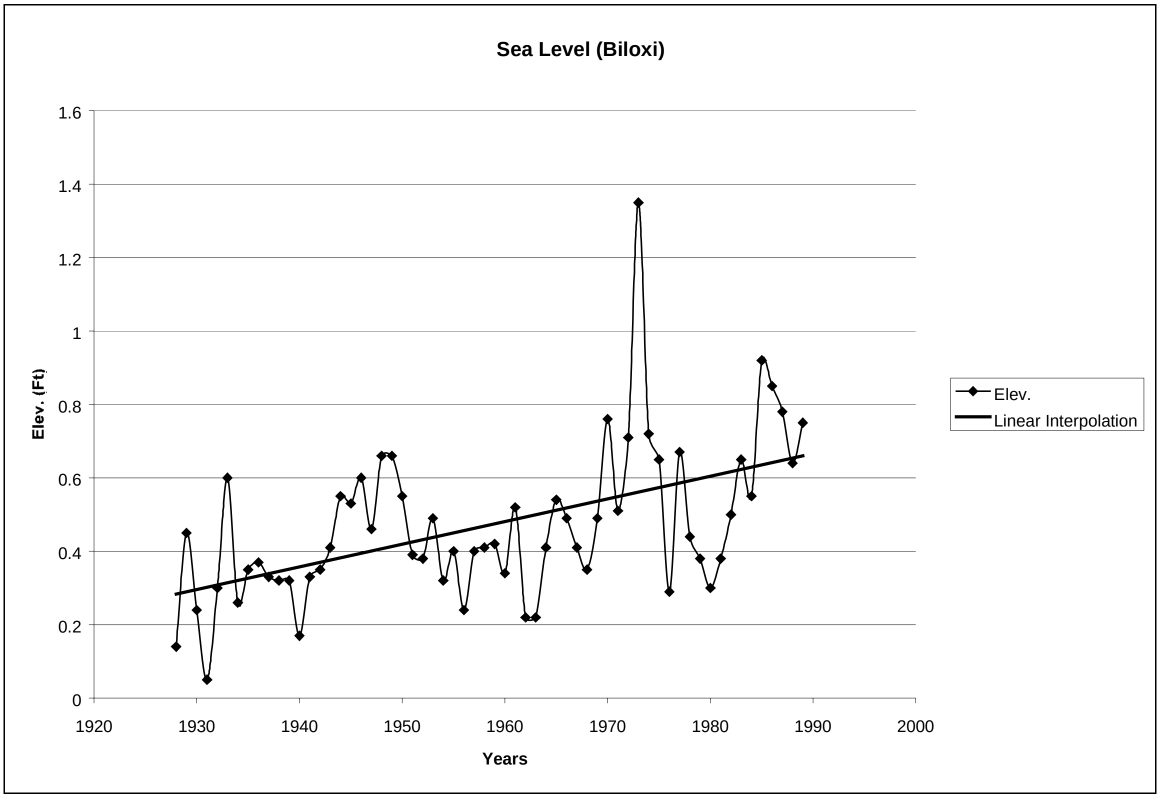

Figure 1. Sea level rise in Mississippi in the past 75 years (from Burdin (1990)).

Methods

Several methods were used to document the shoreline changes occurring in the Hancock County marshes. Historic shorelines provide long-term rates that may be used to explore the sea-level/shoreline change ratio. More-recent GPS surveys provide an up-to-date, yearly change that documents the present conditions. Aerial photographs provide a morphological component as well as a shoreline position. These data sources are used in a Geographic Information System (GIS) to help analyze change rates and change character (morphologic control), and to extrapolate future shoreline change and area loss.

Historic Shorelines

Coast and Geodetic Survey maps made in the 1850's are the earliest accurate documentation of shoreline position in Mississippi. The 1850 map was digitized by the Coastal Studies Institute at Louisiana State University from a 1:20,000 scale T-sheet. Additional historic data include an October, 1969 shoreline survey following Hurricane Camille that was undertaken by the National Geodetic Survey (NGS) for creating nautical charts and a more recent shoreline created for 1986 by the Mississippi Office of Geology from aerial photos. A 1986 shoreline was also created by the National Oceanic and Atmospheric Administration (NOAA) using T-sheets. These maps depict the high water line (HWL) (Shalowitz, 1964), which is a close approximation to the mean high water line (MHWL) (Crowell et al., 1991) used to denote the legal boundary of the State of Mississippi. Errors associated with the shoreline position on the digitized versions of the maps are typically less than 10 m (Crowell et al., 1991). In this report, these maps are used to measure changes that span decades instead of years, so the overall measurement error is small compared to the typical change in shoreline position. Only natural shorelines exposed to waves from the Mississippi Sound are included in this analysis. No shoreline data from bayous and protected inlets were used for the historic shoreline change analysis.

GPS Shorelines

Global Positioning System (GPS) surveys of the HWL shoreline were performed in 1993, 1999, and 2001. These surveys were only carried out on wave-influenced sections of the shoreline and only in areas that were accessible by boat. As a result, these surveys give only partial coverage of the shoreline in the study area. A combination shoreline using 1999 and 2001 data provides the most recent coverage. GPS position accuracies are on the order of 2 m; however, the shoreline surveys have accuracies of 2 to 5 m (Hutchins and Oivanki, 1994) depending on shoreline type (ease of determining the HWL). Marsh shorelines at the site generally had vertical scarps that help reduce errors associated with delineating the actual shoreline position in the field.

Aerial Photographs

Digital Ortho Quarter Quads (DOQQs) from the Mississippi Automated Resource Information System (MARIS) were used in conjunction with the 1999-2001 GPS shoreline to create a master shoreline of the entire shore area. This composite shoreline forms the baseline from which historical shorelines are measured. Additionally, the DOQQs were used to delineate the different types of land cover and shoreline morphology in the studied areas.

Shoreline Change Methods

Shoreline change between years was initially quantified by calculating how much linear distance of shoreline changed at chosen levels (m/yr). The end result is a cumulative graph of shoreline change that can be treated analytically. Three levels of shoreline change (erosion) were used to highlight the range of values. Shoreline erosion is considered ‘Low’ in areas with less than 1 m/year (3 feet/year) erosion, ‘Moderate’ in areas with 1 to 2 m/year (3 to 6 ft/year), and ‘High’ in areas with more than 2 m/year (> 6 ft/year). In nearly all cases there was little to no accretion. The shoreline change categories were then used to categorize the Hancock County marsh shoreline.

Area Change

Area change is a broader look at the system. There are several ways to calculate area change; one way (Method 1) is to create polygons of the entire area in question and compare the polygons through time. This technique is good for long-term comparison of large, completely surveyed areas (historical and aerial photo surveys); however, newer ground-based data like GPS surveys create large gaps in the analysis. To solve this problem with semi-complete surveys other techniques are employed to compute area loss only along surveyed shorelines. The first technique (Method 2) uses the results of the shoreline change analysis; by multiplying the length of shoreline distance changed (meters) by the change value (meters/year) and adding the total, an estimate of area lost per year (meters^2/year) is produced. Another technique (Method 3) is to construct similar buffers on each shoreline and then overlay and cut them. This essentially provides an estimate of the area between the two shorelines. It is an estimate because the buffering process tends to smooth the shorelines. This technique is useful for shoreline surveys taken close in time, i.e. not significantly large shoreline separations. Method 2 is applicable with both long-term and short-term comparisons and used in this report.

Results

Shoreline Change Trends

Shoreline changes from three periods, long-term (1850 to 2001), mid-term (1969 to 2001), and short-term (1986 to 2001), highlight the uniform trends. In general, 45% to 60% of the shoreline was eroding more than 1 m/year during each period (Figure 2). The short-term period shows less overall change, but more areas with high or very high erosion (Figure 3). This is probably a result of the lower resolution with short-term data sets. The mid and long-term change rates are very similar. The median (50%) erosion level for the short-term period is 0.75 m/yr (2.5 ft/yr) and 1.1 m/yr (3.5 ft/yr) in the mid and long-term.

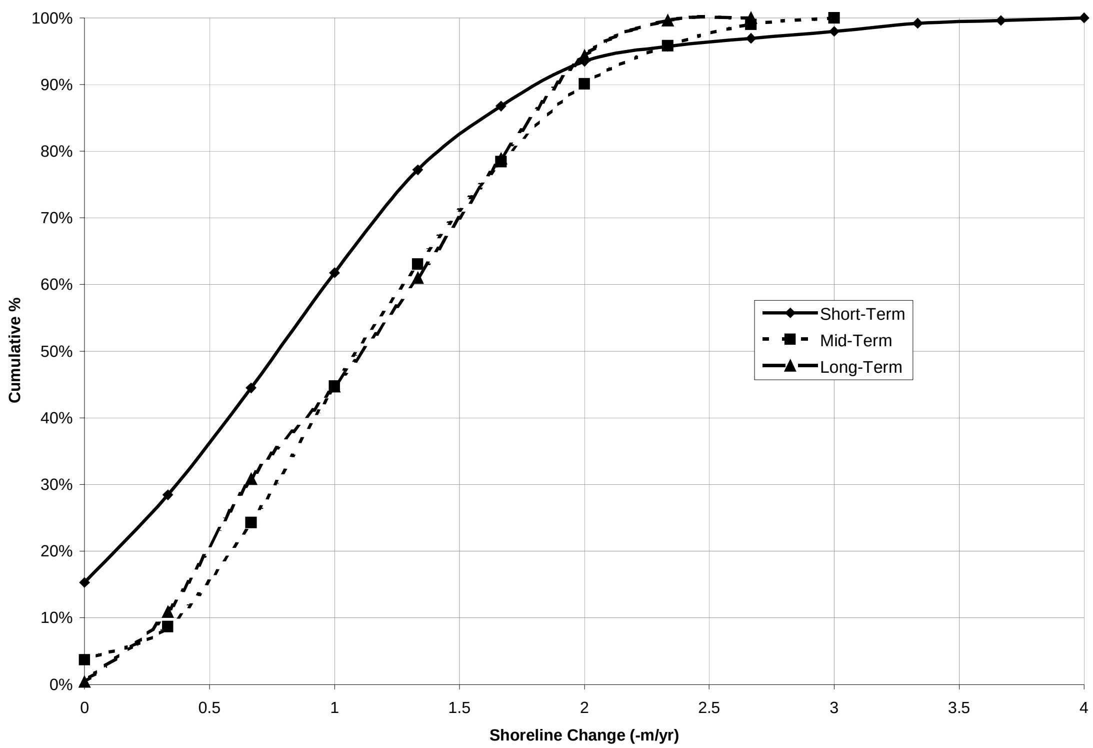

Figure 2. Cumulative percent of shoreline change.

The high percentage of shoreline associated with more than 1 m/yr of erosion in the long-term (Figure 3) suggests that the Hancock County marsh will continue eroding at these levels for the near future. Moreover, this adds to the evidence that this landform was created when a significantly different set of conditions was operating. There is no evidence that any future marsh area will be added, unlike the case at the mouth of the Pascagoula River where some new marsh has been created despite repeated dredging. The fact that no new marsh area is occurring in the Hancock County marsh further suggests that wave erosion is the driving factor in its evolution since its close proximity to the mouth of the Pearl River should provide a significant source of sediment.

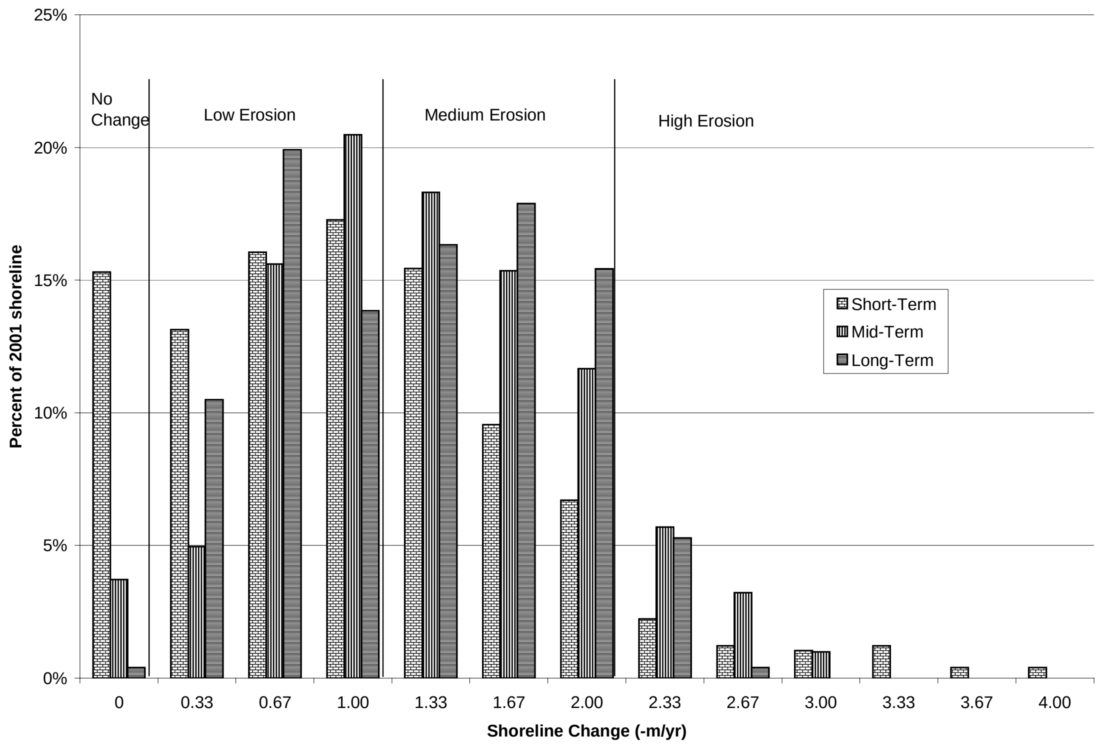

Figure 3. Shoreline change percents.

Shoreline Change Locations

The natural shoreline orientation of the Hancock County marsh system is not uniform, such that some areas are more subject to the dominant wave and wind directions than others are. This is a temporary condition; at some point in the future the shoreline will be straightened and most of the low energy habitats will be lost. Shoreline change maps illustrate the point (Figures 4, 5 and 6).

The shoreline change maps show that the area from Three Oaks Bayou to Heron Bay Point consistently has the highest rates of shoreline change. Erosion of this headland area is significantly higher than 1 m/yr and will be for the foreseeable future. Heron Bay has the lowest shoreline retreat rates in all periods, and will likely maintain that trend. The shoreline orientation and position from Bayou Caddy to Point Clear is controlled by a remnant beach ridge, but has experienced considerable erosion through time. Brush Bayou to the mouth of the Pearl River has erosion rates similar to the Point Clear to Three Oaks Bayou shoreline, both of which are above the median 1 m/yr value.

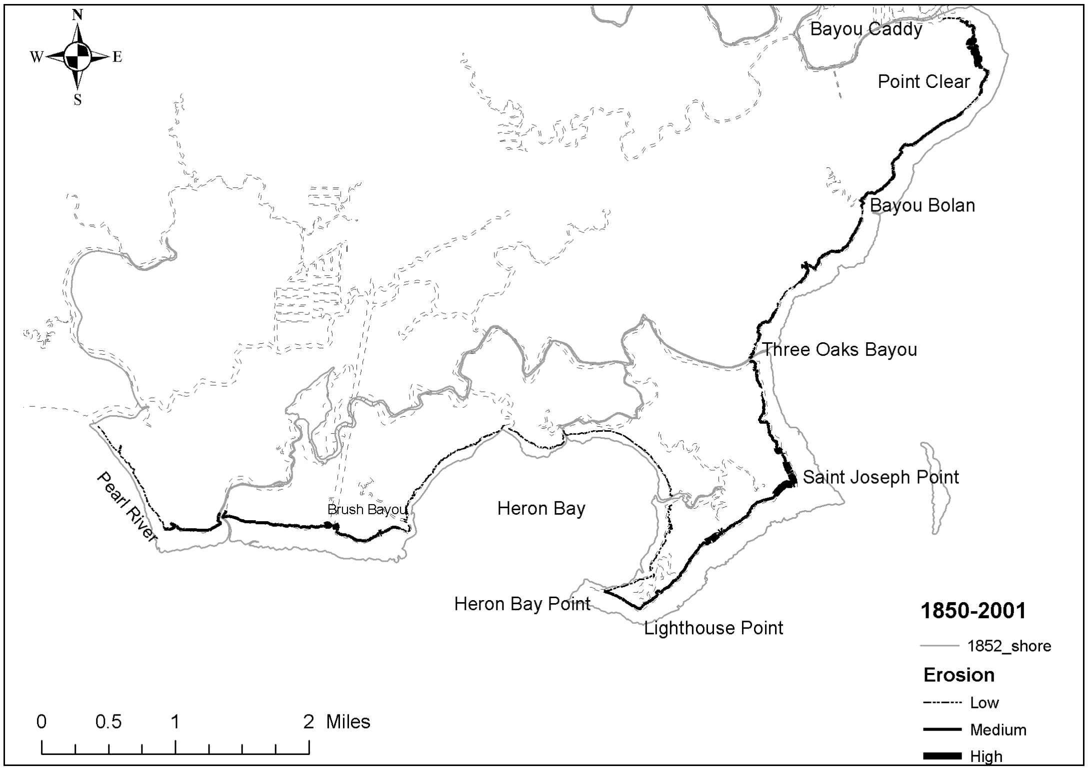

Figure 4. Shoreline change levels between 1850 and 2001.

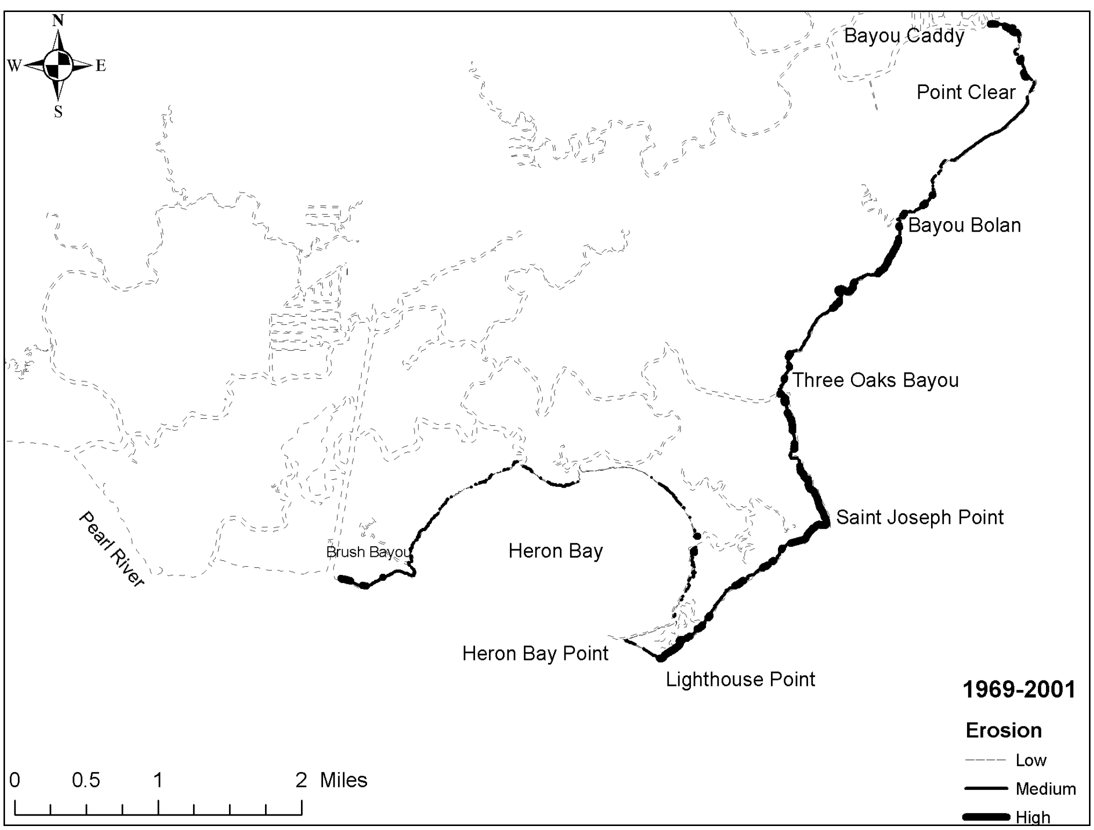

Figure 5. Shoreline change levels between 1969 and 2001.

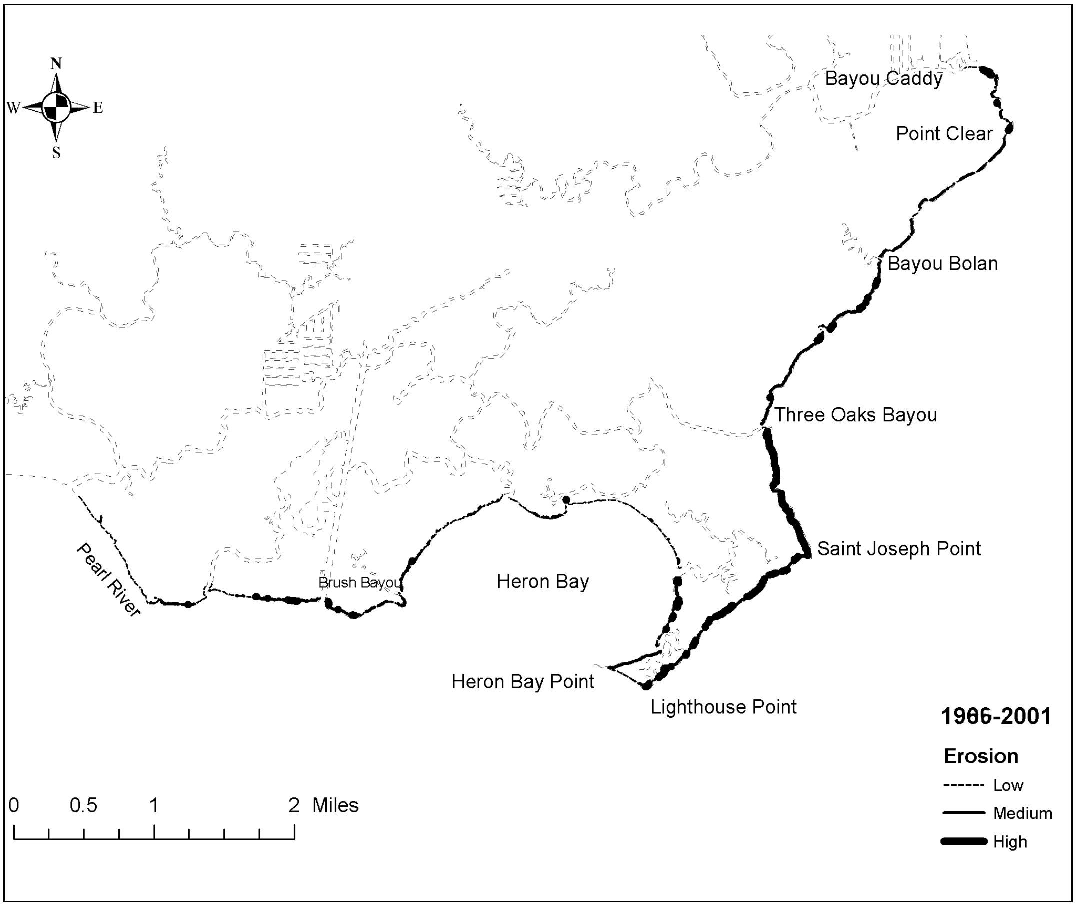

Figure 6. Shoreline change levels between 1986 and 2001.

Area Change

Area change solely from wave erosion at the Hancock County marsh is occurring at a rate of between 6.2 to 7.8 acres/yr. Using Method 1, the area loss between 1986-2001 (short-term) is 7.5 acres/year. This was the only analysis of area loss using this technique. Using Method 2, the short-term loss is 6.2 acres/year. Given that there are errors associated with each method, the value is assumed to be very nearly 7.0 acres/year lost. Using Method 2 (Table 1), the values of mid- and long-term area loss along the shoreline are higher than the short term. The long-term period has the highest rate, 7.8 acres/yr; the mid-term has a rate of 6.6 acres/yr. The lower rate in the short-term may be the result of a decreasing shoreline length and lower overall area due to continual erosion. Again, the average rate is very nearly a loss of 7 acres a year.

Table 1. Area loss for each period using Method 2.

Period	Rate
Long-term (1850-2001)	-7.8 acres/yr
Mid-term (1969-2001)	-6.6 acres/yr
Short-term (1986-2001)	-6.2 acres/yr
Average	-6.9 acres/yr

Area Change Locations

The portions of the marsh with the highest area changes (Figure 7) show the clear correlation with high shoreline change. This map was created using the area differences between 1986 and 2001 in 500m x 500m (62.5 acres) cells. Cells with between about 1 and 2.5 acres of loss are highlighted with a hatched pattern; cells with between 2.5 and 4.0 acres of loss are highlighted in gray; and cells with more than 4.0 acres of loss between 1986 and 2001 are highlighted in black.

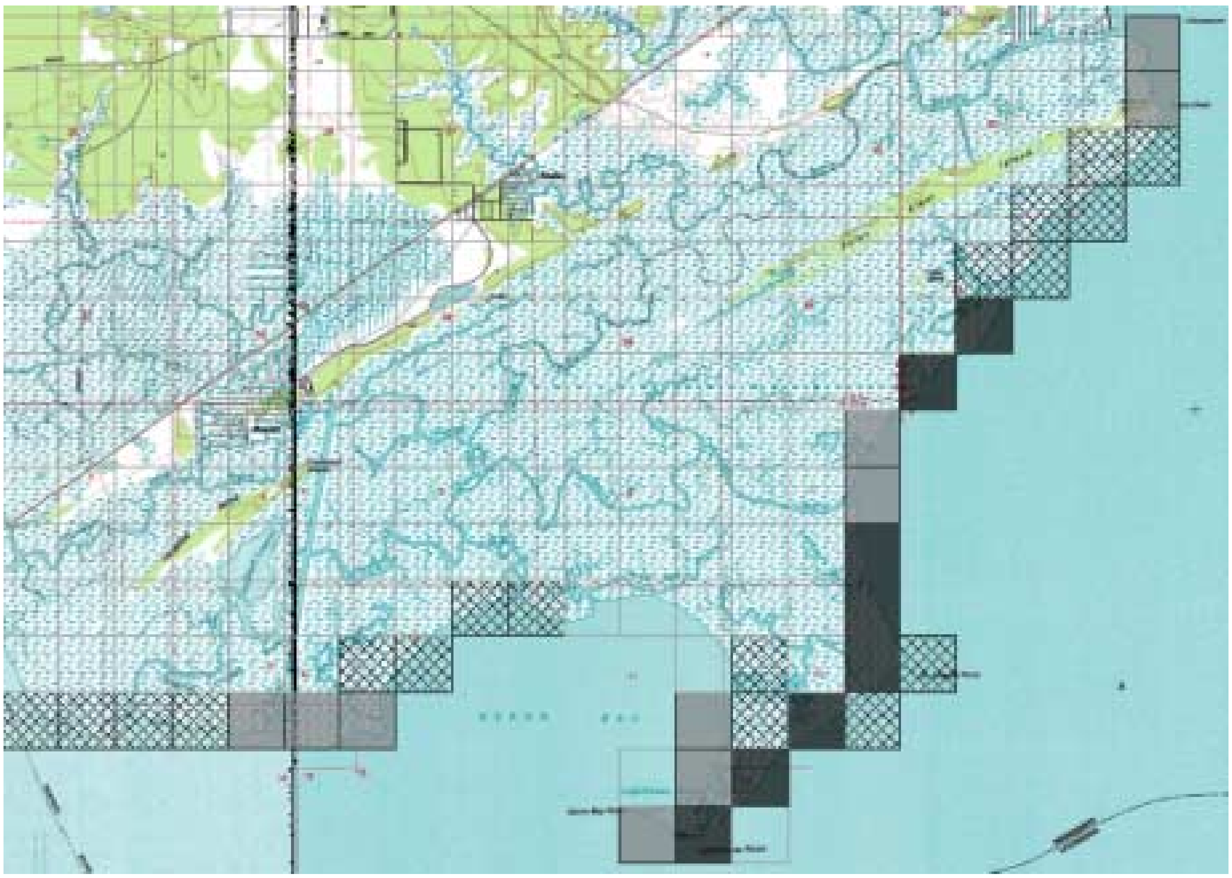

Figure 7. Area loss locations in the Hancock County marsh system.

Discussion

Point Clear to Three Oaks Bayou

This section of the marsh shoreline is distinguished by a marsh platform with a small perched sand beach. The source of this sediment is likely from the continued erosion of the stranded beach ridge system or cheniers that intersect the shoreline at Point Clear. The width of the fronting beach decreases from the northeast to southwest, especially southwest of Bayou Bolan. The projected 2030 shoreline (dark black line) follows the present shoreline, but has a higher level of erosion south of Bayou Bolan (Figure 8).

Figure 8. Aerial photo and 2030 shoreline from Point Clear to Three Oaks Bayou.

Three Oaks Bayou to Heron Bay

Unlike the previous section, the shoreline from Three Oaks Bayou to Heron Bay Point does not have a fronting beach (Figure 9), although in some areas there are considerable concentrations of shell debris that in some places creates a small coarse beach. These areas typically form in small coves or clefts in the shoreline. The projected 2030 shoreline suggests that the Lighthouse Point area will be very nearly pinched off from the main marsh. Once this point of land has been breached, erosion will increase in Heron Bay, where, at present, the shoreline is stable. This point of marsh is also important in the water circulation regime within Heron Bay; loss of the marsh point will likely change the present conditions. It is evident that this highly eroding section of the Hancock County marsh is, in natural terms, very valuable.

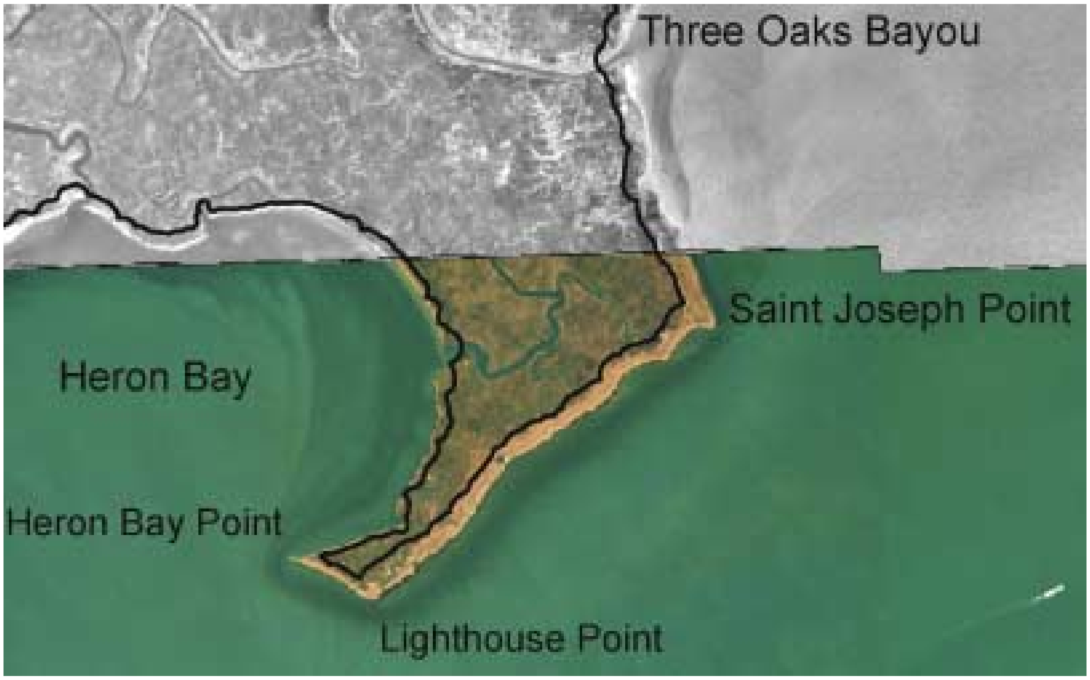

Figure 9. Aerial photo and 2030 shoreline from Three Oaks Bayou to Heron Bay.

Heron Bay to Pearl River

From the interior of Heron Bay to Brush Bayou the change in shoreline position will likely be minor (Figure 10), until Lighthouse Point is entirely eroded. From Brush Bayou to the Pearl River, erosion is more dominant. Near the mouth of the Pearl River there is another small beach ridge or chenier complex that is acting as a stabilizer, and as it slowly erodes on the southern end may be contributing small amounts of sand to the system. Also, notice the circulation pattern; flow is deflected to the left toward Heron Bay, caused by the western point (Louisiana) of the Pearl River mouth.

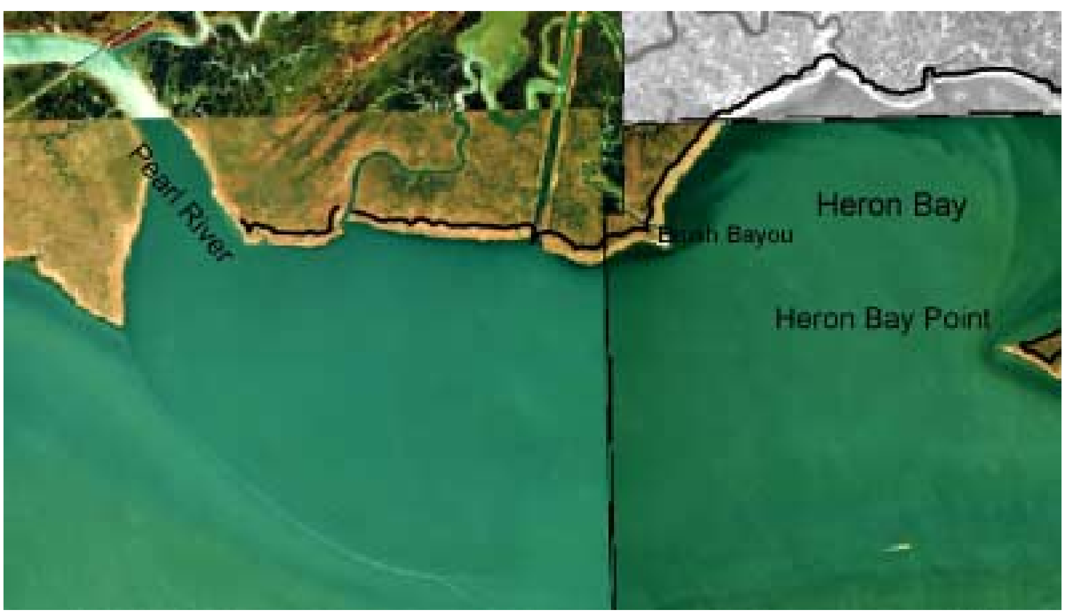

Figure 10. Aerial photo and 2030 shoreline from Heron Bay to Pearl River.

Conclusions

This short report represents an attempt to describe a major cause of marsh loss in the Hancock County marsh system. Canal dredging and conversion of wetlands to uplands by filling are now more closely regulated than in the past, leaving shoreline erosion as the most prolific agent of marsh loss. The combined effects of sea-level rise and subsidence are part of the problem; however, a lack of sediment may be the most important factor. Creation of the marsh system occurred during markedly different conditions, when the Saint Bernard delta lobe was actively supplying sediment; this is no longer the case. Since the abandonment of the Saint Bernard delta lobe, there has likely been a consistent decrease in marsh area along the shoreline, which is evidenced by similar shoreline erosion and area change rates in the long vs. short-term periods. If development had not formed a barrier blocking conversion of upland areas to marsh, the effects of shoreline retreat would be less pronounced in the overall area change. The human modification of the Hancock County marsh system is evident as upland development has limited and in many cases reversed the shoreward shift of marsh development. Humans can and have been described as a geologic force.

This label, while viewed in a negative connotation, holds the potential for positive changes. With advances in techniques in dredge material use for recreating wetlands, the ability to slow or reverse the trend of marsh loss in this area of Hancock County is a reality. The other option to preclude or slow shoreline erosion includes protection of the remaining marsh shoreline with sand renourishment or hardened structures.

To slow shoreline erosion, a soft solution, i.e. sand renourishment, to the problem would typically be recommended because it uses naturally occurring resources that are not dramatically out of context with the physical environment. In this case, eventual loss of the marsh area, which is probably a foregone conclusion, does not leave out of place structures that were designed to protect a specific area and may be useless, or worse, if that area is no longer present. The drawback to soft solutions is that they are not a one-time fix; some sort of maintenance schedule should be instituted.

In the case of the Hancock County marsh, the protection of the St. Joseph Point to Lighthouse Point area is critical to the marsh system as a whole. Loss of this peninsula will expose areas of the marsh that may be more delicate to higher wave energies, thus changing the ecological role of the present shoreline in Heron Bay. Moreover, water circulation will also change in the bay. The need to protect this point may warrant the use of more robust techniques, such as breakwaters or hardened shorelines. To accomplish successful implementation, the marsh protected by the breakwaters would also need to be maintained through time. In either case, a continuation of involvement is necessary to accomplish the long-term goal of reducing marsh loss in Mississippi.

Based on the data presented the following conclusions can be drawn:

1. The median shoreline erosion rates are 1 m/yr (3 ft/yr) in the Hancock County marsh.
2. From shoreline erosion alone, 7 acres of marsh are lost each year.
3. The highest erosion occurs from Three Oaks Bayou to Heron Bay Point; here rates are at least twice as high as the median, and in many cases are greater than 3 m/yr (10 ft/yr).

4. Marsh loss is in direct response to a reduction of source sediments in combination with rising relative sea level.

5. The dynamics of the marsh will change when Lighthouse Point is breached, which seems likely to occur within about 35 years.

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