Appendix B
Littoral Sediment Budget Report

ERDC/CHL TR-12-9

Coastal and Hydraulics Laboratory

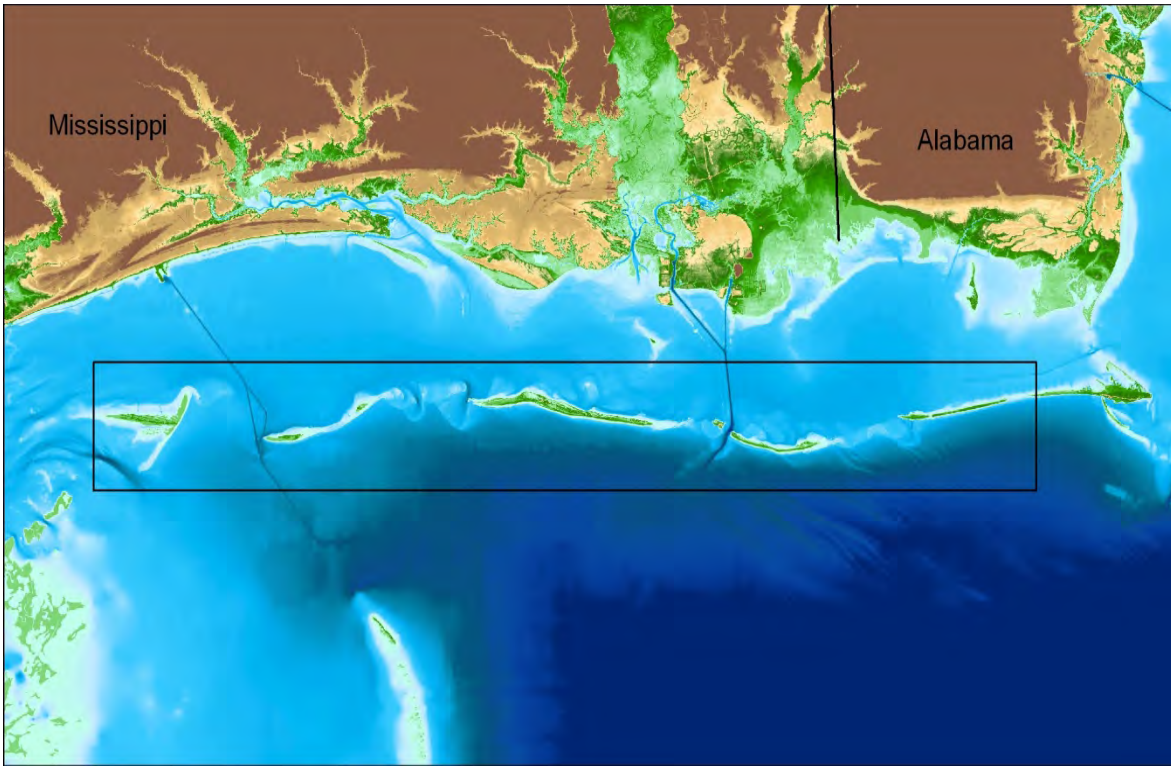
US Army Corps of Engineers®
Engineer Research and Development Center

Mississippi Coastal Improvements Program (MsCIP)

Littoral Sediment Budget for the Mississippi Sound Barrier Islands

Mark R. Byrnes, Julie D. Rosati, Sarah F. Griffee,
and Jennifer L. Berlinghoff

July 2012



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Final report

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Abstract

Shoreline and beach evolution for the barrier islands fronting Mississippi Sound are driven by longshore transport processes associated with storm and normal wave and current conditions. Although beach erosion and washover deposition are processes that have influenced island changes, the dominant mechanism by which sand is redistributed along the barrier islands and in the passes is by longshore currents generated by wave approach from the southeast.

Historical shoreline and bathymetric survey data were compiled for the barrier islands and passes fronting Mississippi Sound to identify net littoral sediment transport pathways, quantify the magnitude of net sand transport, and develop an operational sediment budget spanning a 90-year period. Beach erosion along the east side of each island and sand spit deposition to the west result in an average sand flux of about 300,000 to 400,000 cy/yr to the west throughout the barrier island system. Dog Keys Pass, located updrift of East Ship Island, is the only inlet acting as a net sediment sink and is the widest pass in the system (about 6 miles). As such, a deficit of sand exists along East Ship Island. Littoral sand transport decreases rapidly along West Ship Island, where exchange of sand between islands terminates because of wave sheltering from shoals and islands of the old St. Bernard delta complex, Louisiana. These data are being used to assist with design of a large island restoration project along Ship Island, Mississippi.

Based on sand transport rates derived from the sediment budget, it is recommended that the restoration plan for Ship Island be modified with an additional 5 to 6 million cy of compatible beach sand along East Ship Island. This increased volume will supplement the existing littoral transport for about 20 to 30 years. Additionally, the large restoration area (up to 16 million cy of sand) between East and West Ship Islands (downdrift of East Ship Island) will benefit directly from sand placed along East Ship Island, enhancing the longevity of littoral sand transport in the area.

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Preface

This report describes analyses and results regarding an evaluation of historical dredging records, shoreline surveys, and bathymetric surveys for quantifying littoral sand flux throughout the Mississippi barrier island system and potential impacts of dredging activities on transport quantities. Modifications that potentially alter sediment transport pathways and magnitudes were of critical importance toward development of an operational sediment budget for evaluation and design of a large ecological restoration project on Ship Island, Mississippi. The study was conducted by Dr. Mark R. Byrnes (Applied Coastal), Dr. Julie D. Rosati (U.S. Army Corps of Engineers, ERDC), Sarah F. Griffee (Applied Coastal), and Jennifer L. Berlinghoff (Applied Coastal) for the U.S. Army Engineer District, Mobile under the Mississippi Coastal Improvements Program (MsCIP). Dr. Susan I. Rees (MsCIP Program Manager), Elizabeth S. Godsey (Project Coastal Engineer), and Justin S. McDonald (Lead Project Engineer) were Mobile District points of contact for the study. Richard Wagner, Coastal Engineer with CDM in Jacksonville, FL, provided a detailed external review of the report. Elizabeth Godsey, Justin McDonald, and Dr. Rees provided detailed internal reviews of the document. Operations and maintenance personnel reviewed dredging histories and analyses relative to Horn Island Pass and Ship Island Pass. All technical review comments were incorporated in the report and improved the final document.

COL Kevin J. Wilson was the Commander and Executive Director of ERDC, and Dr. Jeffery P. Holland was the Director.

Unit Conversion Factors

Multiply	By	To Obtain
cubic feet	0.02831685	cubic meters
cubic yards	0.7645549	cubic meters
degrees (angle)	0.01745329	radians
feet	0.3048	meters
hectares	1.0 E+04	square meters
knots	0.5144444	meters per second
miles (nautical)	1,852	meters
miles (U.S. statute)	1,609.347	meters
miles per hour	0.44704	meters per second
square feet	0.09290304	square meters
square inches	6.4516 E-04	square meters
square miles	2.589998 E+06	square meters
square yards	0.8361274	square meters
yards	0.9144	meters

1 Introduction

Most barrier beaches in the northeastern Gulf of Mexico have been migrating landward and losing sand volume with time, and their capacity to protect mainland beaches and infrastructure is diminishing. Barrier islands also can migrate laterally, as through spit growth, and become elongated. If the lateral growth is near an inlet or open-bay navigation channel, the channel will experience persistent shoaling. Along the Mississippi Sound outer coast, barrier island beaches and backbarrier environments help protect mainland beaches from storm impacts (Figure 1.1).

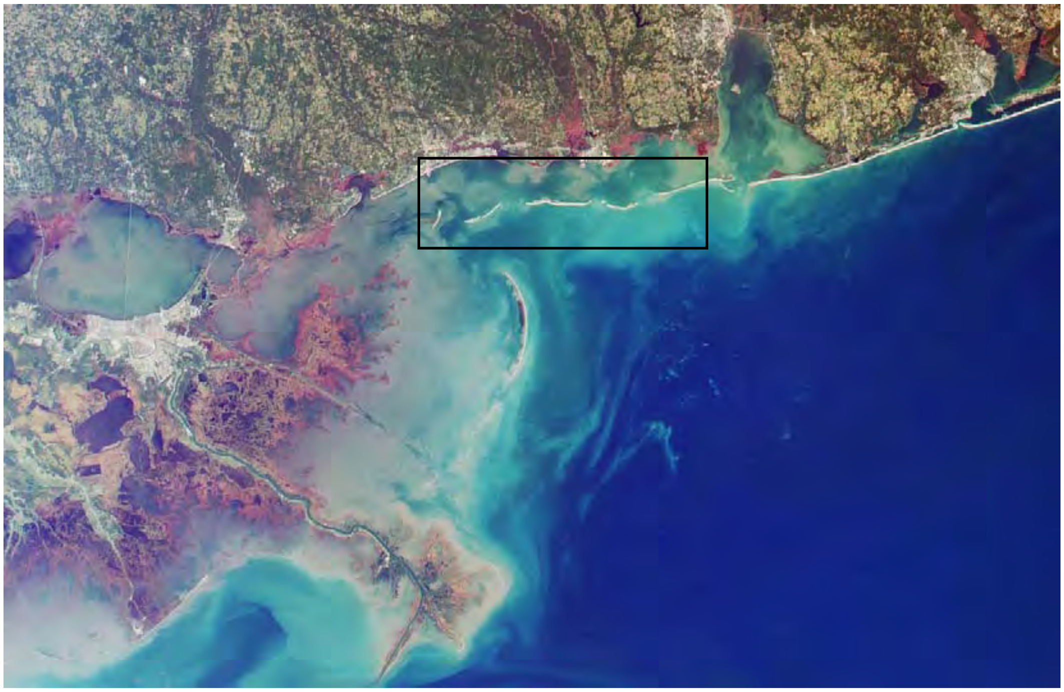

Figure 1.1. High-altitude imagery of the northern Gulf of Mexico between New Orleans, LA and Pensacola, FL. Black box illustrates the approximate location of the study area.

A series of devastating hurricanes over the past century has reduced the width and elevation of barrier beaches along the Mississippi Sound barrier islands, exposing mainland beaches, infrastructure, and navigation channels to increasing storm damage. A comprehensive evaluation of storm impacts requires analysis of historical shoreline and bathymetry data sets to document the evolution of beach, nearshore, and channel environments most directly influenced by major storms for determining net sediment transport pathways, quantifying net changes on a regional scale, and developing detailed sediment budgets. Throughout this report, data compiled and analyzed for Mississippi Sound barrier islands will be used to document historical sand transport patterns and geomorphic change since the mid-1800s toward development of a regional sediment budget.

1.1 Historical background

In early 1699, Pierre LeMoyne, Sieur d'Iberville, appointed by France to lead an expedition to the gulf coast in search of a site for a French settlement, landed near Pensacola Bay and found that the Spanish had arrived in the area a month earlier. D'Iberville continued west in search of the "Great River", identified as a good settlement area by LaSalle in an earlier expedition (Kennedy, 1980). The French fleet first explored a large sand spit fronting the eastern two thirds of Mobile Bay before sailing into a natural harbor near the eastern end of Dauphin Island. They remained in the harbor for a few days to weather a storm, but then continued their voyage westward along the Mississippi Sound barrier islands. D'Iberville named the islands for their most identifying feature; Massacre Island (later renamed Dauphin Island) for the remains of approximately sixty slain men and women found with household belongings on the southwest end of the island (McWilliams, 1981); Horn Island for its shape; Ship Island provided good harbor for vessels; and Cat Island had many unfamiliar raccoons (Kennedy, 1980). Petit Bois Island was not included in the list of islands, suggesting it was not present at the time of their voyage.

A map of coastal Alabama, created by D'Anville in 1732, indicates that Dauphin Island and Petit Bois Island may have been one continuous feature at the time of D'Iberville's voyage in 1699. Reference to this observation is made in a detailed description of Dauphin Island in 1713 by La Mothe Cadillac (governor of Louisiana at the time) stating the island was 6 leagues (1 league = 3 statute miles) long, wooded with pines for the easternmost 1 league, and about one-quarter league wide for the western 5 leagues of white shifting sand beaches and dunes (Kennedy, 1980). Figure 1.2 indicates that Dauphin Island was a long, continuous feature in 1732, with an inlet at its western end, adjacent to Isle aux Corne (Horn Island). Although Sullivan (2009) indicates that the hurricane of August 1717 split Dauphin Island into two islands, maps and other historical accounts suggest the storm of 22 September 1740 breached the western part of Dauphin Island, creating Petit Bois Pass and Petit Bois Island (Otvos, 1979; Otvos and Giardino, 2004).

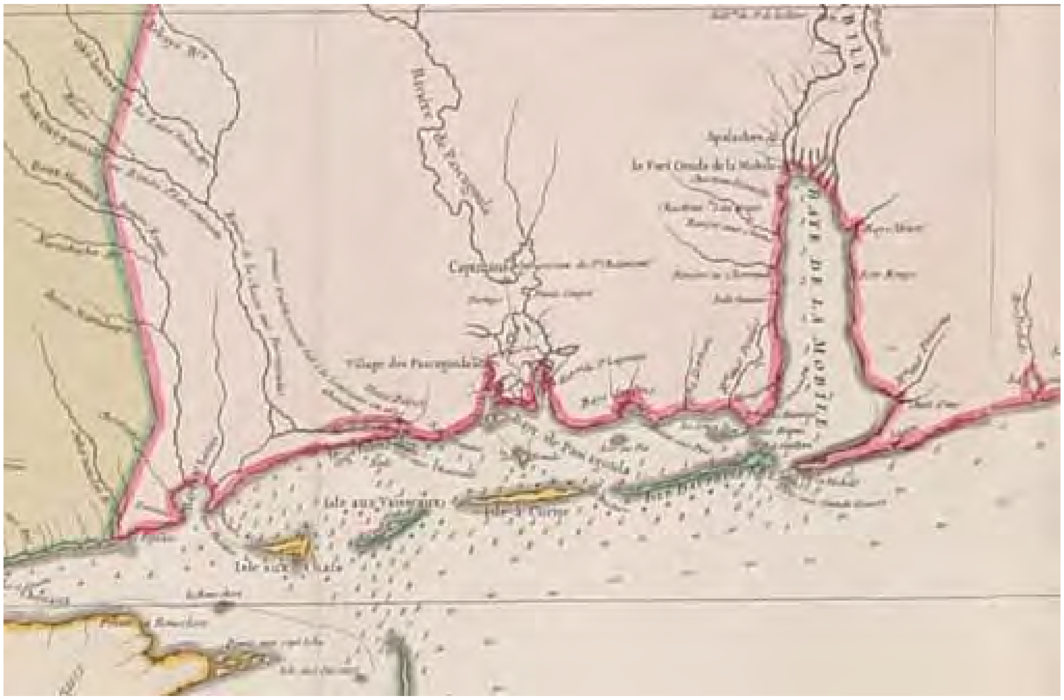

Figure 1.2. 1732 map of coastal Alabama and Mississippi (D'Anville "Carte de la Louisiane") illustrating an elongated Dauphin Island that may have encompassed Petit Bois Island at the time (from David Rumsey Map Collection).

1.2 Project Scope and Purpose

The Mississippi coastal zone consists of four barrier islands that create the offshore boundary for Mississippi Sound; four passes between the islands; three navigation channels and the Gulf Intracoastal Waterway (GIWW) serving three major ports (Gulfport, Biloxi, and Pascagoula); and the mainland coast, consisting of bays, sandy beaches, coastal structures, and wetlands (Figure 1.3). From west to east, the four Mississippi barrier islands are Cat, Ship (West and East), Horn, and Petit Bois. These islands are up to 14 miles offshore, and with Dauphin Island, Alabama, separate the Mississippi Sound from the Gulf of Mexico. The barrier islands provide the first line of defense for the mainland coast and navigation channels, serving to decrease gulf wave energy in their shadow and potentially modify the timing and magnitude of storm surge.

Barrier islands fronting the Mississippi Sound have been losing surface area through time, migrating rapidly to the west (except for Cat Island), and their capacity to protect mainland beaches and infrastructure is diminishing. From 1848 to 1986, long-term island area change rates were -6.2, +4.0,-10.4, -4.2, and -4.9 acres/year for Cat, West Ship, East Ship, Horn, and Petit Bois Islands, respectively (Byrnes et al. 1991; McBride et al. 1995).

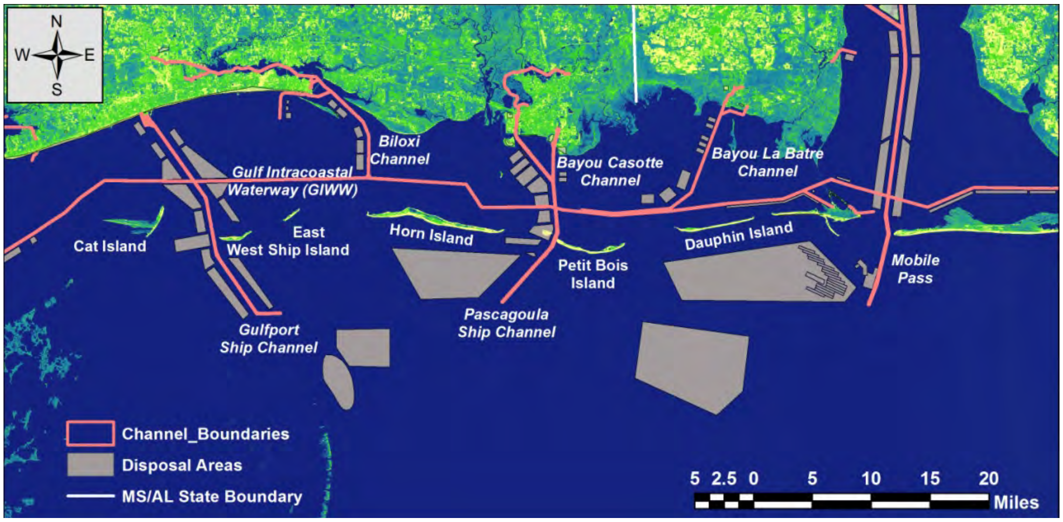

Figure 1.3. Mississippi and Alabama coastal deposits illustrating the barrier island system west of Mobile Pass, including navigation channels and dredged material disposal areas. Background image was acquired via Landsat on February 2, 2010.

Morton (2008) used the shoreline data of Byrnes et al. (1991), augmented with recent shoreline surveys acquired by the Mississippi Office of Geology (1995 to 2002), lidar surveys (2005, 2007), and registered aerial photography (2006), to compare recent shoreline changes with historical trends relative to storms and sea level. Morton stated that historical change trends for the barrier islands will continue as a result of rising sea level, frequent intense storms, and reduced sand supply. However, a detailed analysis of bathymetric change and channel dredging records is absent from Morton (2008), as well as all previous studies, to document long-term sediment transport pathways and quantities relative to engineering activities at the Pascagoula and Gulfport Ship Channels. A primary component of the present study was to evaluate historical dredging records and bathymetric surveys for quantifying sand flux throughout the littoral system and potential impact of dredging activities on transport quantities. As shown in Figure 1.3, the islands and mainland beaches are integrally connected with navigation channels vital to the Mississippi and Alabama coasts. Thus, any modifications that potentially change sediment transport pathways and magnitudes were of critical importance to the regional sediment budget.

Available historical shoreline and bathymetry data were compiled and analyzed to quantify net sand volume changes, document sediment transport pathways, and evaluate the potential impact of barrier island movement and degradation on the regional sand budget. The exchange of sediment between the barrier island littoral drift system, navigation channels, inlet shoals between the islands, and Mississippi Sound controls the sand budget throughout the system. Geomorphic changes caused by normal and storm conditions document cause and effect relationships that are often difficult to capture with short-term, site specific process measurements. Long-term shoreline and bathymetry change analyses record net sediment transport pathways and the volume of material in transit within a barrier island system. Data sets spanning long time intervals accurately describe geomorphic evolution of coastal systems by minimizing measurement uncertainties relative to the magnitude of detected change. In other words, measured change over short time intervals is generally small relative to longer time intervals, but the uncertainty associated with survey measurements remains relatively constant.

The primary goal of this component of the MsCIP study is to quantify net sediment volume changes associated with the historical evolution of nearshore morphology and adjacent beaches for the period 1917/20 to 2005/10. Net sediment transport pathways and quantities derived from these analyses provided the framework upon which island restoration quantities and geometry were designed. Littoral sand budgets derived from these analyses provide an update to the preliminary sand budget (1917/18 to 1961/68) presented in Rosati et al. (2007). Chapter 2 discusses the physical setting and processes within the region. Chapter 3 summarizes shoreline dynamics along the barrier islands, and Chapter 4 presents seafloor morphology and change. Chapter 5 documents calculated littoral sand budgets based on historical survey and dredging data for the periods 1917/18 to 1961/68 and 1917/18 to 2005/10. Chapter 6 summarizes knowledge gained through the study and makes recommendations for future operation and maintenance of navigation channels and restoration of the barrier islands and littoral transport system.

2 Physical Setting

Mississippi Sound barrier islands (Figure 1.3) extend approximately 65 miles from Dauphin Island, AL, to Cat Island, MS, and provide the first line of protection to mainland Mississippi and Alabama from storm waves and surge. Four tidal passes between the islands promote exchange of sediment and water between marine waters of the Gulf of Mexico and brackish waters of the Mississippi Sound. Tidal passes also interrupt the flow of littoral sand to the west from Mobile Pass ebb-tidal shoals and Dauphin Island. Petit Bois Pass is about 5 miles wide, with a poorly developed channel and system of shoals separating Dauphin and Petit Bois Islands. Horn Island Pass is approximately 3.5 miles wide and is occupied by the Pascagoula Ship Channel with a regularly maintained channel depth and width. Dog Keys Pass separates Horn and East Ship Island and has two entrance channels with well-developed ebb-tidal shoals (about 6 miles between the islands). Ship Island Pass exists along the western end of Ship Island and encompasses the Gulfport Ship Channel. Water depth in passes is generally 15 ft or less, except in navigation channels where maximum depths range from about 29 to 64 ft.

2.1 Coastal geology

According to Otvos and Carter (2008) and Otvos and Giardino (2004), the islands formed during a deceleration in sea-level rise approximately 5,700 to 5,000 years ago. At that time, the core of Dauphin Island at its eastern end was the only subaerial feature in the location of the modern barrier island system through which predominant west-directed littoral sand transport from the Florida panhandle via Mobile Pass ebb-tidal shoals could transit and deposit as elongate sand spits and barrier islands. Otvos and Giardino (2004) documented the growth of the Mississippi Sound barrier island system using sediment cores that illustrate shallow shoal platform sand, capped with beach sand transported from Mobile Pass shoals, overlying muddy Holocene nearshore sediment. Eastern Dauphin Island captured and transferred large volumes of littoral sand from Mobile Pass shoals and beaches east of the pass via west-directed longshore currents. The laterally-prograding barrier island system originally extended west to the Mississippi mainland shoreline near the Pearl River, marking the seaward limit of subaerial deposition and the formation of Mississippi Sound.

Beginning approximately 3,500 years ago, the Mississippi River flowed east of New Orleans toward the Mississippi Sound, creating the St. Bernard delta complex (Figure 2.1; Otvos and Giardino, 2004). Delta deposition extended over the western end of the Mississippi barrier island system, west of Cat Island. By about 2,400 years ago, fluvial sediment from the expanding St. Bernard delta created shoals as far west as Ship Island (Figure 2.1 B and C; Otvos, 1979), changing wave propagation patterns and diminishing the supply of west-directed littoral sand to Cat Island. With changing wave patterns and reduced sand supply from the east, the eastern end of Cat Island began to erode, resulting in beach sand transport perpendicular to

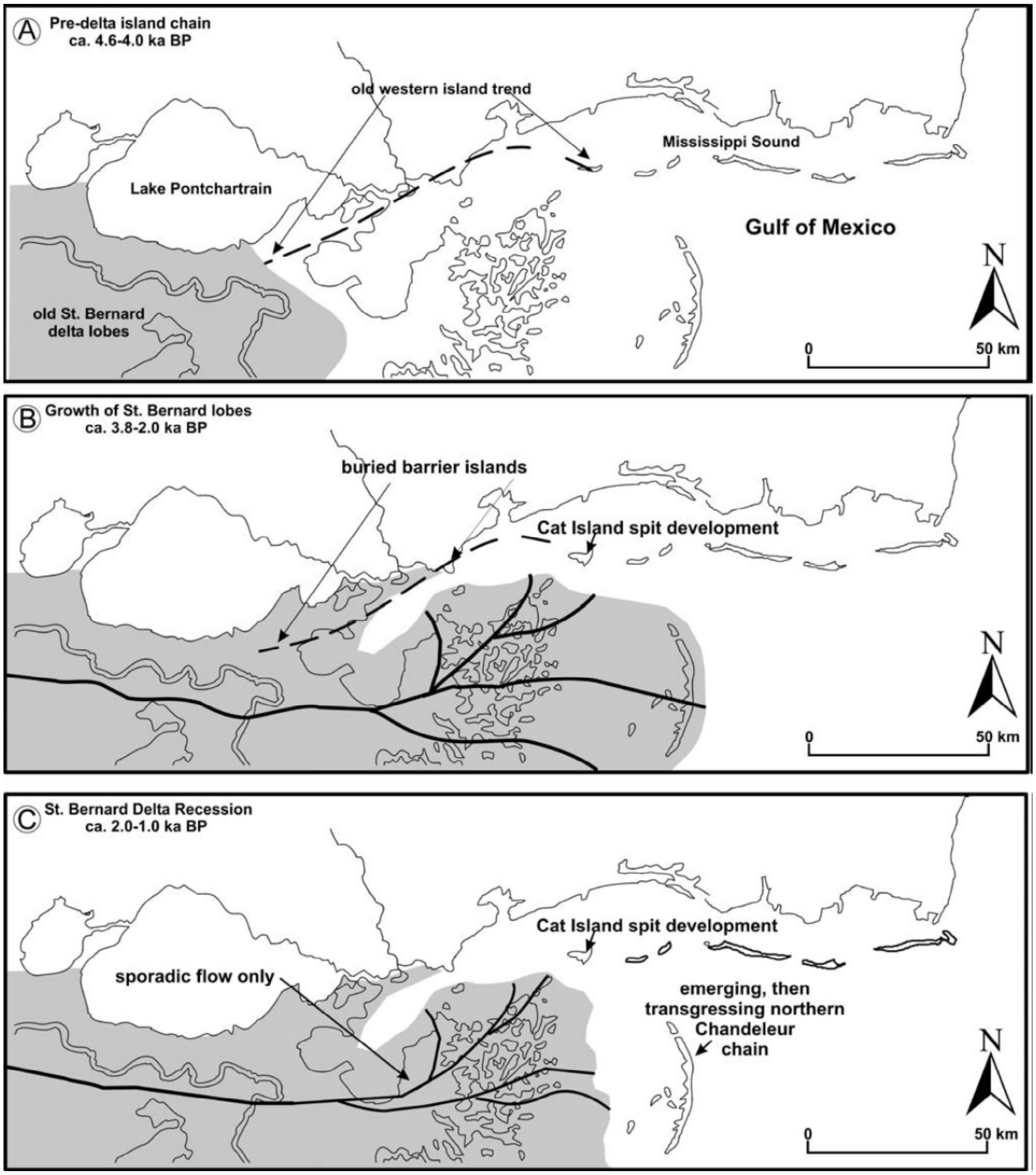

Figure 2.1. Barrier Island and St. Bernard delta lobe development as envisioned by Otvos and Giardino (2004).

original island orientation (Rucker and Snowden, 1989; Otvos and Giardino, 2004). Persistent sand transport from the east has been successful at maintaining island configuration relative to rising sea level for much of the barrier system; however, reduced sand transport toward Ship Island has resulted in increased island erosion and segmentation resulting from tropical storms (Rucker and Snowden, 1989). Waller and Malbrough (1976) and Byrnes et al. (1991) have documented changes in island configuration since the mid-1800s, illustrating westward migrating islands and inlets, with greatest island changes along Ship Island where sand supply is limited at the end of the littoral transport system.

2.2 Coastal processes

The Mississippi Sound is considered a microtidal estuary because its diurnal tide range is only about 1.7 ft (NOAA, 2010). The sound is relatively shallow and elongate (east-west) with an approximate surface area of 800 square miles (Kjerfve, 1986) and a tidal prism of about 3.8×10^{10} cubic feet. Although tidal currents account for at least 50 percent of flow variance, the sound responds rapidly to meteorological forcing, as evidenced by sub-tidal sea level variations of up to 3 ft and persistent net currents in the tidal passes (Kjerfve, 1986). The relatively shallow and large area of the sound creates strong currents in tidal passes between the barrier islands, ranging from 1.63 to 3.3 ft/sec and 5.9 to 11.5 ft/sec on flood and ebb tides, respectively (Foxworth et al. 1962). In winter months, winds from the same direction and of a sufficient magnitude are capable of lowering water surface elevations in the bays and nearshore from 1-2 ft (U.S. Army Corps of Engineers Mobile District 1984). Overall, circulation within the Mississippi Sound is generally weak and variable, and the estuary is vertically well-mixed. The Pascagoula and Pearl Rivers discharge fresh water into the sound at average rates of about 417 and 362 m^3/s, respectively (Kjerfve, 1986). However, during floods, peak discharge may reach 3,000 m^3/s, resulting in variable salinity and sharp frontal boundaries. Meteorological effects during the passage of cold fronts and tropical cyclones can double the strength of tidal currents.

Barrier islands protecting Mississippi Sound experience a low energy wave climate, with average significant wave height at National Data Buoy Center (NDBC) Buoy 42007 (22 nautical miles south-southeast of Biloxi, in 46 ft depth) averaging 2 ft and 1.3 ft in the winter and summer months, with associated average peak wave periods of 4 to 3.5 sec, respectively. Wave transformation modeling by Cipriani and Stone (2001) indicated that breaking wave heights on the barrier islands range from 1 to 2 ft. Waves in the Mississippi Sound are fetch- and depth-limited. The Coastal Studies Institute's Wave-Current Surge Information System (WAVCIS[1]) gage CSI-13 located at Ship Island Pass (23 ft depth) from June 1998 through July 2005 measured an average significant wave height of 0.3 ft and associated average wave period of 2.5 sec.

Littoral sand transport along the islands is predominantly from east to west in response to prevailing winds and waves from the southeast. Reversals in longshore transport occur at the eastern ends of the islands but their impact on net sediment transport is localized and minor relative to dominant transport processes from the southeast. Byrnes et al. (1991) illustrated historical changes in shoreline position along the MS barrier islands to document the dominance in east-west directed sand transport and quantify changes in island position and surface area since the mid-1800s. Morton (2008) documented similar trends using the shoreline data of Byrnes et al. (1991), modern GPS surveys from the Mississippi Office of Geology (1995 to 2002), lidar surveys (2005, 2007), and registered aerial photography (2006).

The barrier islands are composed of beach sand that is derived from updrift beaches east of Mobile Pass and from ebb-tidal shoals at the entrance. Although Cipriani and Stone (2001) and Otvos and Giardino (2004) stated that offshore sources may provide some sediment to the barrier islands, historical onshore movement of sand from outside the littoral zone was not indicated along the barrier island system based on initial sediment budget determinations (Rosati et al. 2007). Furthermore, Cipriani and Stone (2001) discussed that a well-defined cellular structure exists for each barrier island where little sand transfer exists between islands. However, dredging records at Horn Island and Ship Island Passes (called Pascagoula Bar Channel and Gulfport Bar Channel, respectively) suggest that infilling with littoral sand from adjacent barrier islands occurs, indicating the potential for transport of sand between islands.

2.3 Tropical cyclones

Otvos and Carter (2008), Morton, (2008), Byrnes et al. (2010), and many others have discussed the importance of tropical cyclones and other storms on sediment transport and geomorphic change throughout the barrier

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[1] http://www.wavcis.lsu.edu/, accessed 24 May 2011.

island system. Geomorphic changes recorded by sequential shoreline and bathymetric surveys along the barrier islands illustrate that storm processes dominate the signature of change. Although storm-induced cross-shore processes (e.g., island breaching and washover) are important factors influencing littoral transport and island configuration, longshore currents have provided vast quantities of sand to repair storm damage and promote growth on the western end of the islands (e.g., Byrnes et al. 2010).

The history of tropical cyclone occurrences for the Mississippi Sound barrier islands has been summarized by numerous authors (e.g., Blake et al. 2007; Sullivan, 2009; Byrnes et al. 2010) and web portals (Stormpulse, 2010; Hurricane City, 2010). Table 2.1 summarizes the tropical cyclone history for locations between New Orleans, LA and Gulf Shores, AL for the period 1872 through 2009. Byrnes et al. (1993) and Byrnes et al. (2010) document additional tropical cyclones for the study area between 1852 and 1872, the most important of which to island configuration is the “Great Mobile” hurricane of 1852 that made landfall on Horn Island (Sullivan, 2009) and breached Ship Island in the present location of Camille Cut (Figure 2.2). Three years later, the “Middle Gulf Shore” hurricane made landfall near Bay St. Louis as a Category 3 storm resulting in substantial damage along the western Mississippi coast. Five years later, another Category 3 hurricane caused significant damage along the Mississippi coast. Landfall was near Biloxi which meant that the greatest damage was recorded within a 30-mile radius of this location (Sullivan, 2009). These three major hurricanes within a period of eight years resulted in significant changes along the barrier islands and substantial damage to coastal communities in Louisiana, Mississippi, and Alabama.

In Table 2.1, the term “direct hit” indicates that the storm made landfall within 40 miles of the area of interest. The term “brush” indicates the storm made landfall within a 40- to 60-mile radius of the area of interest. The frequency of direct landfall varies from 10 to 12 years per storm for the central portion of the study area (Biloxi to Pascagoula) to 13 to 15 years per direct hurricane hit west and east of this area (New Orleans to Gulfport and Dauphin Island to Gulf Shores). However, all locations listed in Table 2.1 have been brushed or hit historically with a tropical storm or hurricane approximately once every 3 to 4 years. Cold fronts, although less intense than tropical storms and hurricanes, occur more frequently at approximately 30 to 40 times per year (Stone et al. 2004).

Table 2.1. Tropical cyclones within 60 miles of selected cities in LA, MS, and AL, 1872 to 2009 (from Hurricane City, 2010).

Location	Storm Type by Year ts=tropical storm; br=brush; h=hurricane	Frequency of Occurrence (yr)	
		Brush or Hit	Direct Hit
New Orleans, LA	1879h, 1879ts, 1887h, 1888br, 1897br, 1892ts, 1893h, 1900tsbr, 1901h, 1905ts, 1907ts, 1909h, 1914ts, 1915h, 1916br, 1932ts, 1934tsbr, 1936ts, 1944tsbr, 1947h, 1948h, 1949ts, 1955ts, 1964bdts, 1965h, 1969br, 1979h, 1985br, 1988ts, 1992br, 1998ts, 2002(2)ts, 2004tsbr, 2005ts, 2005h, 2008br, 2009tsbr	3.7 (38 in 139 years)	12.6 (11 in 139 years)
Gulfport, MS	1872ts, 1879br, 1881br, 1885ts, 1885tsbr, 1887ts, 1892ts, 1893h, 1895ts, 1900ts, 1901br, 1904-05tsbr, 1906h, 1907tsbr, 1912br, 1914tsbr, 1916h, 1923ts, 1926h, 1932br, 1934tsbr, 1944ts, 1947h, 1947ts, 1955tsbr, 1960ts, 1965br, 1969h, 1979br, 1985h, 1988br, 1998h, 2002tsbr, 2002(2)ts, 2004br, 2005ts, 2005h, 2009ts	3.5 (40 in 139 years)	15.4 (9 in 139 years)
Biloxi, MS	1879br, 1880br, 1881ts, 1885ts, 1885tsbr, 1887ts, 1892tsbr, 1893h, 1895h, 1900ts, 1901h, 1906h, 1907tsbr, 1912h, 1916h, 1923ts, 1926h, 1932h, 1934tsbr, 1947h, 1955tsbr, 1960ts, 1969h, 1985h, 1997br, 1998h, 2002ts, 2002tsbr, 2004br, 2005ts, 2005h, 2009ts	4.3 (32 in 139 years)	11.6 (12 in 139 years)
Pascagoula, MS	1872br, 1877br, 1881ts, 1885ts, 1885tsbr, 1887ts, 1889tsbr, 1893h, 1893br, 1895ts, 1900ts, 1901h, 1902tsbr, 1904tsbr, 1906h, 1911ts, 1912h, 1914tsbr, 1916h, 1923tsbr, 1926h, 1932h, 1934tsbr, 1944tsbr, 1947br, 1950br, 1960br, 1969h, 1979h, 1985h, 1997h, 1998h, 2002 ts, 2004h, 2005ts, 2005h, 2009ts	3.8 (37 in 139 years)	9.9 (14 in 139 years)
Dauphin Island, AL	1880br, 1881ts, 1882br, 1885ts, 1887ts, 1893h, 1895tsbr, 1900ts, 1901ts, 1902ts, 1904ts, 1906h, 1910h, 1911br, 1912br, 1914tsbr, 1916br, 1919tsbr, 1922tsbr, 1923tsbr, 1926h, 1932h, 1934ts, 1939ts, 1944tsbr, 1947ts, 1950h, 1956br, 1959ts, 1960tsbr, 1979h, 1985h, 1985tsbr, 1995br, 1997h, 1998br, 2002ts, 2004h, 2005(2)tsbr, 2005h, 2009ts	3.3 (42 in 139 years)	12.6 (11 in 139 years)
Gulf Shores, AL	1881br, 1882h, 1885ts, 1887br, 1889h, 1893br, 1901ts, 1902ts, 1904ts, 1906h, 1911h, 1912br, 1914tsbr, 1916h, 1919ts, 1922ts, 1926h, 1932br, 1934ts, 1939ts, 1947ts, 1950h, 1956br, 1959ts, 1979h, 1985br, 1985ts, 1995h, 1995br, 1997br, 1998br, 2002ts, 2004h, 2005ts, 2005h, 2009ts	3.9 (36 in 139 years)	12.6 (11 in 139 years)

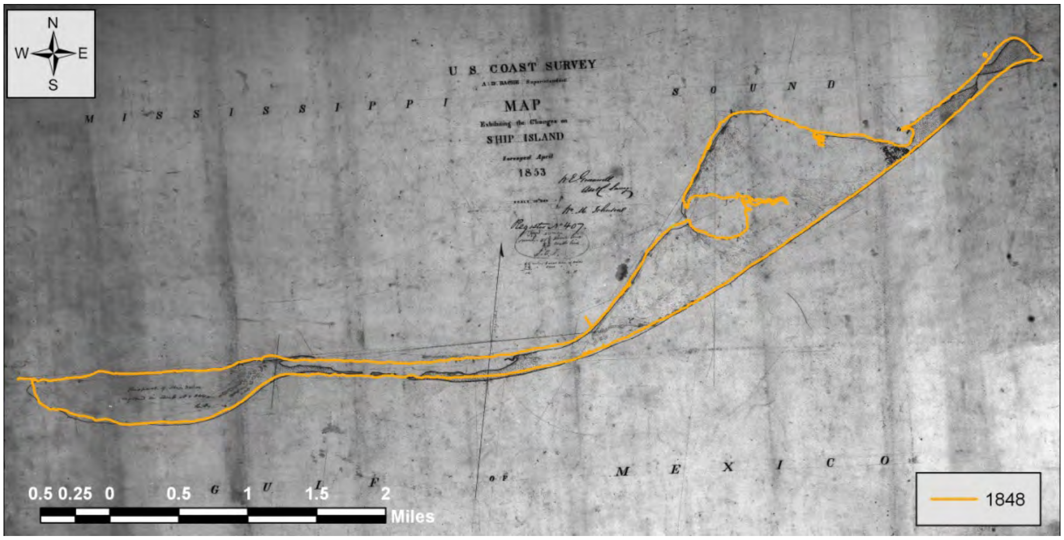

Figure 2.2. Island breaching between West and East Ship Island in response to the 1852 "Great Mobile" hurricane that made landfall near Horn Island.

2.4 Channel dredging and placement history

When d'Iberville first explored coastal Mississippi in search of a location for a permanent settlement in early 1699, he named Ship Island because the channel west of the island leading to the sound provided excellent depth for vessels sailing to the natural harbor of refuge north of the western tip of the island (Kennedy, 1980). The French, British, and Spanish used the natural harbors behind western Ship and Horn Islands for protection during storms and as strategic anchorage during times of conflict. During the War of 1812, the British amassed a large fleet of vessels at Ship Island in support of attacks on New Orleans. After Mississippi was admitted as a state into the Union in 1817, American military leaders recognized the benefit of Ship Island Pass and harbor, and the strategic importance of fortifying the island – the construction of Fort Massachusetts began in 1857.

Although the River and Harbor Act of 3 March 1881 authorized an initial examination of the harbors and passes at Horn and Ship Islands, it was not until 3 June 1896 and 3 March 1899 that Congress authorized channels be dredged to 21 and 26 ft mean low water, respectively (see Appendices A and B for detailed navigation channel histories). All channel dredging was driven by local industry (particularly timber) and the need for vessels to access protected harbors for loading and transporting product. Authorized project dimensions were not attained at Horn Island Pass until July 1907 (21 ft deep, 300 ft wide across the outer bar); however, channel dimensions for Ship Island Pass were completed in March 1900 (26 ft deep).

As shown in Figure 1.3, the study area is traversed by many navigation channels: two outer bar channels that extend through Horn Island Pass (also called Pascagoula Bar Channel) and Ship Island Pass (also called Gulfport Bar Channel); the Gulf Intracoastal Waterway (GIWW) that runs east-west through Mississippi Sound; and five sound navigation channels that extend from Gulfport, Biloxi, Pascagoula, Bayou Casotte, and Bayou La Batre. The Mobile District is responsible for maintaining authorized dimensions for these channels on a regular basis. Sediment dredged from the GIWW and other channels extending through the Mississippi Sound (primarily silt and clay) was side-cast or placed in designated disposal areas outside the littoral zone (see Figure 1.3). As such, dredging and placement activities in the sound do not influence the littoral sand budget for the barrier islands. However, channel dredging and placement adjacent to the barrier islands (Horn Island Pass and Ship Island Pass) must be considered when quantifying the littoral sediment budget. Table 2.2 provides a

Table 2.2. Summary of channel dredging quantities for Horn Island Pass and Ship Island Pass, Mississippi (see Appendices A and B for details).

Horn Island Pass/Pascagoula Bar Channel (1897 to 2009)			
Date	Authorized Channel Dimensions	New Work (cy)	Maintenance (cy)
Feb 1897 to March 1948	21-ft deep, 300-ft wide (July 1907 to May 1940) 25-ft deep, 300-ft wide (June 1940 to March 1948)	1,080,765	1,633,375 (40,600 cy/year)
May 1949 to Jan 1965	35-ft deep, 325-ft wide (June 1949 to April 1961) 38-ft deep, 325-ft wide, 2.8 mile long (June 1962 to January 1965)	2,015,520	3,607,240 (232,100 cy/year)
April 1965 to Sept. 1993	40-ft deep, 350-ft wide; Impoundment area along the western end of Petit Bois Island (August 1965 to September 1993)	1,305,589	14,309,352 (509,400 cy/year)
Sept. 1995 to Nov. 2009	44-ft deep, 450-ft wide; Impoundment area along the western end of Petit Bois Island (January 2000 to November 2009)	4,980,040	5,399,492 (394,600 cy/year)
1897 to 2009	Total Dredging	9,381,914	24,949,459 (245,000 cy/year)
Ship Island Pass/Gulfport Bar Channel (1899 to 2009)			
Nov 1899 to March 1948	26-ft deep, 300-ft wide, about 4,000-ft long (March 1900 to March 1948)	207,401	2,071,584 (43,200 cy/year)
Nov. 1949 to Sept 1991	32-ft deep, 300-ft wide, 8 miles long (April 1950 to September 1991)	3,679,044	10,710,570 (258,800 cy/year)
May 1992 to June 2009	38-ft deep, 300-ft wide; channel realigned to the west (November 1993 to June 2009)	5,943,023	2,708,966 (173,800 cy/year)
1899 to 2009	Total Dredging	9,829,468	15,491,120 (141,800 cy/year)

summary of channel dredging quantities for authorized channel dimensions as detailed in Appendices A and B. Figures 2.3 and 2.4 illustrate cumulative maintenance dredging quantities since channel authorization. The timing for authorized channel dimension changes is shown on each diagram, and the rate at which sand has been extracted from the channel is documented for specific segments of time when channel dimensions are consistent.

The littoral sand budget for barrier beaches is a balance between natural sand sources to the system, depositional zones or sinks within the system, natural sediment transport to locations outside of the littoral zone, and placement of dredged material from the littoral zone (e.g., navigation channel dredging; borrow site excavation) seaward of the zone of active sand transport under incident waves and currents. Disposal of littoral sand from channel dredging (new work and maintenance) at Horn and Ship Island Passes has not been consistent for the periods of sediment budget evaluation (1917/18 to 1961/68 [short-term]; 1917/18 to 2005/10 [long-term]). Tables 2.3 and 2.4 summarize sand placement quantities within the active littoral zone relative to total maintenance and new work channel dredging for both passes. When the quantity of maintenance dredging equals the quantity placed in the active littoral zone, the sand budget due to engineering activities is balanced. For Horn Island Pass, the difference

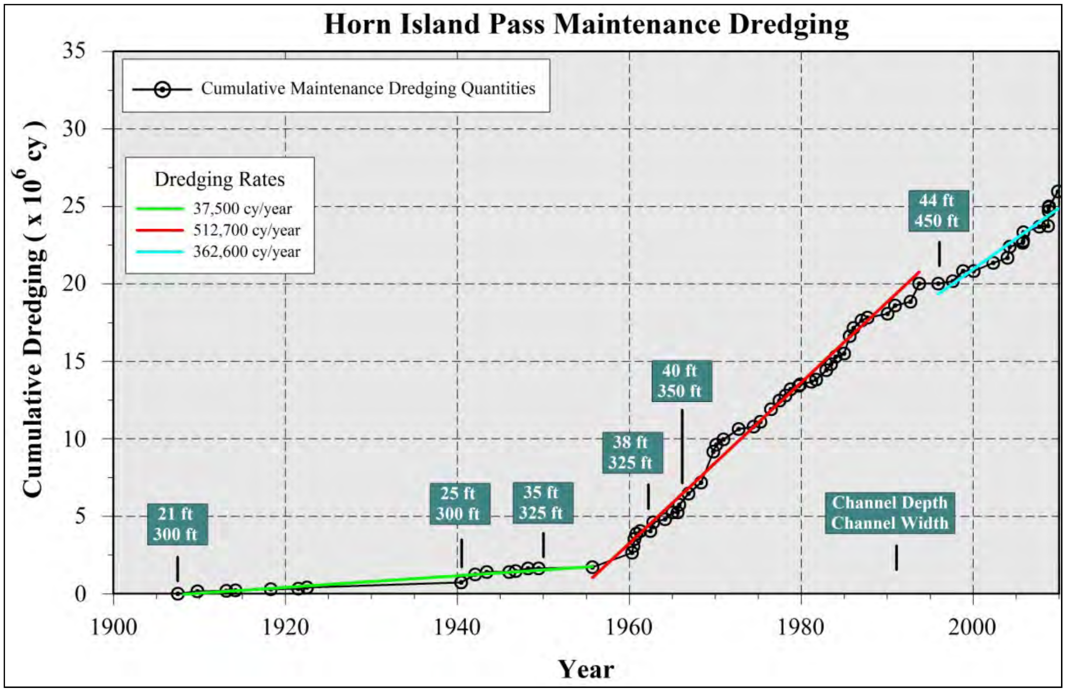

Figure 2.3. Cumulative maintenance dredging volumes and associated sand dredging rates for Horn Island Pass.

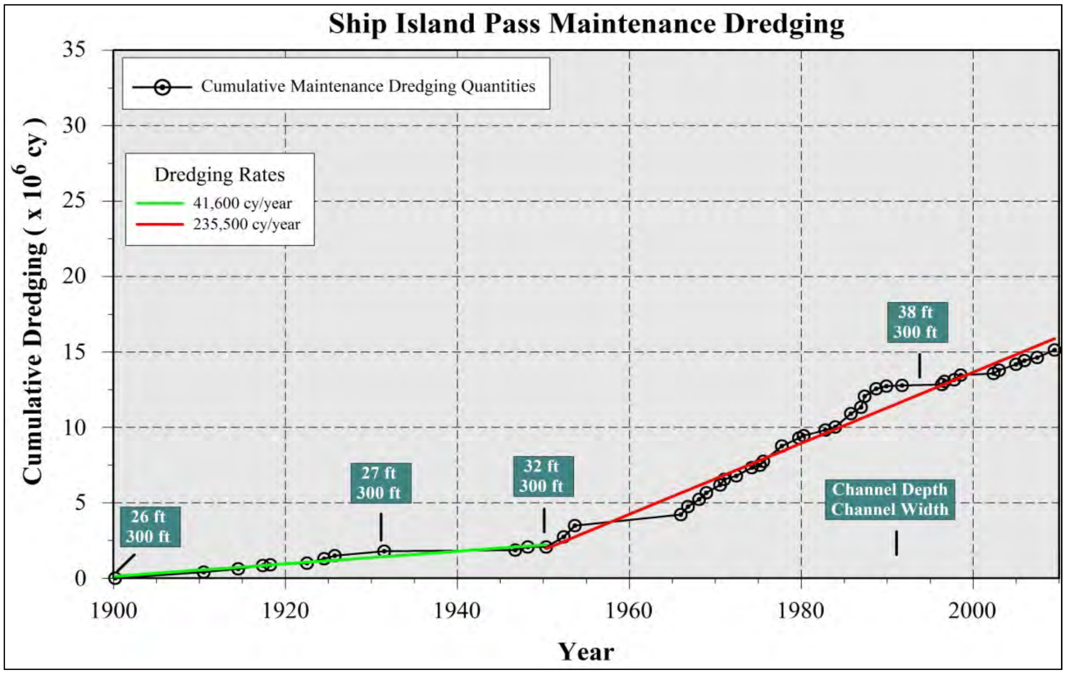

Figure 2.4. Cumulative maintenance dredging volumes and associated sand dredging rates for Ship Island Pass, MS.

Table 2.3. Summary of dredged material placement quantities for Horn Island Pass/Pascagoula Bar Channel, Mississippi (see Appendix A for details).

September 18, 1917 to November 9, 1961 (short-term sediment budget)			
September 18, 1917 to June 20, 2009 (long-term sediment budget)			
Dredged Material Placement Location (see Figure 2.5)	New Work (cy)	Maintenance (cy)	New Work plus Maintenance (cy)
BN and D/A #10	0	0	0
	3,121,564 (34,000 cy/year)	6,853,557 (74,700 cy/year)	9,975,121 (108,700 cy/year)
Littoral Zone	0	0	0
	1,858,476 (20,200 cy/year)	383,272 (4,200 cy/year)	2,241,748 (24,400 cy/year)
Pre-1992 Open Water (western lobe of ebb shoal)	0	0	0
	Unknown	5,268,152 (57,400 cy/year)	5,268,152 (57,400 cy/year)
Placement Before August 1962 (offshore western lobe of ebb shoal)	0	3,820,969 (86,600 cy/year)	3,820,969 (86,600 cy/year)
	1,257,815 (13,700 cy/year)	3,820,969 (41,700 cy/year)	5,078,784 (55,400 cy/year)
Total Dredging	1,257,815 (28,500 cy/year)	3,820,969 (86,600 cy/year)	5,078,784 (115,100 cy/year)
	8,592,664 (93,600 cy/year)	23,768,376 (259,000 cy/year)	32,361,040 (352,600 cy/year)

Table 2.4. Summary of dredged material placement quantities for Ship Island Pass/Gulfport Bar Channel, Mississippi (see Appendix B for details).

<table>
<tr><td colspan="4">September 18, 1917 to March 18, 1968 (short-term sediment budget)</td></tr>
<tr><td colspan="4">September 18, 1917 to June 16, 2009 (long-term sediment budget)</td></tr>
<tr><td>Dredged Material Placement Location (see Figure 2.6)</td><td>New Work (cy)</td><td>Maintenance (cy)</td><td>New Work + Maintenance (cy)</td></tr>
<tr><td rowspan="2">Fort Massachusetts</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>0</td><td>1,080,301
(11,800 cy/year)</td><td>1,080,301
(11,800 cy/year)</td></tr>
<tr><td rowspan="2">Littoral Zone</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>5,943,023
(64,800 cy/year)</td><td>1,003,225
(10,900 cy/year)</td><td>6,946,248
(75,700 cy/year)</td></tr>
<tr><td rowspan="2">Total Dredging</td><td>3,723,044
(73,700 cy/year)</td><td>4,389,070
(86,900 cy/year)</td><td>8,112,114
(159,600 cy/year)</td></tr>
<tr><td>9,666,067
(109,700 cy/year)</td><td>13,703,904
(155,500 cy/year)</td><td>23,369,971
(265,200 cy/year)</td></tr>
</table>

between littoral zone placement and maintenance dredging is about -3,821,000 cy (1917 to 1961) and -6,283,000 cy (1917 to 2009; net deficit to the littoral sand budget). However, maintenance dredging sand placed in D/A #10 (about 6,854,000 cy) primarily has accumulated in the northern portion of the littoral zone where transport to eastern Horn Island is limited. As such, the effective deficit to the littoral sand budget due to maintenance dredging at Horn Island Pass is approximately 13,137,000 cy (1917 to 2009). For Ship Island Pass, the difference between littoral zone placement and maintenance dredging is about -4,389,000 cy (1917 to 1968) and -5,677,000 cy (1917 to 2009) (Table 2.4). Because Ship Island Pass is the terminal location for littoral transport along the Mississippi barrier shoreline, sand placement cannot be considered a net loss to the natural transport system from channel dredging.

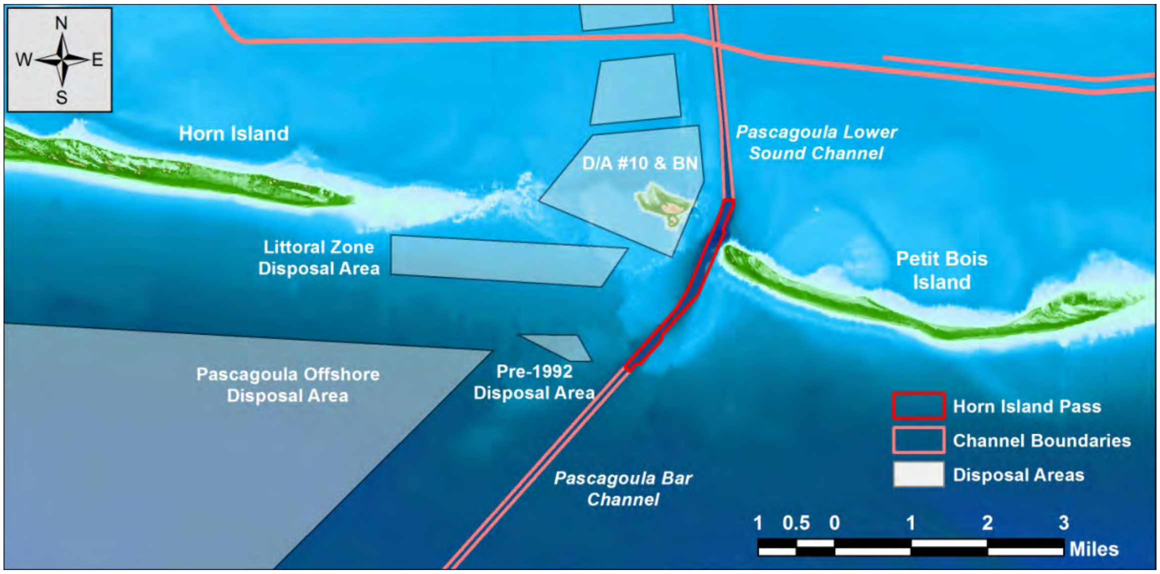

Figure 2.5. Location of Horn Island Pass in the Pascagoula Bar Channel and dredged material disposal sites. Dredged sand quantities from Horn Island Pass are documented in Appendix A and summarized in Tables 2.2 and 2.3. Background surface is a compilation of October 2005 lidar data for the islands and September 2005 bathymetry data for the channel and entrance area.

Figure 2.6. Location of Ship Island Pass in the Gulfport Bar Channel and dredged material disposal sites. Dredged sand quantities from Ship Island Pass are documented in Appendix B and summarized in Tables 2.2 and 2.4. Background surface is a compilation of October 2005 lidar data for the islands and September 2005 bathymetry data for the channel and entrance area.

3 Shoreline Dynamics

Shoreline change along the Mississippi Sound barrier islands reflects the imbalance between sand supply and energy (waves, currents, and wind) required to move sand throughout the system. Natural perturbations to sand transport throughout the study area result from variations in high energy storms and normal transport processes relative to the sand availability. Historical shorelines document natural and human-induced changes depending on the frequency of data collection relative to the frequency of events resulting in change.

Although metric-quality maps of shoreline position were not available prior to 1847, historical depictions of shoreline shape in the study area suggest that the Mobile Pass ebb-tidal delta and eastern Dauphin Island were the primary sources of sand to downdrift barrier islands fronting Mississippi Sound. Prior to becoming part of the United States, a map of the Mississippi Sound barrier islands, created by D'Anville in 1732, indicated that Dauphin Island and Petit Bois Island may have been one continuous feature (Figure 1.2). Based on this map, Otvos (1979) and Otvos and Giardino (2004) stated that Dauphin and Petit Bois Islands formed a single unit in the early 18th century. However, in 1816, William Darby published a map of coastal Mississippi/Alabama indicating that Dauphin and Petit Bois Islands were separated by a pass (Figure 3.1). The map also illustrates that the presence of Dog Island, between Horn and Ship Islands, was possibly a remnant of eastern Ship Island before a storm breach/pass formed. Regardless of island configuration, historical maps record a continuous sequence of islands and passes that have acted as efficient conduits for west-directed transport of sand from western Florida and eastern Alabama to barrier beaches fronting the Mississippi Sound.

3.1 Data sources

Twelve regional outer coast shoreline surveys were used to document historical shoreline change between Cat Island, MS (west) and Dauphin Island, AL (east) for the period 1847/49 to 2010. The first five surveys were conducted by the US Coast & Geodetic Survey (USC&GS; presently the National Ocean Service [NOS]) in 1847/49, 1916/17, 1950/57, 1966/70, and 1981/86, and surveys obtained between 1993 and 2000 were completed by Mississippi Office of Geology personnel. The 2001/02 and 2010 shorelines

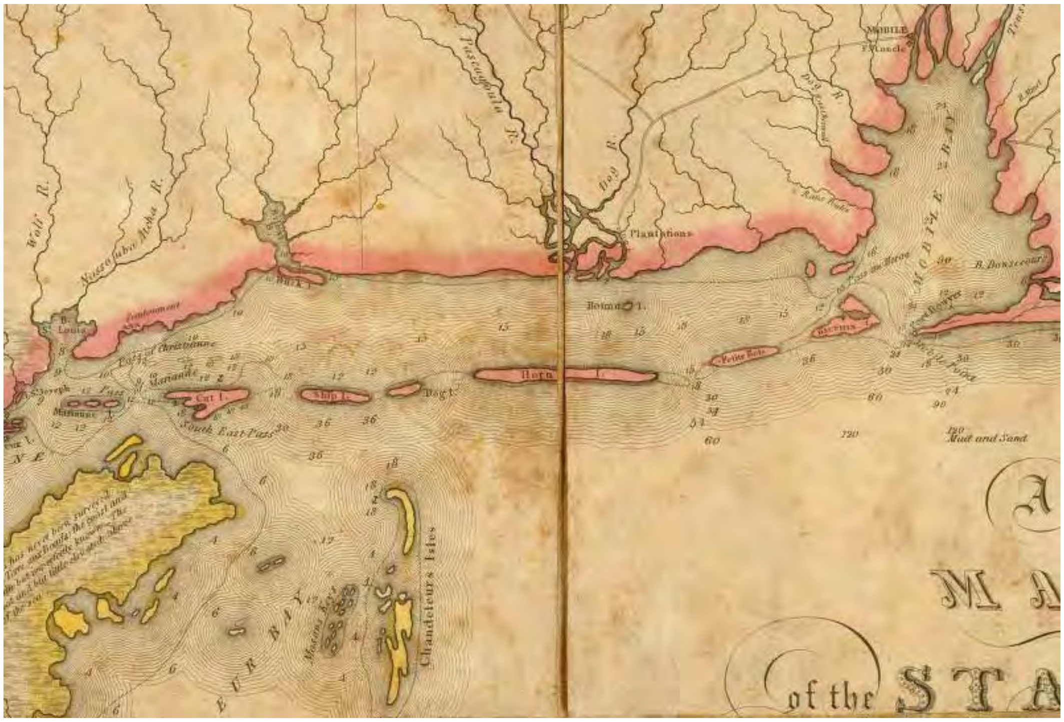

Figure 3.1. 1816 map of coastal Alabama and Mississippi by William Darby illustrating the existence of Petit Bois Island west of a pass/breach near central Dauphin Island (from David Rumsey Map Collection).

were derived by Applied Coastal personnel (see Table 3.1). The 1847/49 and 1916/17 surveys were completed as field surveys using standard planetable techniques; the 1950/57, 1966/70, 1981/86, 2002, and 2010 shoreline surveys were interpreted from registered aerial photography or high-resolution orthoimagery; and the 1993 through 2001 shoreline surveys were conducted using differential Global Positioning System (GPS) equipment with a ground resolution of about ±3 ft.

Digital shoreline data for 1847/49, 1916/17, 1950/57, 1966, and 1981 were compiled at Applied Coastal from scanned USC&GS topographic sheets using techniques described in Byrnes and Baker (2003) and Baker and Byrnes (2004). Digital shoreline data for the period between 1993 and 2001 were developed from GPS survey points collected on the ground at the interpreted position of the high-water shoreline for each survey date. The 1970, 1993, 2002, and 2010 shorelines were interpreted by Applied Coastal personnel from rectified digital aerial photography and high-resolution orthoimagery using on-screen Geographic Information System (GIS) digitizing procedures. All imagery was supplied by the USACE Mobile District.

Table 3.1. Shoreline source data characteristics.

Date	Data Source	Comments and Map Numbers
1847/49	USC&GS Topographic Maps; 1:20,000	First regional shoreline survey throughout study area using standard planetable surveying techniques; May and June 1847 - Dauphin Island (T-240); 1848 – Cat Island (T-242), Ship Island (T-244), Petit Bois Island (T-245); February 1849 - Horn Island (T-274).
1916/17	USC&GS Topographic Maps; 1:40,000	Second regional shoreline survey along the seaward coast of the study area using standard planetable surveying techniques (regional-scale reconnaissance survey); 1916/17 – Cat Island and Ship Island (T-3701); August to December 1917 – Petit Bois Island (T-3702); August to September 1917 – Horn Island (T-3703); October to December 1917 - Dauphin Island (T-3711).
May 1950 and November 1957	USC&GS Topographic Maps; 1:20,000 (T-9383, T-9384, T-9385, T-9655); 1:10,000 (all others)	All maps produced from interpreted aerial photography; 15 May 1950 – Cat Island (T-9383), Ship Island (T-9384, T-9385), western Horn Island (T-9385); 9 November 1957 – Dauphin Island (T-10761, T-10762, T-10770, T-10771, T-10772), Horn Island (T-10763, T-10764, T-10765, T-10766), Petit Bois Island (T-10767, T-10768).
January 1966 and May 1970	USC&GS Topographic Maps, 1:10,000; USACE Aerial Photography, 1:24,000	All maps produced from interpreted aerial photography; 27 January 1966 – Cat Island (T-13036, T-11946, T-11947, T-11949), Ship Island (13032, T-13033, T-13034), Horn Island (T-13035); May 1970 – USACE aerial photography registered and interpreted by Applied Coastal.
February/March1981 and October 1986	USC&GS Topographic Maps, 1:20,000; USACE Aerial Photography, 1:24,000	All maps produced from interpreted aerial photography; 3 February and 6 March 1981 – Dauphin Island (TP-00929, TP-00930); 17 October 1986 – interpreted from USACE aerial photography using control points from USGS topographic map.
June 1993	Differential GPS Ground Survey (1:1); USACE Aerial Photography, 1:24,000	West and East Ship, Horn, and Petit Bois Islands surveyed by the MS Office of Geology on 15 June 1993. June 1993 - Dauphin Island; USACE aerial photography registered and interpreted by Applied Coastal.

Date	Data Source	Comments and Map Numbers
September 1994 and April 1995	Differential GPS Ground Survey (1:1)	Cat Island surveyed on 15 April 1995; other MS Sound barriers surveyed on 5 September 1994 (MS Office of Geology)
15 October 1997	Differential GPS Ground Survey (1:1)	MS Sound Barrier Islands surveyed by the MS Office of Geology
1 October and 1 November 1998	Differential GPS Ground Survey (1:1)	MS Sound Barrier Islands surveyed by the MS Office of Geology
June and August 2000	Differential GPS Ground Survey (1:1)	MS Sound Barrier Islands surveyed by the MS Office of Geology on 1 June (Cat Island) and the National Park Service 1 August (West and East Ship, Horn, and Petit Bois)
June 2001 and October/November 2002	Differential GPS Ground Survey (1:1); USACE Orthoimagery, 1:4,800	MS Sound Barrier Islands surveyed by the National Park Service – 24 October 2002 (Ship Island), 25 October 2002 (Horn Island), 21 November 2002 (Petit Bois Island); USACE Orthoimagery – February 2002 (Dauphin Island); Applied Coastal GPS Ground Survey (Dauphin Island) 1 June 2001.
9-25 April 2010	Digital Orthophotography	MS Sound Barrier Islands; 1-foot resolution imagery

The horizontal position of the GPS high-water shoreline was determined visually using a hierarchy of criteria dependent on morphologic features present on the subaerial beach. The primary criterion was a well-marked limit of uprush by waves associated with high tide. This generally was recognized on the beach as the berm crest (Figure 3.2). If the berm crest did not exist, a debris line generally could be identified, above which aeolian processes dominate sediment transport and below which wave and current processes create a relatively smooth foreshore. The criteria adopted are consistent with those used by field topographers and photo interpreters in developing NOS T-sheet shorelines (Shalowitz, 1964). All high-water shoreline data were converted to shapefile format and projected into a common horizontal coordinate system and datum, in this case Universal Transverse Mercator (UTM) Zone 16 (ft), North American Datum of 1983 (NAD83).

3.2 Measurement uncertainty

In determining shoreline position change, all data contain inherent uncertainties associated with data acquisition and compilation procedures. It is important to quantify limitations in survey measurements and document

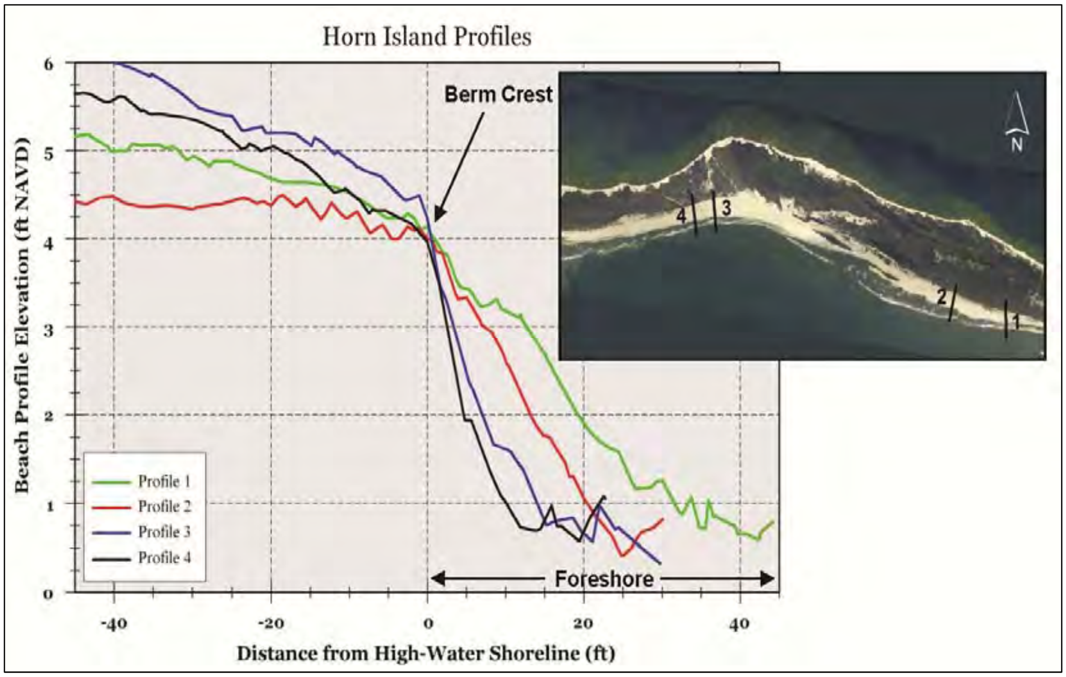

Figure 3.2. High-water shoreline elevation based on beach profile data derived from April 2010 lidar data, Horn Island, MS. Elevation of the high-water shoreline is about +4 ft NAVD. The foreshore is the zone of sand transport by swash and backwash, resulting in beach and shoreline changes.

potential systematic errors that can be eliminated during quality control procedures (Anders and Byrnes, 1991; Crowell et al. 1991; Byrnes and Hiland, 1995; Baker and Byrnes, 2004). Substantial effort was spent ensuring that any systematic errors were eliminated prior to change analysis. As such, measurement errors associated with present and past shoreline surveys are considered random. However, data compilation uncertainties should be quantified to gauge the significance of measurements used for research/engineering applications and management decisions. Table 3.2 summarizes estimates of potential uncertainties at any given point along the MS Sound barrier islands for shoreline data sets illustrating temporal and spatial changes. Because individual uncertainties are considered to represent standard deviations, root-mean square estimates are calculated as a realistic assessment of combined potential uncertainty. Positional random errors for each shoreline can be calculated using the information in Table 3.2; however, change analysis requires comparing two shorelines from the same geographic area, but different time periods. Table 3.3 presents a summary of potential random errors associated with change analyses computed for specific time periods. As expected, maximum positional uncertainties are associated with the oldest shorelines (1847/49 and 1916/17) at the smallest scale (1:40,000). However, most change estimates for the study area document shoreline advance or recession greater than these values. Overall, because random errors are considered equally distributed, they can be neglected statistically relative to average change calculations over long coastal reaches containing many change measurements.

3.3 Previous studies

Prior to the present analysis of shoreline dynamics, five studies documented shoreline change for the barrier islands of the Mississippi Sound. Waller and Malbrough (1976) provided the first quantitative summary of sound and gulf shoreline changes using maps and aerial photography for the period 1848 to 1973. Otvos (1979) established a qualitative history of shoreline evolution for the barrier islands using mid-18th century maps and written accounts and the historical data of Waller and Malbrough (1976). Shabica et al. (1984) documented relatively short-term changes in shoreline

Table 3.2. Estimates of potential random error associated with shoreline surveys.

Traditional Engineering Field Surveys (1847/49 and 1916/17)			
Location of rodded points	±3 ft		
Location of plane table	±7 to 10 ft		
Interpretation of high-water shoreline position at rodded points	±10 to 13 ft		
Error due to sketching between rodded points	up to ±16 ft		
Cartographic Uncertainties (1847/49, 1916/17, 1950/57, 1966, and 1981)	Map Scale		
	1:10,000	1:20,000	1:40,000
Inaccurate location of control points on map relative to true field location	up to ±10 ft	up to ±20 ft	up to ±40 ft
Placement of shoreline on map	±16 ft	±33 ft	±66 ft
Line width for representing shoreline	±10 ft	±20 ft	±40 ft
Digitizer error	±3 ft	±6 ft	±12 ft
Operator error	±3 ft	±6 ft	±12 ft
Historical Aerial Surveys (1950/57, 1966/70, 1981/86,1993, and 2002)	Map Scale		
	1:10,000	1:20,000	1:40,000
Delineating high-water shoreline position	±16 ft	±33 ft	±66 ft
2010 Orthophotography (delineating shoreline)	☐6 ft		
GPS Shoreline Surveys (1993, 1994, 1997, 1998, 2000, 2001)			
Delineating high-water shoreline	±3 to 10 ft		
Position of measured points	±6 to 16 ft (specified) ±3 to 10 ft (field tests)		

Sources: Shalowitz, 1964; Ellis 1978; Anders and Byrnes, 1991; Crowell et al. 1991.

Table 3.3. Maximum root-mean-square potential uncertainty for shoreline change data from Cat Island, MS to Dauphin Island, AL.

	1916/17	1950/57	1966/70	1981/86	2000/01	2010
1847/49	±104.2[1]	±74.5/±56.8	±56.8/±74.5	±74.5	±53.4	±50.3
	(±1.5)[2]	(±0.7/±0.5)	(±0.5/±0.6)	(±0.6)	(±0.3)	(±0.3)
1916/17		±106.9/±95.4	±95.4/±106.9	±106.9	±93.5	±91.7
		(±3.1/±2.3)	(±1.9/±2.0)	(±1.6)	(±1.1)	(±1.0)
1950/57			±54.3/±61.5	±61.5/±78.1	±58.4/±33.0	±55.6/±27.7
			(±3.4/±4.7)	(±2.0/±2.7)	(±1.2/±0.7)	(±0.9/±0.5)
1966/70				±61.5/±78.1	±33.0/±58.4	±27.7/±55.6
				(±3.1/±4.9)	(±1.0/±1.9)	(±0.6/±1.4)
1981/86					±53.4	±55.6
					(±2.8)	(±1.9)
2000/01						±19.8
						(±2.0)

[1] Magnitude of potential uncertainty associated with high-water shoreline position change (ft); [2] Rate of potential uncertainty associated with high-water shoreline position change (ft/yr).

position for the Mississippi Sound barrier islands (1957 to 1980) using aerial photography. Byrnes et al. (1991) applied computer mapping and GIS technology to compile and analyze source data from NOS to quantitatively document changes in shoreline position and island area for the period 1848 to 1986. Most recently, Morton (2008) used the digital map data of Byrnes et al. (1991), ground level GPS surveys of high-water shoreline position acquired by the Mississippi Office of Geology (1995 to 2002), lidar surveys (2005, 2007), and registered aerial photography (2006) to update the historical data set to 2007.

Waller and Malbrough (1976) used United States Geological Survey (USGS) 7.5-minute quadrangle maps as base maps for their study; all T-sheets and aerial photographs were either enlarged or reduced to the precise scale of the USGS topographic maps for comparison of shoreline position. Rates of change were calculated at 1,000-ft longshore intervals and shoreline change measurements were made to ±50 ft. Long-term rates of gulf shoreline movement for Petit Bois Island were estimated to be about 5.9 ft/yr along the western half of the island and -11.5 ft/yr for the eastern shoreline. Horn Island showed an average retreat of about 2.0 ft/yr, whereas Ship Island averaged about -9.8 ft/yr but showed considerable variability in magnitude and direction. Magnitudes of shoreline change along the gulf side of Cat Island were more consistent than those recorded for Ship Island and averaged -7.9 ft/yr between 1848 and 1973. Recognizing the importance of lateral island migration in response to westward-directed longshore transport, Waller and Malbrough (1976) tabulated net average rates of erosion and accretion on the east and west ends of the island systems: Petit Bois Island - 322 ft/yr (east), 118 ft/yr (west); Horn Island - 119 ft/yr (east), 125 ft/yr (west); Ship Island - 44 ft/yr (east), 38 ft/yr (west). Knowles (1989) illustrates the same trend for western Ship Island.

Shabica et al. (1984) documented short-term shoreline change for the Mississippi barrier islands using near-vertical aerial photographs. Prior to annotating high-water shoreline position, 1:5000 scale base maps were produced by photo-enlarging USGS 7.5-minute quadrangles. Aerial photographs were then enlarged (but not rectified) to the scale of the base map, and measurements of shoreline position change were estimated. The average retreat rate for Petit Bois Island was 2.6 ft/yr, and net shoreline advance of about 1.0 ft/yr was documented for Horn Island for the period 1957 to 1980. West Ship Island exhibited net progradation (2.0 ft/yr) whereas East Ship Island retrograded an average -21.0 ft/yr. Rates of shoreline recession along Cat Island for the period 1932 to 1978 averaged about 8.2 ft/yr, a much lower rate of change than recorded along East Ship Island.

Byrnes et al. (1991) applied a computer-based shoreline mapping methodology, within a GIS framework, to compile and analyze changes in historical shoreline position and island area between 1847/49 and 1986. The dominant direction of movement for Dauphin, Petit Bois, Horn, and Ship Islands was to the west, whereas cross-shore change in shoreline position was the primary mechanism by which beaches on Cat Island responded to incident processes. Average shoreline change for the study area was about -5.6 ft/yr; however, Horn Island illustrated no net cross-shore change for the period of record and the western halves of Petit Bois and Ship Islands were net accretional. The magnitude of lateral island migration was determined to be an order of magnitude greater than cross-shore movements. East of Dog Keys

Pass, the islands migrated to the west by updrift erosion and downdrift accretion at rates exceeding 100 ft/yr. Byrnes et al. (1991) illustrated the greatest lateral movement along the eastern end of Petit Bois Island (approximately 295 ft/yr between 1848 and 1986). Long-term changes recorded for the ends of Ship Island were significantly smaller, primarily due to the proximity of the Gulfport navigation channel and distance from a sand source, limiting the quantity of sand available for natural bypassing to the west at the distal end of the longshore transport system.

Morton (2008) documented similar shoreline change trends illustrated in previous studies. However, he suggested that recent data sets indicate an acceleration in change trends. Morton documents that the Mississippi barriers are undergoing systematic land loss and lateral movement to the west associated with an imbalance in subaerial erosion (east) and deposition (west) along the islands, island narrowing as a result of erosion along the gulf and sound shorelines, and barrier segmentation related to storm breaching. Morton (2008) suggests that the principal causes of land loss are frequent intense storms, relative rise in sea level, and a sediment-budget deficit due to channel dredging at Mobile and Horn Island Passes, although detailed dredging/placement quantities and bathymetric change data are not provided to support this contention.

3.4 Spatial and temporal trends

Storm-related processes are the primary cause of geomorphic change along the Mississippi Sound barrier islands. Island breaching and overwash processes promote northward-directed transport of sand from ocean beaches, across the islands and into the Mississippi Sound. Lateral movement of Dauphin, Petit Bois, Horn, and western Ship Islands, due to the dominant east-to-west gradient in littoral transport, produces rapid island growth (west) and erosion (east), whereas sporadic events like hurricanes and tropical cyclones produce cross-shore movement of sand into the sound resulting in long-term landward migration of the islands (e.g., Dauphin and eastern Ship). This process of island migration is termed barrier rollover, and it is best illustrated along eastern Ship Island. Washover deposition is the geomorphic response to overwash, and inlet formation can result from island breaching (e.g., Camille and Katrina Cuts).

Byrnes et al. (2010) provide a detailed analysis of historical shoreline and bathymetric changes for the sandy gulf shoreline of Alabama. Shoreline positions along the western end of Dauphin Island illustrate consistent westward growth of the island and movement of Petit Bois Pass (Figure 3.3). In response to westward sand flux and deposition along western Dauphin Island, eastern Petit Bois Island eroded rapidly, resulting in sand deposition along the western end of Petit Bois (east-to-west translation of the islands and pass to dominant wave- and tide-driven currents). The greatest changes in lateral island movement occurred between 1848 and 1957, where net rates of island growth along the west ends of Dauphin and Petit Bois Islands were 192.0 and 127.6 ft, respectively. However, erosion along the eastern end of Petit Bois Island resulted in 350.6 ft of westward island migration for the same period, creating a pass between the islands that was nearly twice as large as what existed in 1848.

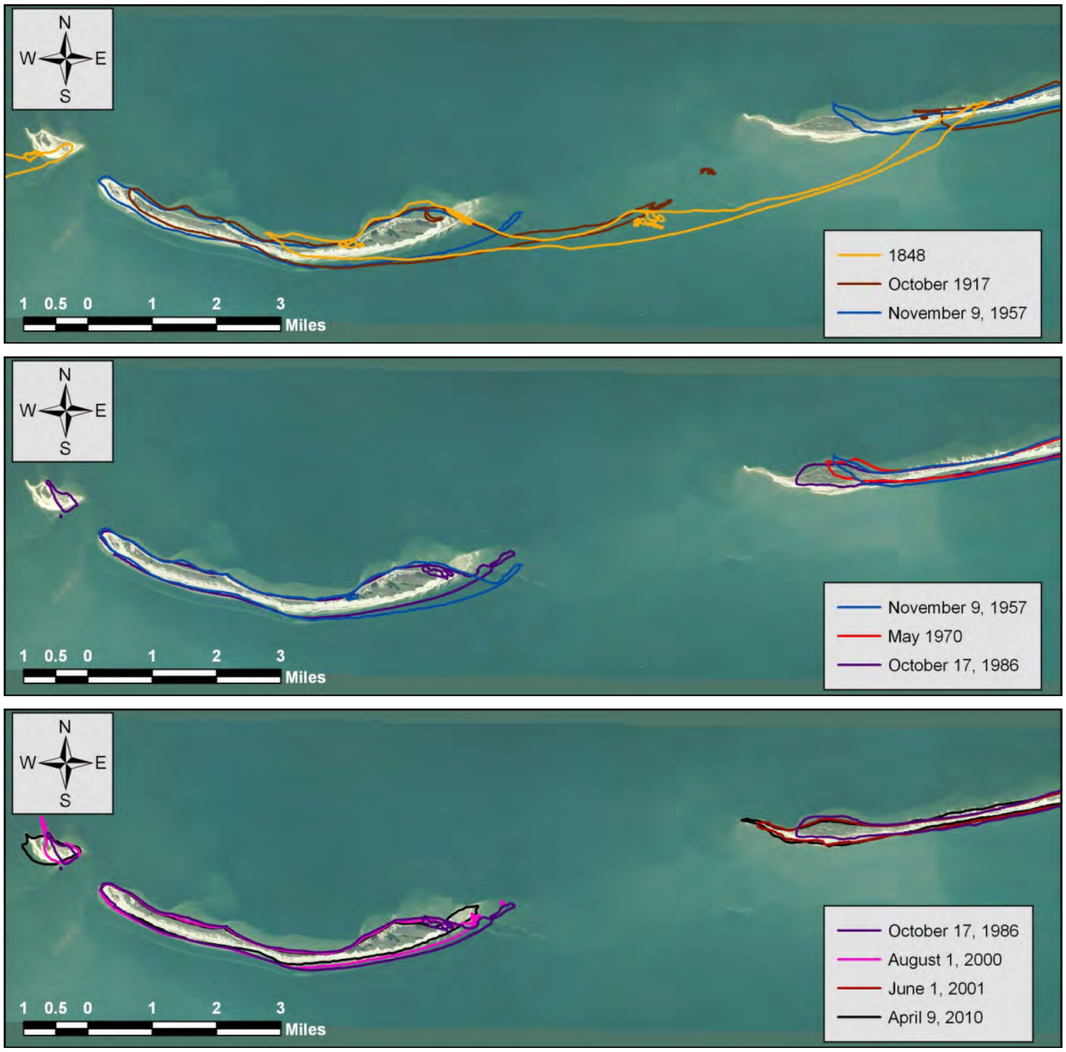

Figure 3.3. High-water shoreline position for western Dauphin Island, AL and Petit Bois Island, MS, 1848 to 2010. Background imagery was flown October 1, 2008.

Table 3.4 documents changes in lateral island migration for the Mississippi Sound barrier islands since 1847/49. Net change trends indicate that westward island and inlet migration consistently decreased from 1847/49 to 1957. Although the rate of decrease was not constant at all locations, the pattern of change was consistent. The trend of decreasing lateral island migration continued through 2010 for western Dauphin Island and Petit Bois Island, with the greatest reduction in island migration associated with Petit Bois. Figure 3.3 illustrates that after 1957, the greatest changes in island morphology took place along the eastern half of the island where south-facing beaches adjacent to Petit Bois Pass were eroding and migrating landward at a rate of about 28 ft/yr (see Appendix C for detailed shoreline change calculations). Furthermore, dominant westward growth of western Petit Bois Island ceased because the end of the island abuts the navigation channel at Horn Island Pass (see Figure 3.4). Westward growth of western Dauphin Island continued during this period, albeit slightly slower than at any time in the past 100 years (see Table 3.4).

Changes in island surface area generally reflected trends in high-water shoreline movement. Western Dauphin Island consistently grew to the west at about 150 ft/yr between 1847 and 2010, although lateral growth was slightly greater prior to 1957. Byrnes et al. (2010) illustrated net narrowing of Dauphin Island for the period of record, resulting in about an 11 percent loss in surface area (Table 3.5). Petit Bois Island recorded much greater losses in surface area since 1848 in response to storm and normal

Table 3.4. Lateral Island migration for islands fronting the Mississippi Sound.

	Ship Island		Horn Island		Petit Bois Island		Dauphin Island	
	West End	East End	West End	East End	West End	East End	West End	East End
1847/49 to 1917	+2,590[1] (+37.6)[2]	+3,480 (+50.4)	+10,570 (+155.4)	+7,120 (+104.7)	+11,450 (+165.9)	+26,000 (+376.8)	+14,300 (+204.3)	
1917 to 1950/57	+1,250 (+37.9)	+1,720 (+52.1)	+2,500 (+62.5)	+6,220 (+155.5)	+2,460 (+61.5)	+12,220 (+305.5)	+6,630 (+165.8)	
1950/57 to 2010	+660 (+11.0)	+1,900 (+31.7)	+2,070 (+39.1)	+7,540 (+142.3)	-250 (-4.7)	+3,580 (+67.5)	+7,550 (+142.5)	
1917 to 2010	+1,910 (+20.5)	+3,620 (+38.9)	+4,570 (+49.1)	+13,760 (+148.0)	+2,210 (+23.8)	+15,800 (+169.9)	+14,180 (+152.5)	
1847/49 to 2010	+4,500 (+27.8)	+7,100 (+43.8)	+15,140 (+94.0)	+20,880 (+129.7)	+13,660 (+84.3)	+41,800 (+258.0)	+28,480 (+150.2)	

[1] change magnitude (ft); [2] change rate (ft/yr); + equals westward movement; - equals eastward movement; green = deposition; red = erosion

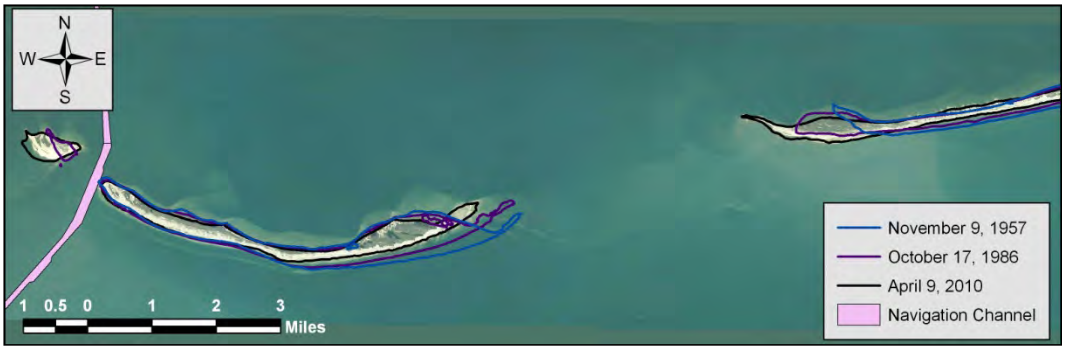

Figure 3.4. High-water shoreline position for western Dauphin Island, AL and Petit Bois Island, MS, 1957 to 2010, illustrating the location of the Horn Island Pass navigation channel relative to the western end of Petit Bois Island. Background imagery was flown October 1, 2008.

Table 3.5. Barrier island area change (acres) for the islands fronting the Mississippi Sound.

	Cat Island	Ship Island	Horn Island	Petit Bois Island	Dauphin Island
Initial Island Area	2,996.1	1490.0	3697.7	2056.4	3794.0
1847/49 to 1917	-271.9	-150.3	-126.8	-276.9	-632.2
1917 to 1950/57	-308.4	-186.6	-246.8	-284.2	648.8
1950/57 to 2010	-571.7	-697.7	-577.6	-613.4	-439.9
1917 to 2010	-880.1	-884.3	-824.4	-897.5	208.9
1847/49 to 2010	-1,152.0	-1,034.6	-951.2	-1,174.5	-423.3
Percent Change	-38.5	-69.4	-24.0	-57.1	-11.2

incident processes and an expanding inlet between Dauphin and Petit Bois (Petit Bois Pass) between 1848 and 1957. Expansion of Petit Bois Pass created greater separation in the beach littoral transport system, making it more difficult for sand transported to the west end of Dauphin Island to bypass the entrance on its way west to Petit Bois Island. Sand transport to Petit Bois Pass has filled a portion of the entrance with littoral beach sand from Dauphin Island since 1957 and the pass has narrowed. As the inlet stabilizes or becomes narrower, perhaps sand bypassing to Petit Bois Island will become more efficient.

Horn Island is the most extensive barrier island in the Mississippi barrier chain. Island changes illustrate the same general trend of erosion along the eastern end of the island and westward island growth as eroded beach sand is transported to the west toward Dog Keys Pass. Although lateral movement of the island was quite extensive and consistent for the period of record, areas of cross-shore recession and advance were recorded, resulting in minor net cross-shore changes for the central portion of the island (see Figure C25 in Appendix C). Figure 3.5 documents changes in island configuration and location between 1849 and 2010. Substantial westward movement was recorded at both ends of the island with net beach erosion along eastern Horn Island exceeding net deposition and island lengthening to the west. Prior to 1917, island growth to the west exceeded shoreline erosion along eastern Horn Island, resulting in net island growth (Table 3.4). However, the island was slightly narrower than its original configuration, producing a net loss of about 127 acres for this 68-yr period (Table 3.5).

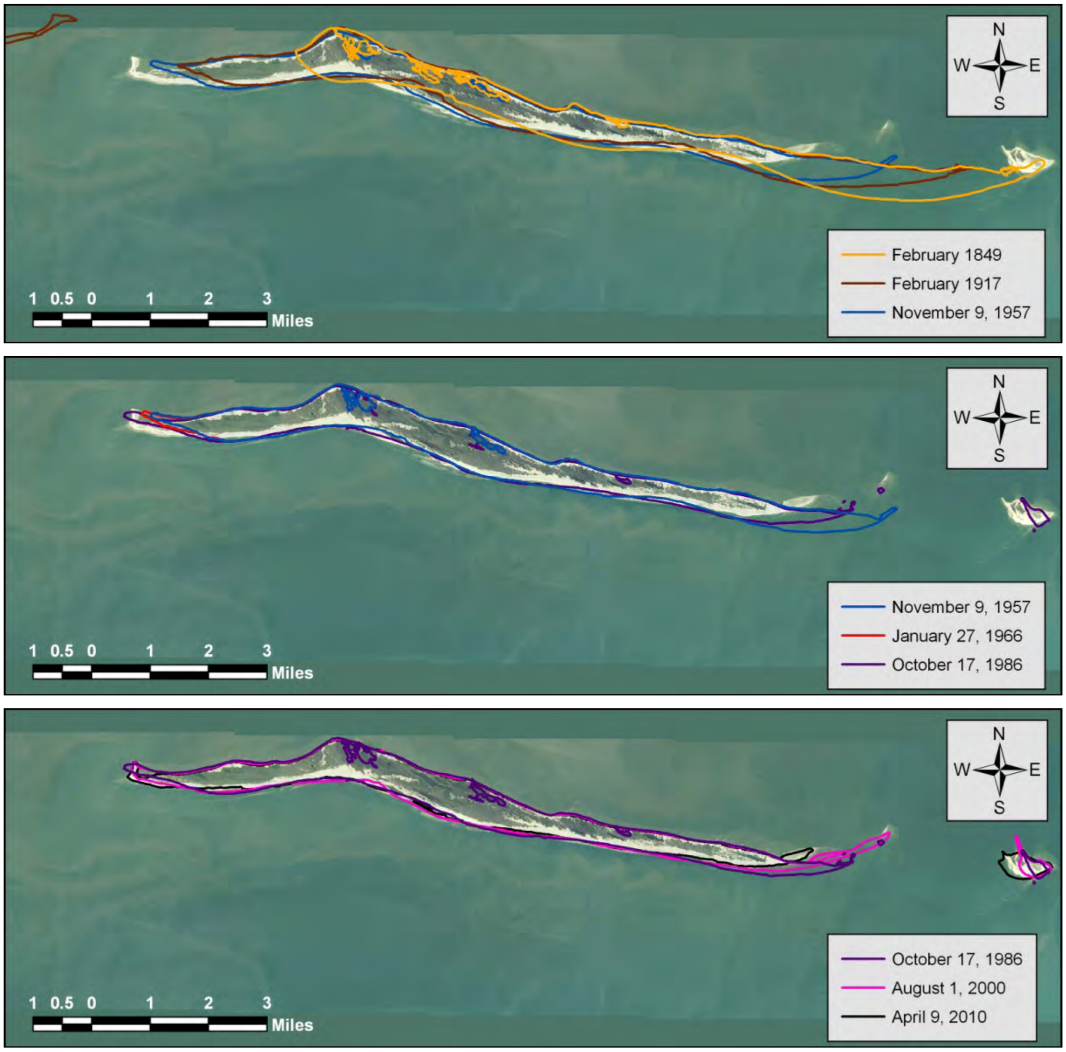

Figure 3.5. High-water shoreline position for Horn Island, MS, 1849 to 2010. Background imagery was flown October 1, 2008.

After 1917, the rate of lateral growth decreased along western Horn Island and erosion and westward shoreline translation along eastern Horn Island increased (Table 3.4). As such, island growth to the west was approximately

30 to 35 percent of lateral shoreline movement recorded along eastern Horn Island. The natural channel adjacent to the western end of Horn Island apparently had developed tidal currents capable of reducing the rate of westward island growth. This combination of geomorphic responses resulted in a shorter and narrower island by 2010, producing a net loss of island area of about 824 acres (93-yr period). The net result was a wider inlet at Horn Island Pass, creating greater accommodation space for littoral sand deposition from the east, and less sand transport to Horn Island. This pattern of geomorphic evolution suggests that greater quantities of sand derived from beach erosion presently reside as subaqueous shoals within the barrier system (see Chapters 4 and 5). Similar to Petit Bois Island and Pass, as Horn Island migrates farther from Horn Island Pass, littoral sand transport becomes less efficient at supplying sand to the subaerial beach.

Ship Island is the westernmost barrier shoreline of the historical Mississippi Sound barrier islands. It is the downdrift end of the coastal littoral transport system that supplies sand to gulf beaches from the Florida Panhandle to coastal Mississippi (Otvos and Carter, 2008). As such, the island is most vulnerable to morphologic change resulting from redistribution of sand by storm and normal transport processes. Island breaching by storm waves has been a primary factor influencing littoral transport throughout the historical record. The narrow, low-lying central portion of the island (current location of Camille Cut) was breached historically during the passage of the 1852 “Great Mobile” hurricane (see Figure 2.2); however, older maps illustrate that the area was vulnerable to breaching prior to this time (the pass between Dog Island and Ship Island on Figure 3.1).

Since 1853, coastal surveys by USC&GS have recorded breaches near central Ship Island in response to the 1947 hurricane and Hurricane Camille (1969). Figure 3.6 documents that the inlet that existed three years after the hurricane impacted this area and the narrow strip of beach that formed between 1950 and 1966. Low-lying, narrow stretches of barrier beach are susceptible to rapid changes during storm events, so when Hurricane Camille crossed the coast in 1969, it was no surprise that Camille Cut formed, producing what is now East and West Ship Islands. As with post-storm response after the 1947 hurricane, sand eroded from eastern Ship Island and supplied from Dog Keys Pass promoted growth of a narrow sand spit along the western end of East Ship Island in an attempt to connect the islands. However, a series of tropical cyclones impacted the coast between 1985 and 2008, resulting in sand dispersion from the spit

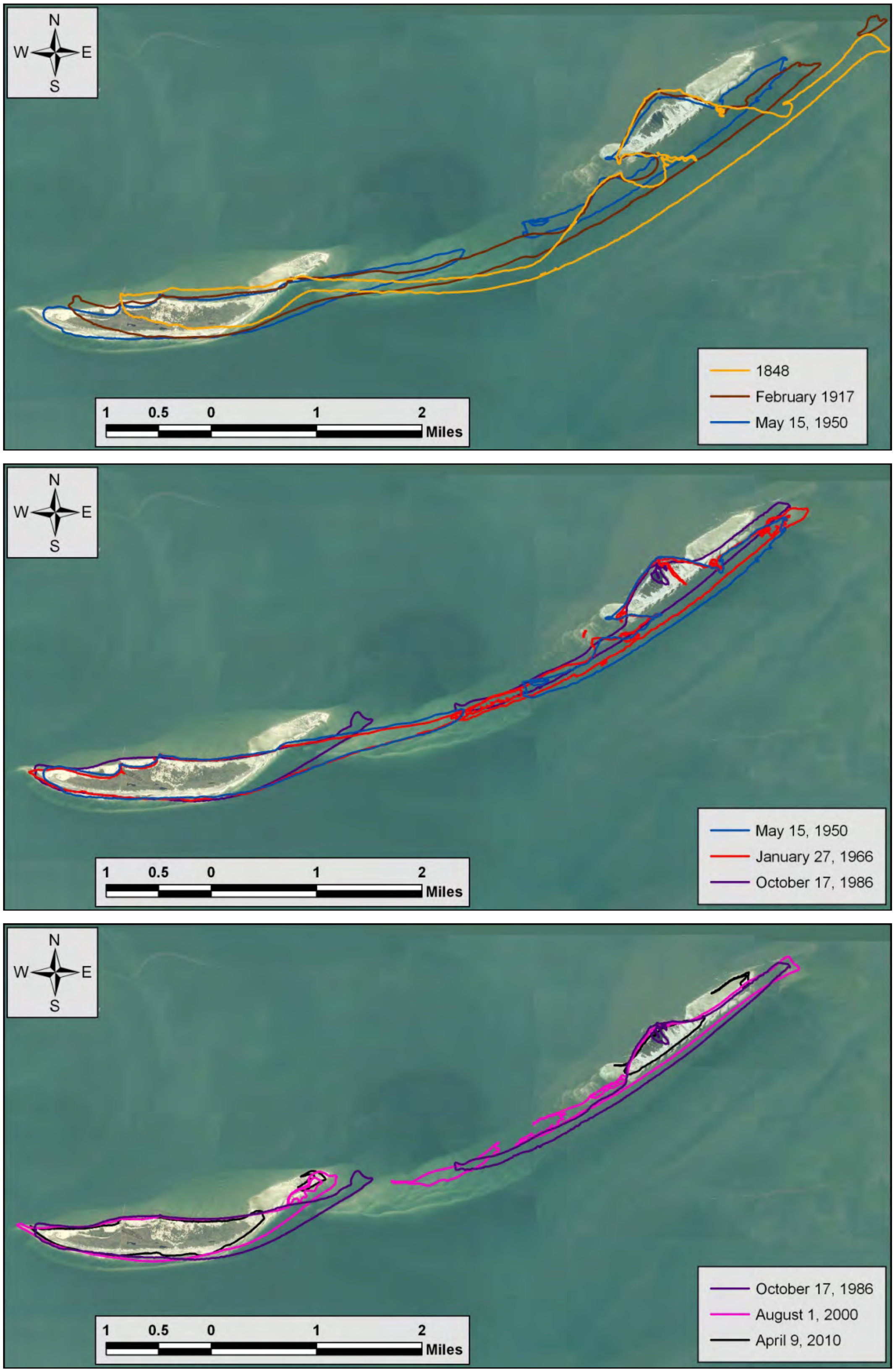

Figure 3.6. High-water shoreline position for Ship Island, MS, 1848 to 2010. Background imagery was flown October 1, 2008.

and development of a wide subaqueous spit platform. Prior to persistent breaching at Camille Cut, shoreline recession along eastern Ship Island was approximately 11 ft/yr; after Hurricane Camille, shoreline recession increased to about 32 ft/yr, and the island has not been continuous since this time (see Figures C29-C33 in Appendix C). As a result of increased shoreline recession, the quantity of sand supplied from erosion of East Ship Island is diminishing as the island is reduced in size and elevation.

Figure 3.7 illustrates changes in island position between 1986 and 2010. Sand spit growth between East and West Ship Islands between October 1986 and October 1997 was supplied by sand from Dog Keys Pass and beach erosion along the gulf side of East Ship Island. This pattern of westward island growth is consistent with all other island responses throughout the Mississippi barrier island system. After the passage of Hurricane Georges in late September 1998, sand on the spit likely was transported to subaqueous shoals in the cut. Although subaerial sand deposition on the spit platform continued during post-storm recovery, hurricanes Katrina (2005) and Gustav (2008) caused extensive erosion and overwash transport on East Ship Island, leaving only a small portion of the island remaining. Sand flux from this diminished island remnant provides substantially less sand to downdrift beaches.

Like other Mississippi barrier islands, westward shoreline movement along the eastern end of the island was greater than deposition at the west end of West Ship Island (about 40 percent greater; see Table 3.4). Furthermore, the breach at Camille Cut has contributed significantly to loss of island area. Between 1848 and 1950, island area decreased by about 337 acres. In contrast, island area decreased by about 698 acres between 1950 and 2010 (see Table 3.5). Historical degradation of Ship Island is primarily the result of island breaching, erosion along East Ship Island, and low sand supply from Dog Keys Pass.

For recent geologic time, core data suggest that Ship Island provided sand to Cat Island through littoral transport processes (Otvos and Giardino, 2004). However, since the development of the St. Bernard Delta complex, incident waves and currents that transport sand along the Mississippi Gulf Coast have been altered by the relative position of the delta lobe and shoals, decreasing the sand transport potential west of Horn Island. Overall, the location of the St. Bernard delta limited wave approach from the gulf to a narrow southeast direction, resulting in the partial reworking of the eastern

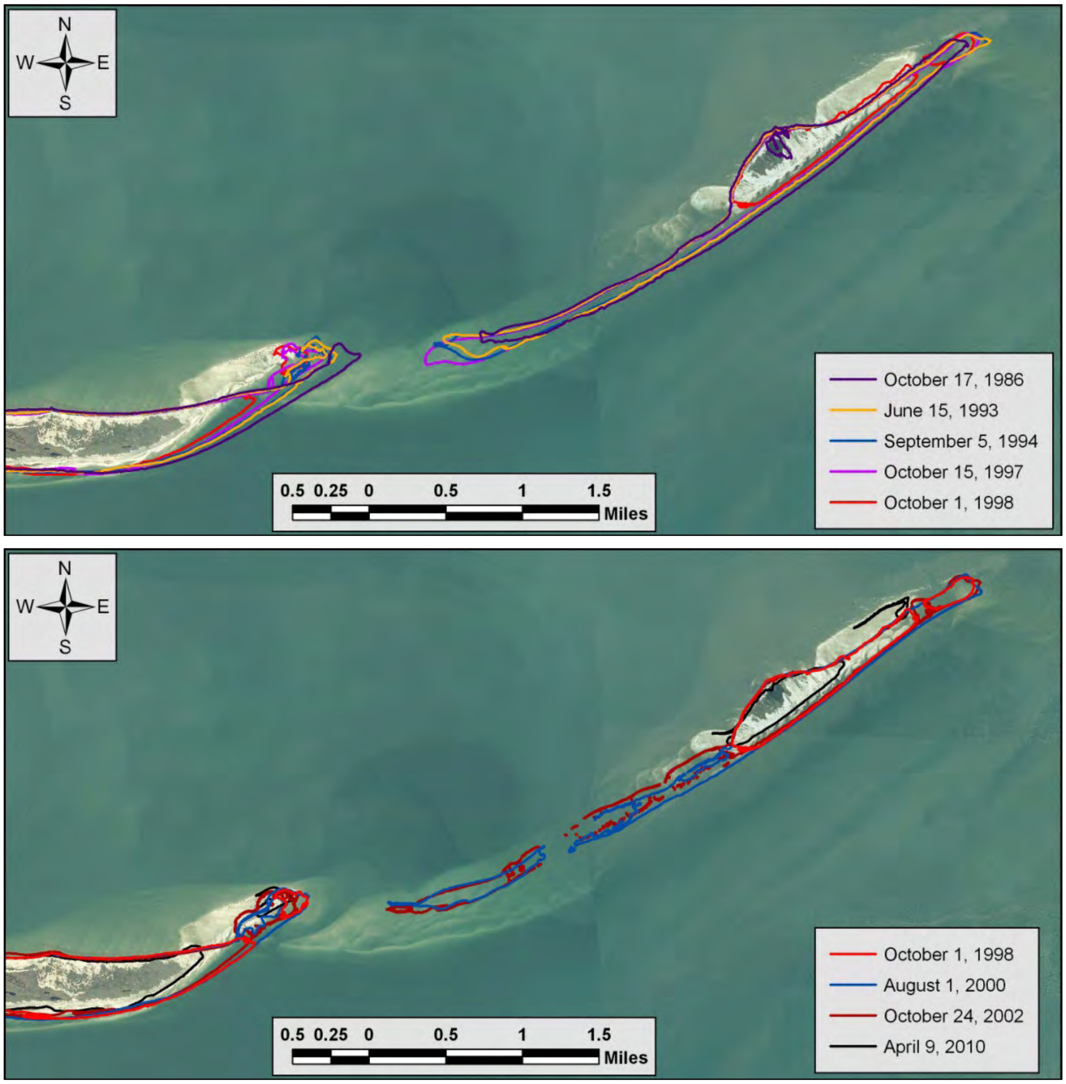

Figure 3.7. High-water shoreline position for Ship Island, MS (1986 to 2010), illustrating sand spit growth and dispersion along the western end of East Ship Island. Background imagery was flown October 1, 2008.

end of the Cat Island beach ridge complex into a northeast-southwest trending shoreline (see Figure 3.8). Reworked sand from this progradational beach ridge complex is the only source of sand to beaches along Cat Island (Rucker and Snowden, 1989).

Littoral transport along Cat Island beaches diverges just north of the primary beach ridge complex, transporting sand eroded from the beach ridges north and south. The sand spit developed along the south end of the island has always been longer, narrower, and more vulnerable to storm wave and current processes. The southern sand spit grows and disperses periodically in relation to storm activity, whereas long-term changes along

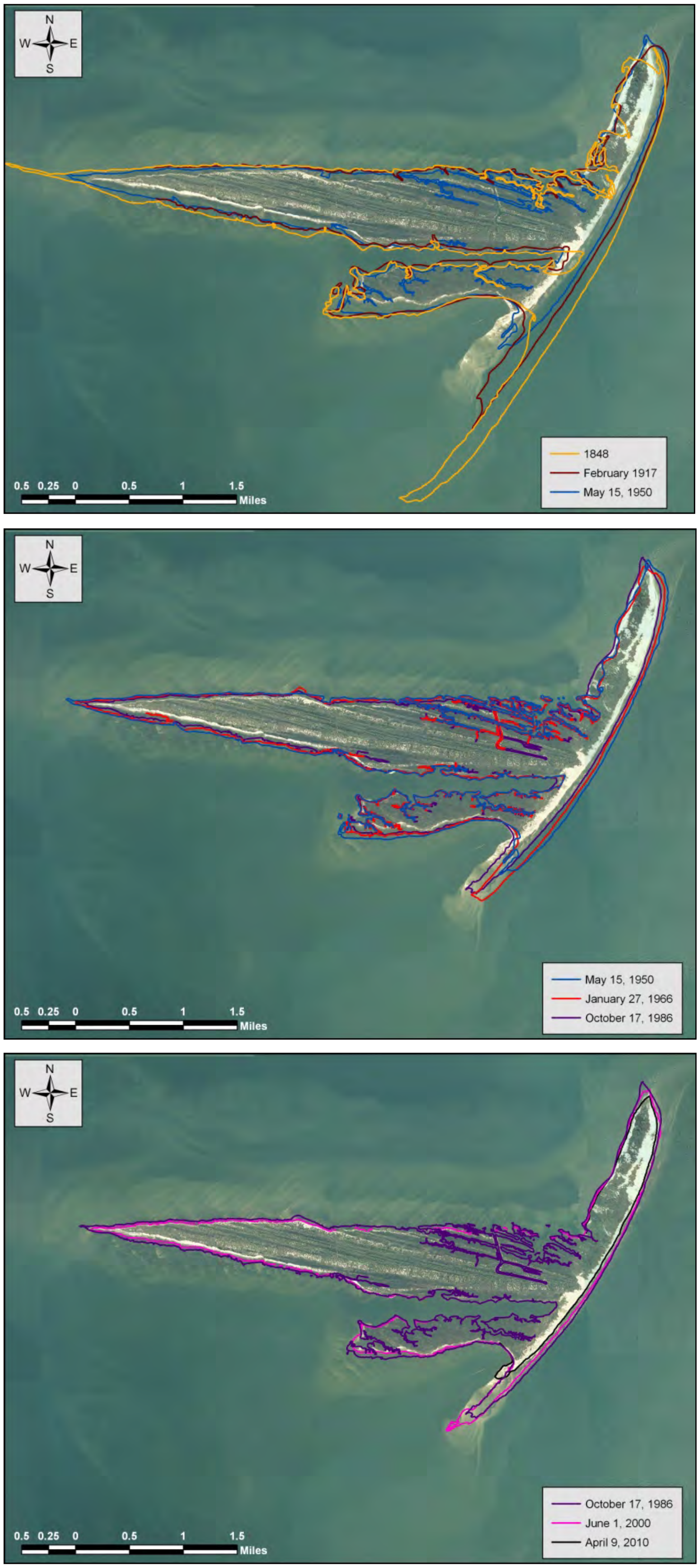

Figure 3.8. High-water shoreline position for Cat Island, MS, 1847 to 2010. Background imagery was flown October 1, 2008.

the northern end of the island are slower and more stable. Net rates of shoreline recession vary from 0 to 2 ft/yr along north Cat Island to 10 to 20 ft/yr along the southern sand spit where beach changes reflect greater vulnerability to gulf storm and normal wave conditions (see Figure C41). Island area changes are consistent with those documented for barriers to the east, with the greatest area loss rates occurring between 1950 and 2010 (Table 3.5).

3.5 Summary of island changes

Shoreline and beach evolution for the barrier islands fronting the Mississippi Sound is driven by longshore transport processes associated with storm and normal wave and current conditions. Although beach erosion and washover deposition are processes that have influenced island changes, the dominant mechanism by which sand is redistributed along the barrier islands and in the passes is by longshore currents generated by wave approach from the southeast. Geomorphic changes along the islands illustrate the dominance of net sand transport from east to west.

Figure 3.9 summarizes the development of western Dauphin Island and eastern Petit Bois Island. Beach erosion along the gulf shoreline of the low-lying sand spit of Dauphin Island, in addition to sand transport onto the beach from Pelican Island (subaerial sand deposit on the west lobe of the Mobile Pass ebb shoal), supplied sediment for rapid and continuous deposition at the western end of Dauphin Island between 1848 and 2010. The island grew about 5.4 miles to the west during this time at an average rate of about 150 ft/yr. Net westward movement forced Petit Bois Pass in the same direction, resulting in net erosion along the eastern end of Petit Bois Island and net widening of the pass. Most sediment eroded from eastern Petit Bois Island was deposited along the sand spit at the western end of the island and in the navigation channel at Horn Island Pass (Figure 3.10). Since 1957, the west end of the island has remained in its present location because it abuts the maintained navigation channel. Before this time, westward island migration forced Horn Island Pass and eastern Horn Island to the west at about 127 ft/yr (Table 3.4). As a result, western Horn Island migrated to the west.

Minor net changes were recorded along the central portion of Horn Island as littoral sand was mobilized from the east end of the island and transported westward by longshore currents. Sand transported to the west was deposited in a 2.9 mile-long, relatively wide sand spit that projected into

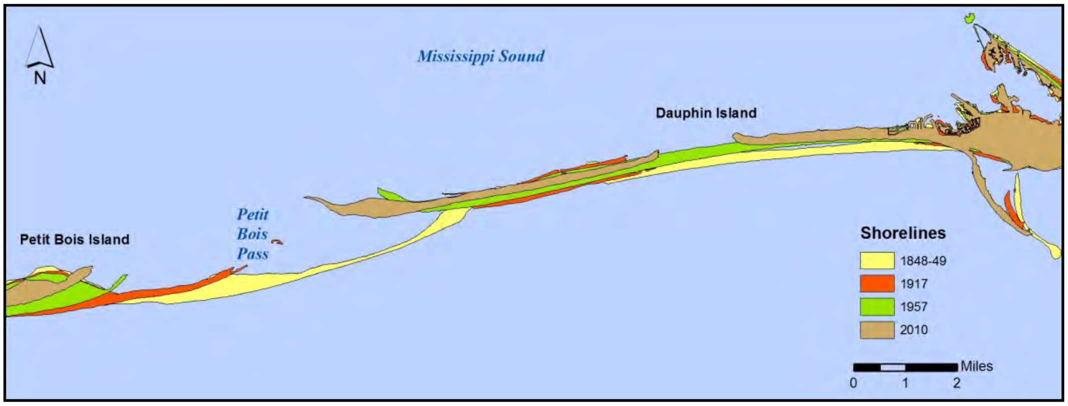

Figure 3.9. Composite island changes for Dauphin Island and eastern Petit Bois Island, 1848 to 2010.

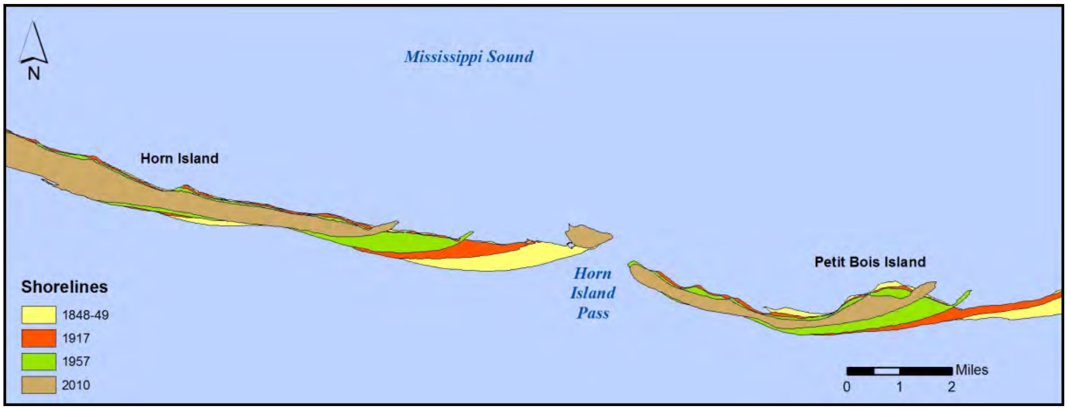

Figure 3.10. Composite island changes for Petit Bois and eastern Horn Island, 1848 to 2010.

Dog Keys Pass (Figure 3.11). Westward island growth produced a narrower inlet as the primary channel at Dog Keys Pass was forced westward toward Dog Island and East Ship Island. Little Dog Keys Pass (to the west of Dog Island) originated as a secondary channel at the entrance, but as Horn Island migrated westward historically, Dog Island (also referred to as Isle of Caprice [Rucker and Snowden, 1988]) eroded and dispersed into entrance shoals as hydraulics changed in the inlet. Presently, Little Dog Keys Pass is the deepest channel between the islands and it has had a marked influence on sand bypassing to East Ship Island.

Ship Island is the downdrift terminus of the Mississippi Sound barrier islands and is the most vulnerable island in the barrier system due to distance from a sand source. Historical data illustrate that the central portion of the island has been narrow and low, and highly susceptible to breaching during tropical cyclones. The east end of the island is strongly erosive, and sand transported from this area deposits at the west end of the island, which resulted in net westward migration of about 4,500 ft

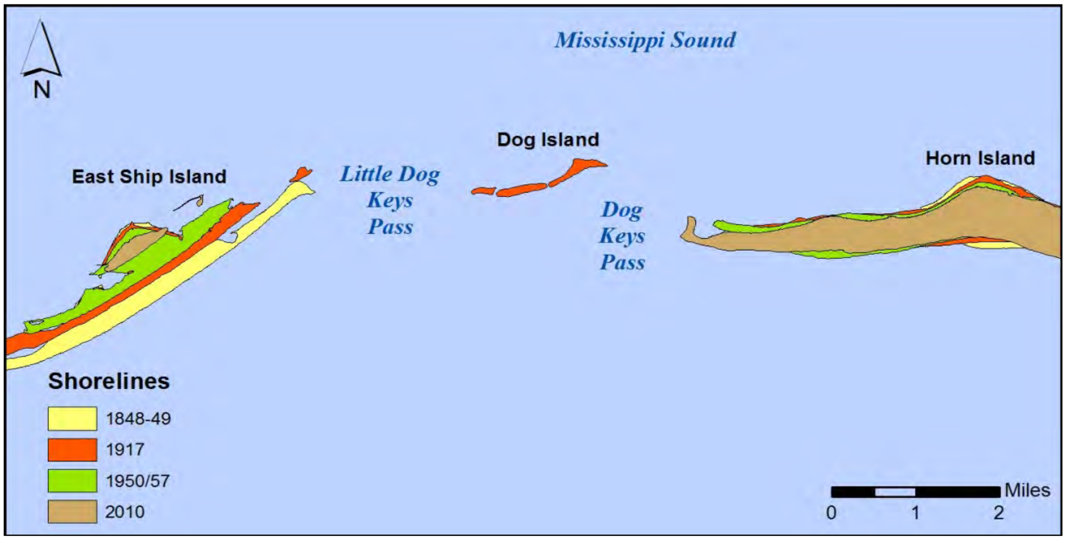

Figure 3.11. Composite island changes for western Horn Island and East Ship Island, 1848 to 2010.

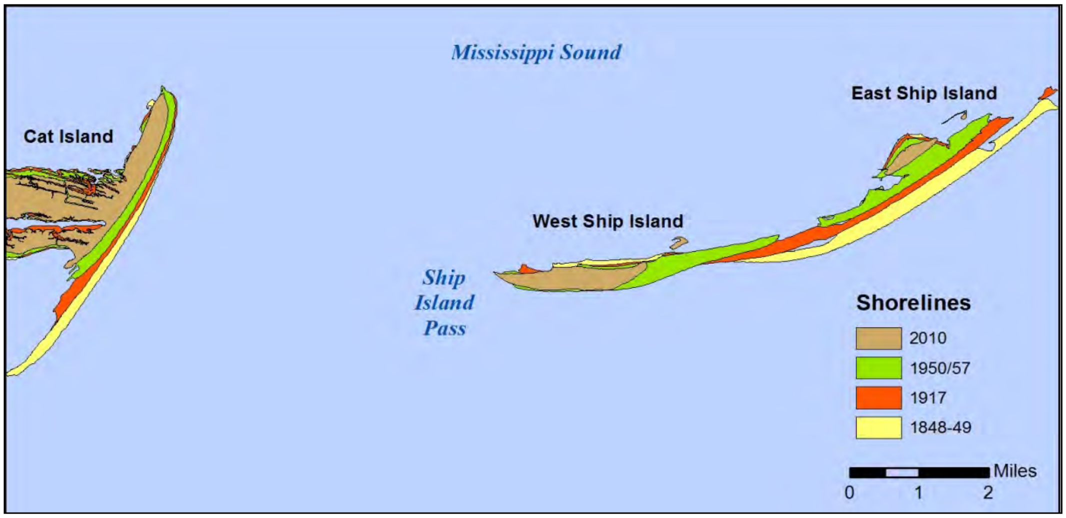

Figure 3.12. Composite island changes for West Ship Island and Cat Island, 1848 to 2010.

between 1848 and 2010. Sand transport from Dog Keys Pass has never been able to counteract beach erosion along the eastern end of Ship Island, so chronic erosion in this area is pervasive. Camille Cut has been on the verge of closing on a few occasions since 1969, but storms have dispersed the subaerial sand spit developed between East and West Ship Island allowing persistent exchange of water and sediment between the gulf and sound. Beach erosion and overtopping along East Ship Island has been so common since 1969 that the island is in danger of complete degradation within the next 10 to 20 years. Major changes in inlet shoal and channel morphology at Dog Keys Pass have reduced sand transfer to East Ship Island, perhaps aggravating the magnitude of erosion along the island. The Ship Island system would benefit most from habitat restoration.

Since the development of the St. Bernard Delta complex between 3,500 and 1,500 years ago, Cat Island has been segregated from west-directed sand transport along the barrier islands. Changes in dominant wave orientation have promoted reworking of the beach ridge complex developed prior to formation of the St. Bernard Delta and shoals. Longshore transport has been bi-directional, causing sand spit deposition north and south of the primary beach ridge trend. Erosion of the beach ridge complex provides sand to interior portions of the island via washover and to distal ends of the island via longshore transport. This trend has been consistent and predictable without influence from outside sources, and it is expected to continue.

3.6 Estimate of change contribution from relative sea-level rise

In addition to storm and normal wave and current processes, relative sea-level variations (rise and fall of water level relative to a fixed vertical reference plane) can cause permanent change in shoreline position. However, unlike change induced by waves and currents, those associated with rising or falling sea level typically require much longer periods of time before noticeable shoreline changes are recorded. In fact, short-term response of beaches to wave and current processes is often so large (particularly during storms) that long-term sea level change becomes background noise that may appear to have little influence on geomorphic change. From a geological timeframe, sea-level rise (or fall) is a dominant mechanism causing shoreline movement and coastal inundation. On a decadal to century scale, waves and currents are dominant processes causing coastal erosion, deposition, and shoreline migration. These time scales of change were described by Larson and Kraus (1995) for sediment transport and beach morphology.

Mississippi Sound barrier island beaches erode, accrete, and migrate primarily in response to variations in wave energy. However, sea-level rise over the past century may have contributed to morphologic change recorded by historical shoreline positions mapped since the mid-1800s. To estimate the contribution of change associated with sea-level rise, the Bruun Rule of erosion (Bruun, 1962) was applied for Dauphin Island, eastern Petit Bois Island, and East Ship Island. The underlying assumption of the two-dimensional geometric rule is that a closed material balance exists between the beach and nearshore bottom profile (Figure 3.13). Assuming an equilibrium profile shape, under long-term sea level rise (S), shoreline recession (R) and beach erosion must be associated with an equal amount of offshore deposition and seafloor rise to a maximum depth (h_d) and distance (L) of exchange of sand between the beach and offshore (Bruun, 1983).

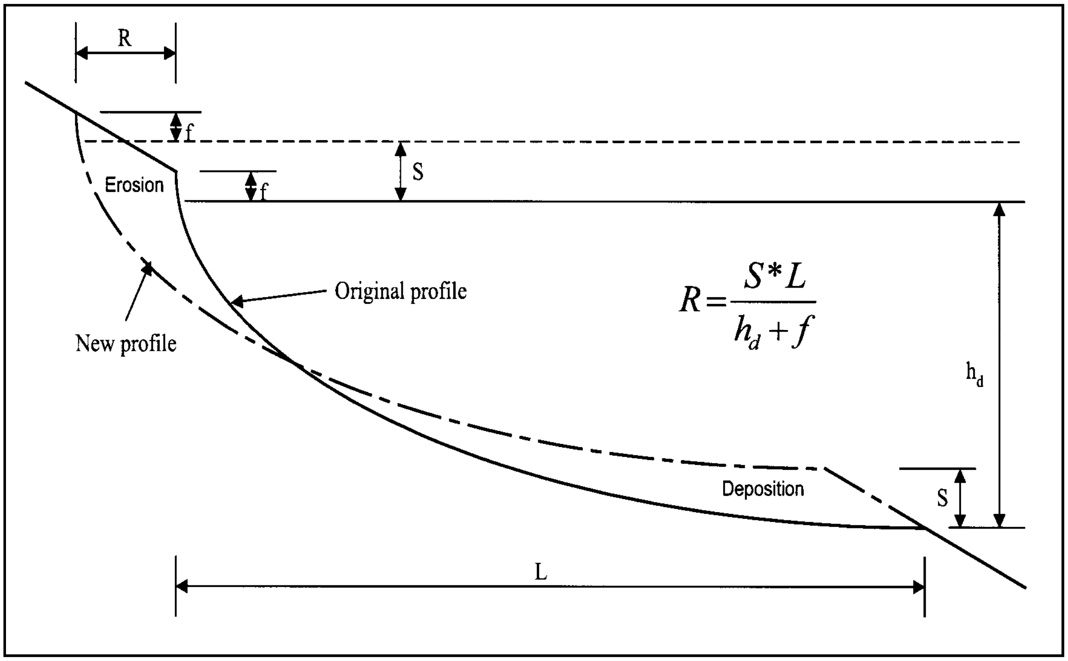

Figure 3.13.Translation of a beach profile under rising sea level in a two-dimensional closed material balance system (after Bruun, 1962).

The validity of applying the Bruun Rule to predict three-dimensional natural beach systems has been discussed for years (e.g., Bruun, 1988; Pilkey et al. 1993). Despite its simplicity and assumptions, the concept works well in many settings (Morang and Parson, 2002). In this study, the intent is not to predict where the shoreline may be at some time in the future under current rising sea levels. Instead, we are interested in estimating the percentage of change in historical shoreline positions that may be associated with rising sea level during the change period. Implicit in this analysis is that sediment supplied to a section of beach from outside sources does not exist. Because beaches along the Mississippi and western Alabama coasts receive sand via littoral transport processes from sources in western Florida and eastern Alabama, estimates of shoreline change associated with long-term sea level rise may overstate the contribution to measured historical trends.

3.6.1 Tide gauge records

Two long-term water level gauges were used to document sea-level change along the Mississippi Sound barrier islands. For the western portion of the study area, mean annual and monthly data collected at a water level gauge maintained by the USACE in Biloxi Bay (#02480350; Figure 3.14) for the period of 1896 to 2010 produced a rise rate of about 0.0116 ft /year (Figure 3.15). Prior to 1928, all data were provided as annual averages, but since this date, monthly averages documented seasonal and long-term variability in water surface elevation (relative to the National Geodetic Vertical Datum [NGVD]) under storm and normal conditions.

Figure 3.14. USACE (Biloxi 02480350) and NOAA (Dauphin Island 8735180) tide gauge locations.

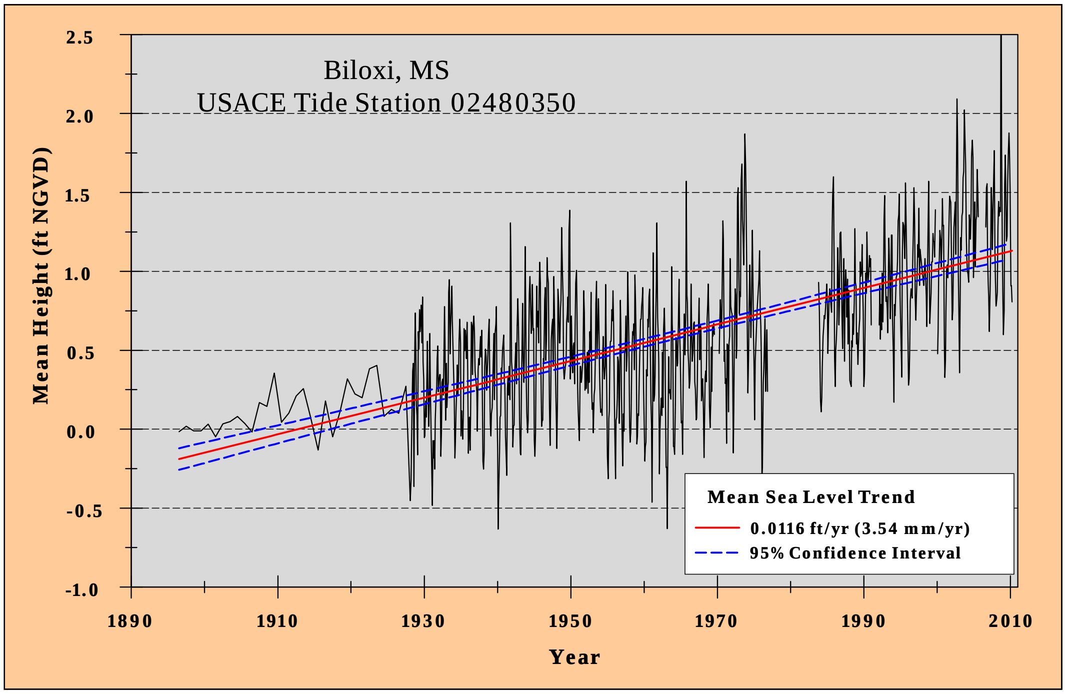

Figure 3.15. Mean annual and monthly water level measurements and sea-level rise trend at Biloxi, MS gauge 02480350, 1896 to 2010.

NOAA tide gauge 8735180 at Dauphin Island, AL collected water level data for a shorter period of time (44 years), but the average rate of sea-level rise (0.00956 ft /year; Figure 3.16) is similar to that recorded at the Biloxi gauge. Although subtle changes exist in sea-level rise rates at these sites, the average rate of change is about 0.0106 ft /year. This trend was used for estimating the magnitude of shoreline change associated with sea-level change throughout the study area.

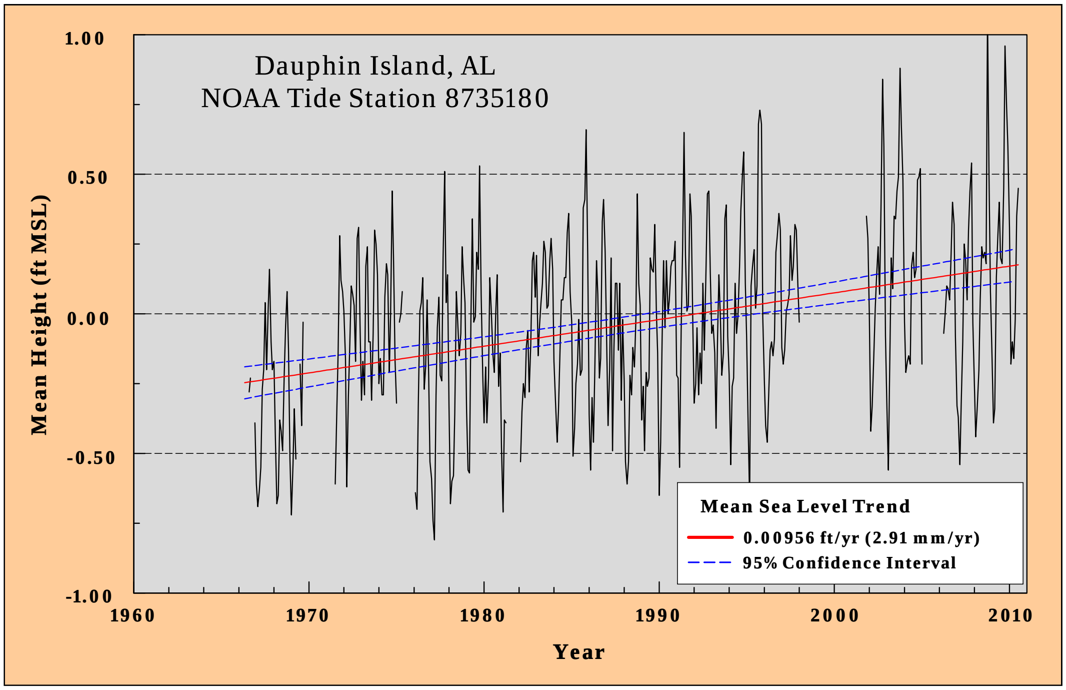

Figure 3.16. Monthly mean water level measurements and sea-level rise trend at Dauphin Island, AL gauge 8735180, 1966 to 2010.

3.6.2 Bruun Rule calculation

Under a long-term sediment supply deficit, Bruun (1983) argues that as sea level rises, sediment must be deposited offshore equal to the amount of sea level rise to maintain a profile of equilibrium. If sediment is not available from elsewhere, it will be eroded from the adjacent beach face (see Figure 3.13). Using the equation

$$R*(h_d+f)=S*L \tag{3.1}$$

shoreline recession (R), resulting from long-term rising sea level (S), can be estimated by defining the maximum depth of exchange of littoral sediment between the nearshore and offshore (h_d) and the berm crest (f), and associated distance offshore from the berm crest (L). Based on a comparison of bathymetry data offshore central portions of the Mississippi Sound barrier islands, it was determined that h_d was equal to about 24 ft relative to the North American Vertical Datum (NAVD88) for central Dauphin and Petit Bois Islands. Maximum depth of littoral sediment exchange (h_d) for East Ship Island was determined to be about 20 ft (NAVD88). Based on recent lidar data for barrier beaches not influenced by inlet processes, height of the berm crest (f) was estimated at 4.0 ft (NAVD88). Distance offshore to the 24- and 20-ft depth contours was about 2,000 and 4,000 ft, respectively. Based on the tide gauge data presented above, average sea level rise for the Mississippi Sound barrier islands is estimated at 0.0106 ft /year.

Applying appropriate values, shoreline recession on Dauphin and Petit Bois Islands that could be associated with long-term sea level rise is about 0.76 ft/yr. Based on long-term shoreline change calculations for open gulf beaches on both islands, the average rate of recession is about 15 ft /year, implying that sea level rise may be associated with approximately 5 percent of the total change signal. For East Ship Island, net shoreline recession between 1917 and 2010 was about 32 ft /year, suggesting that sea level rise may be responsible for about 4 percent of the total change signal. As such, for locations of net long-term erosion in the study area, sea-level rise contribution to shoreline change is minor relative to the impact of storm waves and currents.

4 Seafloor Morphology

The most direct method for evaluating regional sediment transport pathways and quantifying long-term net transport for the Mississippi Sound barrier island system is to quantify historical change in inlet and nearshore morphology with a time-series of shoreline and bathymetric surveys. Shoreline data were presented in Chapter 3; this chapter focuses on evaluating bathymetry data collected between 1847 and 2010. For some coastal areas, survey data are lacking for drawing detailed and confident conclusions regarding beach and nearshore evolution relative to dominant sediment transport pathways and quantities. However, the Mississippi Sound and nearshore were surveyed on four separate occasions over a 160-year period, providing ample data for documenting beach and inlet shoal evolution, regional sediment transport pathways, net transport quantities, and the exchange of sediment between ebb-tidal shoals and adjacent shorelines for determining regional sediment budgets.

Although shoreline change patterns (two dimensions) contain a record of the influence of coastal processes on beach response, regional assessment of inlet and nearshore morphology (three dimensions) better reveals dominant processes controlling the magnitude and direction of sediment transport throughout a coastal system. Analysis of long-term change in seafloor and island morphology provides a method of identifying net sediment transport pathways, quantifying volume changes, and evaluating sediment budgets for assessing large-scale evolution of the Mississippi Sound barrier island coastal depositional system.

4.1 Data sources

Seafloor elevation measurements, compiled from historical hydrographic surveys, were used to identify seafloor morphology and change to quantify sediment transport pathways and rates relative to natural processes and engineering activities. Four bathymetry data sets were compiled to document seafloor changes between 1847/55 and 2005/10. Data sets were compiled from hydrographic surveys completed by the USC&GS in 1847/55, 1917/20, 1960/69, and 2005/06. Recent survey data for the barrier islands and passes, and adjacent seafloor, were collected by the United States Geological Survey (USGS) and the US Army Corps, Mobile District survey section (USACE) between 2008 and 2010 (Table 4.1; Appendix D). Regional

Table 4.1. Bathymetry source data characteristics

Date	Data Source	Comments and Map Numbers
1847/55	USC&GS Hydrographic Sheets 1:20,000	First regional bathymetric survey within the study area. 19 February to 31 March 1847 - North of Dauphin Island (H-00191); 19 June 1847 to 20 May 1848 - Entrance and Approaches to Mobile Bay (H-00192); 8 January to 28 April 1848 - Lower Part of Mobile Bay (H-00193); 24 May to 27 June 1848 - Harbors of Cat and Ship Islands (H-00194 parts 1 and 2); West of Fort Morgan (H-00261); 9 April to 4 May 1852 - Mississippi Sound (H-00329); 8 March to 31 May 1853 - Mississippi Sound, Including Horn Island Pass (H-00328 parts 1 and 2); 27 May to 16 June 1853 - Round Island to the East End of Horn Island (H-00365); 1854 - South of Horn and Ship Islands (H-00430); 30 April to 18 May 1855 - Gulfport to Cat Island (H-00488); 14 February to 9 May 1855 -West End of Horn Island to West End of Ship Island (H-00489 parts 1 and 2).
1917/20	USC&GS Hydrographic Sheets 1:40,000 (all others) 1:80,000 (H-04171)	Second regional bathymetric survey. 21 February to 21 September 1917 - Gulfport to Chandeleur Islands (H-04000); 18 September 1917 to 15 March 1918 -Pascagoula to the Eastern Limit of Mississippi Sound (H-04020); 18 September 1917 to 15 March 1918 - Biloxi to Pascagoula, Mississippi (H-04021); 20 July 1917 to 15 March 1918 - Mobile Bay, Lower Part Including Entrance (H-04023); 10 June to 9 November 1920 - Mobile Bay Entrance to Chandeleur Islands Offshore (H-04171).
1960/69	USC&GS Hydrographic Sheets 1:10,000 (all others) 1:20,000 (H-08647, H-08924, H-08971, H-09004)	Third regional bathymetric survey. 26 January to 26 July 1960 - Vicinity of Dauphin Island (H-08524); 7 March to 9 August 1960 - Entrance to Mobile Bay (H-08526); 26 July to 17 October 1961 - Vicinity of Pass Aux Herons (H-08642); 27 July 1961 to 20 March 1962 - Isle Aux Herbes to Dauphin Island (H-08643); 26 September 1961 to 21 May 1962 - Petit Bois Pass and Approaches to Mississippi Sound (H-08647); 9 November 1961 to 24 May 1962 - Horn Island Pass and Vicinity (H-08646); 13 February to 22 May 1962 - Vicinity of Horn Island (H-08651); 14 March to 24 May 1962 - Vicinity of Round Island and Horn Island (H-08652); 12 January 1967 to 5 March 1968 - Approaches to Biloxi Bay (H-08924); 18 March to 28 May 1968 - Ship Island Pass (H-08971); 6 December 1968 to 22 April 1969 - Cat Island (H-09004).
2005/10	USC&GS Hydrographic Sheets US Geological Hydrographic and Lidar Surveys US Army Corps of Engineers, Mobile District hydrographic surveys (all digital surveys)	Fourth regional bathymetric survey. 11 January to 12 July 2005 - Horn Island Pass (H-11386); 12 January to 5 July 2005 - Bayou Casotte to Lower Pascagoula Channel (H-11385); 9 to 20 September 2005 - Horn Island Pass and Approaches (H-11512); 13 October to 4 November 2005 – Approaches to Gulfport (H-11513); 30 May to 5 December 2006 - South of Horn Island Pass (H-11546); 18 September to 14 December 2006 - Dauphin Island (H-11622); 4 October to 15 December 2006 - Grand Bay to Petit Bois Sound (H-11621); 27 to 30 June 2007 – Lidar survey for the barrier islands (USGS); June 2008 – swath bathymetry survey adjacent to Ship and Horn Islands (USGS); June 2009 - swath bathymetry survey adjacent to Horn and Petit Bois Islands (USGS); December 2009 – single beam hydrographic survey in western MS Sound (USACE); January 2010 - single beam hydrographic survey in eastern MS Sound (USACE); January 2010 - single beam hydrographic survey offshore Cat Island (USACE); 20 July to 8 October 2009 – Gulfport Sound channel survey (USACE); October 2010 – offshore Cat and Ship Islands, and Horn Island Pass, multibeam survey (USACE); 20 to 28 April 2010 – offshore Dog Keys Pass east to Petit Bois Pass multibeam survey (USACE); April 2010 – swath bathymetry survey offshore Ship Island Pass (USGS).

comparisons were made between 1847/55, 1917/20, 1960/69, and 2005/10 to document historical seafloor changes. Regional data extend from the east side of Dauphin Island to west of Cat Island and offshore to about the 50-ft depth contour for 1847/51, 1917/20, and 1960/69; 2005/10 bathymetry data extend offshore to about the 35-ft depth contour.

In addition to digital hydrographic data compiled by the National Geophysical Data Center (NGDC), USGS, and the USACE Mobile District, digital survey data were developed from scanned hydrographic survey sheets that were digitized at Applied Coastal using standardized digitizing and registration procedures (see Baker and Byrnes, 2004). All bathymetry data sets were combined with concurrent shoreline data to produce bathymetric surfaces that extend offshore from the high-water shoreline. An elevation of 4.0 ft (NAVD) was assigned to the high-water shoreline based on berm crest elevations identified in 2010 lidar data for Horn Island (see Figure 3.2).

4.1.1 Vertical adjustments

Because historical seafloor elevations are temporally inconsistent for the entire data set (i.e., reference tidal datums change with time), adjustments to depth measurements were made to bring all data to a common plane of reference (NOAA, 2003). These adjustments included changes in tidal datums due to relative sea level change and differences in reference vertical tidal datums. Vertical adjustments were made to each data set based on the time of data collection and the original vertical reference datum.

USC&GS hydrographic survey data were obtained online from the NOS hydrographic survey viewer, and all data were compiled relative to the mean low water (MLW) vertical tidal datum, the average of all the low water heights for each tidal day observed at a specific tidal station over the National Tidal Datum Epoch (NTDE; 18.6-year tidal epoch, rounded to a full year cycle, over which tide observations are recorded and reduced to establish mean values for tidal datums; NOAA, 2001). Reference tidal datum epochs are necessary for measurement standardization because of periodic and secular trends in relative sea level. The MLW tidal datum, therefore, varies with changes in sea level over time depending on the 19-year cycle referenced for measurement (Marmer, 1951; Harris, 1981; Hess, 2004; Foxgrover et al. 2004; Meyer et al. 2004). Because relative sea level changes, tidal datums at a specific site become out-of-date and must be updated to account for long-term vertical adjustments, such as global sea level change, subsidence, and glacial rebound (Hicks, 1981; NOAA, 2003). As such, all bathymetric data were adjusted to a common vertical reference plane (relative to 2010) to account for changing tidal datums accompanying fluctuations in relative sea level for the period of record (Table 4.2). In addition, all depths were referenced to the North American Vertical Datum of 1988 (NAVD88) using the National Geodetic Survey (NGS) VDatum tool to account for spatial variations in adjustment between MLW and NAVD88.

Table 4.2. Vertical adjustments to historical bathymetry data for accurate comparison of surface change between 1847/51 and 2005/10.

Survey Date	Sea Level Rise Adjustment (ft)
1847/51	-1.46
1917/20	-0.80
1960/69	-0.39
2005/10	0.00

Vertical tidal datum adjustments were based on NOAA tidal benchmark #8735180 (Dauphin Island, Mobile Bay; Figure 3.14). Although sea-level observations at the USACE Biloxi gauge were longer than changes recorded at the Dauphin Island gauge, USC&GS, USGS, and USACE bathymetric surveys referenced the Dauphin Island gauge for tidal corrections during surveys. Water level measurements at the USACE Biloxi gauge indicated a sea-level rise trend consistent with that recorded at Dauphin Island (0.00956 ft /year; see Figure 3.16). Table 4.2 documents the vertical adjustments used to bring historical bathymetric surfaces to the same vertical reference datum used for the 2005/10 bathymetric surveys. The unit of measure for all surfaces is feet, and final values were rounded to tenths of feet before cut and fill computations were completed.

4.1.2 NAVD88 reference elevation

From the shoreline to a distance offshore of about 500 to 800 ft, bathymetry data do not exist for most historical surveys. To better estimate beach and nearshore profile shape for change comparisons, the position of the 0 NAVD88 line was determined using documented distances between the position of NAVD88 and the position of the high-water line (HWL) on recent USACE lidar surveys. The average horizontal position of the 0 NAVD88 line (0.23 ft MLLW) was on average approximately 100 ft seaward of the HWL. To verify the accuracy of this relationship, an NAVD88 line was established about 100 ft seaward of the HWL for the 2007 lidar and

2008/09 USGS survey composite. Two surfaces were created; one included beach and nearshore elevations from the original surveys, and the other used the HWL, estimated 0 NAVD88 line, and offshore data deeper than 8 ft from the 2008/09 survey. Cross-sections were compared for each surface to evaluate beach shape obtained using each method. After completing many similar comparisons, it was determined that the described technique for estimating the profile shape between the HWL and offshore bathymetry data provided a good estimate of profile shape in the absence of nearshore survey data.

4.2 Measurement uncertainty

As with shoreline data, measurements of seafloor elevation contain inherent uncertainties associated with data acquisition and compilation. It is important to quantify limitations in survey measurements and document potential systematic errors that can be eliminated during quality control procedures (Byrnes et al. 2002). Most measurement errors associated with present and past surveys are considered random over the survey area. As such, random errors cancel relative to change calculations derived when comparing two surfaces. A method for determining limits of reliability for erosion and accretion is to quantify measurement uncertainty associated with bathymetric surfaces. Interpolation between measured points includes a degree of uncertainty associated with terrain irregularity and data density. The density of bathymetry data, survey line orientation, and the magnitude and frequency of terrain irregularities are the most important factors influencing uncertainties in volume change calculations between two bathymetric surfaces (Byrnes et al. 2002). Volume uncertainty relative to terrain irregularities and data density can be determined by comparing surface characteristics at adjacent survey lines. Large variations in depth between survey lines (i.e., few data points describing variable bathymetry) will result in large uncertainty calculations between lines. Additionally, surveys with track lines oriented parallel to major geomorphic features can result in large uncertainty calculations between lines. Computing differences in surface characteristics based on survey data distribution provides the best estimate of uncertainty for gauging the significance of volume change calculations between two surfaces.

Uncertainty estimates were calculated for all bathymetric surfaces using the methods outlined in Byrnes et al. (2002) and Byrnes et al. (2010). Results of uncertainty calculations are summarized in Tables 4.3 and 4.4. Estimates were generated for each bathymetric surface, including the ebb shoal/channel regions. As expected, areas with greatest uncertainty were located along the channel and ebb-tidal delta at passes. To identify potential uncertainty associated with sediment transport calculations, a separate calculation was made for channel/ebb shoal areas. Overall, potential depth uncertainty ranged from ±0.54 to 1.30 ft for calculations made across the entire surface, and from ±1.78 to 2.59 ft for the ebb shoal/channel area specifically (Table 4.3). Combining this information to gauge the impact of potential uncertainties associated with volume change calculations derived from these surfaces resulted in a root-mean-square variation of ±1.22 ft (entire surface) and ±2.59 ft (inlet shoals) for the 1847/55 to 1917/20, ±1.0 ft (entire surface) and ±2.36 ft (inlet shoals) for the 1917/20 to 1960/69 change surface, and ±1.41 ft (entire area) and ±2.96 ft (inlet shoals) for the 1960/69 to 2005/10 change surface (Table 4.4). As presented in Byrnes et al. (2010), this translates to a net sand transport uncertainty of about ±43,500 to 70,000 cy/yr. Based on the results of this uncertainty analysis, ±2 ft was used to delineate areas considered to represent no determinable change.

Table 4.3. Potential uncertainty for bathymetric surfaces at and adjacent to the Mississippi Sounds barrier islands.

	Entire Surface (ft)	Inlet Shoals/Channels (ft)
1847/55	±0.89	±1.78
1917/20	±0.84	±1.88
1960/69	±0.54	±2.30
2005/10	±1.30	±2.59

Table 4.4. Maximum root-mean-square potential uncertainty for bathymetric change data at and adjacent to the Mississippi Sounds barrier islands (units in feet).

	1917/20	1960/69	2005/10
1847/55	±1.22[1] ±2.59[2]	±1.04 ±2.28	±1.58 ±3.14
1917/20		±1.00 ±2.36	±1.55 ±3.20
1960/69			±1.41 ±2.96

[1]Entire Surface, [2]Inlet Shoals/Channels

4.3 Surface modeling

Digitized soundings and shorelines were used to create digital elevation models of the seafloor for the period 1847/55 to 2005/10. The Triangulated Irregular Network (TIN) method was used in this study to form surfaces of continuous connected triangular planes based on irregular points (Petrie, 1991). The elevation of each point in the model is determined by solving equations for its horizontal location on the triangulated surface. Therefore, only points existing in the original data sources are used to create the surface model, as opposed to grid models which interpolate evenly spaced points from original data. TIN model surfaces were used for all calculations of bathymetric volumes and change; however, grid surfaces were generated for graphic display purposes.

4.4 Regional morphology

Nearshore sediment transport processes influence the evolution of shelf sedimentary environments to varying degrees depending on temporal and spatial response scales. Although micro-scale processes, such as turbulence and individual wave orbital velocities, determine the magnitude and direction of individual grain motion, variations in micro-scale processes are considered noise at regional-scale and only contribute to coastal response in an average way. By definition, regional-scale geomorphic change refers to the evolution of depositional environments for large coastal reaches (10 km or greater) over extended time periods (decades or greater) (Larson and Kraus, 1995). An underlying premise for modeling long-term morphologic change is that a state of dynamic equilibrium is approached as a final stage of coastal evolution. However, the interaction between the scale of response and forces causing change often results in a net sediment deficit or surplus within a system, creating disequilibrium. This process defines the evolution of coastal depositional systems.

Four regional bathymetric surfaces were established for the barrier islands fronting the Mississippi Sound coastal zone for the periods 1847/55, 1917/20, 1960/69, and 2005/10 to describe large-scale variations in coastal and nearshore morphology. Sediment transport patterns and processes in the vicinity of the Mississippi Sound barrier islands and passes are of primary interest, and regional morphology and change provide insight regarding dominant transport pathways relative to sediment sources and sinks.

4.4.1 1847/55 Bathymetric surface

Bathymetry data for the period 1847/55 were combined with 1847/49 shoreline data to create a continuous surface from the shoreline seaward to about the 50-ft depth contour (NAVD). The most prominent geomorphic features throughout the study area are channels and shoals associated with passes between the barrier islands (Figure 4.1). A series of inlet shoals and channels reflect the redistribution and conveyance of littoral sand between barrier islands within a relatively narrow zone of sand transport bound by the 30- to 35-ft depth contour in the gulf and the 10- to 15-ft contour in the sound. This approximate 1 to 4 mile wide nearshore region (narrower for islands, wider for passes) encompasses the zone of littoral sand transport through which islands and inlets fronting the Mississippi Sound have evolved in response to storm and normal coastal processes. Channel orientation is primarily north-south, and overall deposition on ebb shoals is skewed to the west. This observation is consistent with net shoreline migration, documenting the influence of net westward sediment transport along the shelf and shoreline in coastal Mississippi and Alabama.

Unlike Mobile Pass and ebb shoal at the eastern boundary of Figure 4.1, inlet shoals and channels of the Mississippi Sound barrier island system do not extend far offshore, reflecting the geomorphic characteristics of wave-dominated inlets. The ebb shoal at Dog Keys Pass (between Ship Island and Horn Island) is the most extensive shoal system along the barrier island chain, followed by shoals associated with Horn Island Pass (between Horn Island and Petit Bois Island). Although Ship Island Pass has the deepest natural inlet west of Mobile Pass, ebb shoal deposits are not well developed, perhaps reflecting a natural decrease in sand transport (and therefore, wave energy) toward the west end of Ship Island (terminal point in the longshore transport system). Inlet shoals and channels at all entrances are oriented to the west, consistent with the dominant direction of net sand transport resulting in westward lateral growth of the islands. Between the passes, offshore contours appear relatively straight and parallel to shoreline orientation.

4.4.2 1917/20 Bathymetric surface

Bathymetry data for the period 1917/20 were combined with 1916/17 shoreline data to create a continuous surface from the sound seaward to about the 60-ft depth contour (NAVD). Most general characteristics of the surface around the islands, entrances, and on the shelf seafloor are similar to those identified from the 1847/55 surface (Figure 4.2). However, there are a few notable exceptions:

1. Dauphin and Petit Bois Islands were decimated by the July 1916 hurricane, creating a wide breach along 5 miles of central Dauphin Island and an eroded eastern end of Petit Bois Island;
2. Channels through Petit Bois Pass, Horn Island Pass, and Dog Keys Pass were better defined and all were oriented to the southwest;
3. All islands exhibited significant erosion on their eastern ends and significant island growth to the west, thereby forcing inlet channels westward; and
4. Little Dog Keys Pass (adjacent to eastern Ship Island) became a dominant inlet channel between Dog Island and eastern Ship Island.

Channel dredging at Horn Island Pass and Ship Island Pass was initiated in the late 1890s, and by 1917, 25-ft and 26-ft deep channels through the outer bars (both 300-ft wide) were maintained to support commercial navigation. Initial authorized depths were consistent with natural channel depths, so the presence of well-defined dredged channels was not very evident (Figure 4.2 versus Figure 4.1).

Although large sections of central Dauphin Island were dispersed by the 1916 hurricane, net westward island growth was illustrated between 1847/52 and 1917/18, consistent with all Mississippi Sound barrier islands for this period. Furthermore, natural channel migration to the west was forced by large quantities of littoral sand being transported from east to west throughout the system, filling old channel locations in response to net island growth. The ebb shoals at Petit Bois Pass, Horn Island Pass, and Little Dog Keys Pass were better defined than shoal deposits surveyed in the mid-1800s. Again, offshore contours appear relatively straight and parallel to shoreline orientation between the passes.

4.4.3 1960/69 Bathymetric surface

Bathymetric surface characteristics for the period 1960/69 are similar to the 1917/20 surface with a few exceptions (Figure 4.3). First, geomorphic features are better defined because the number of data points is larger for the more recent period. Although the general shape and position of shoals is consistent for each period, significant changes have occurred since 1917/20. Second, deposition along the western end of Dauphin Island caused rapid growth of the beach and migration of the inlet channel to the west (see

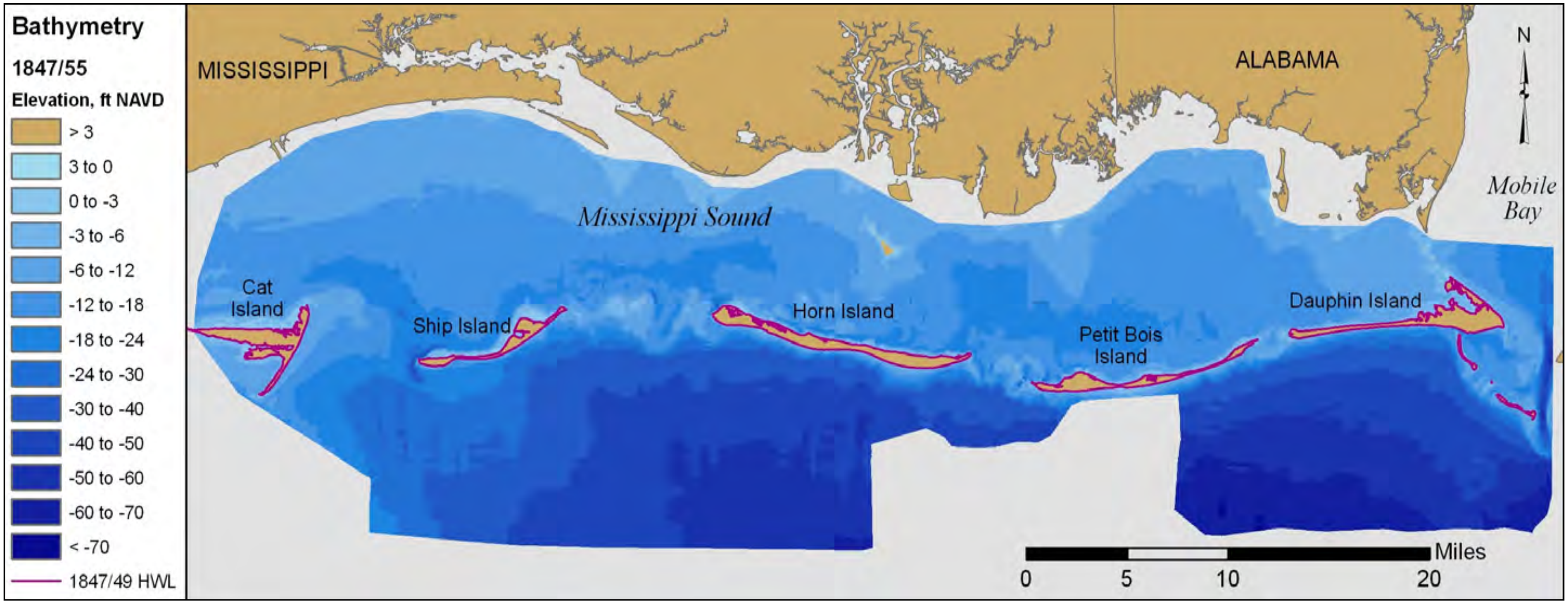

Figure 4.1. Regional bathymetric surface for the study area, 1847/55.

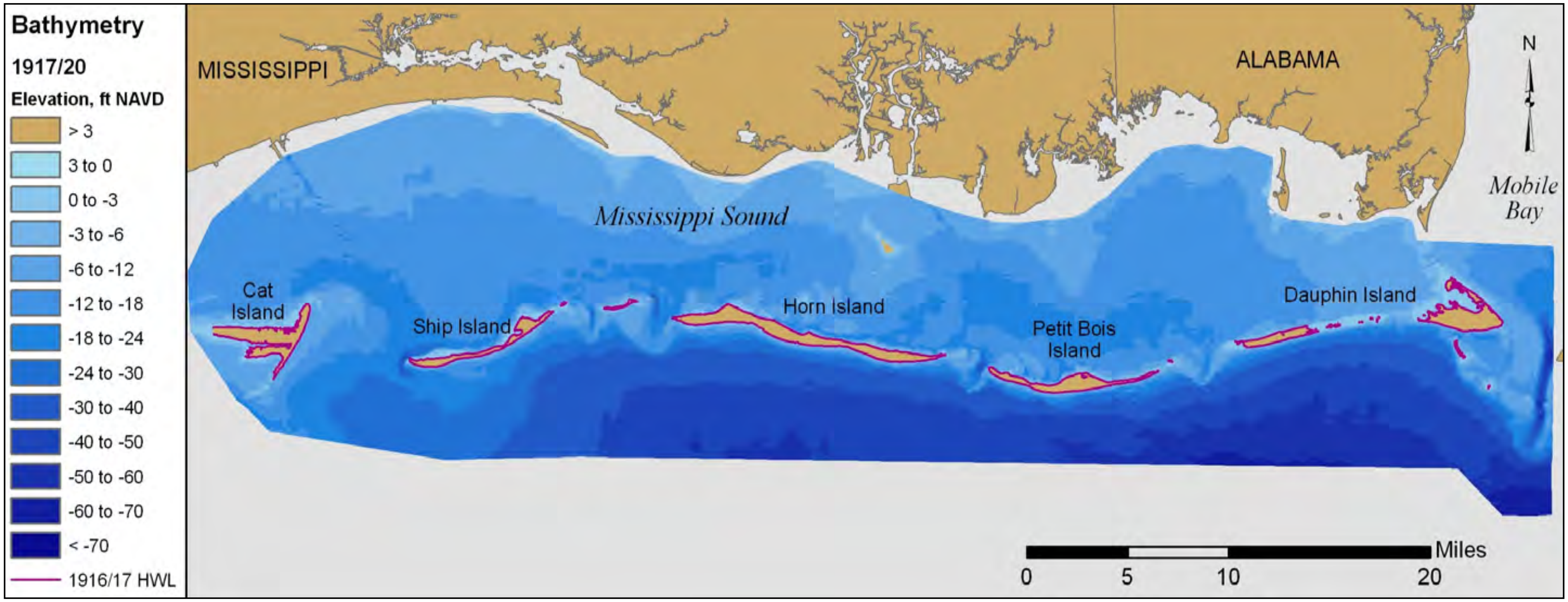

Figure 4.2. Regional bathymetric surface for the study area, 1917/20.

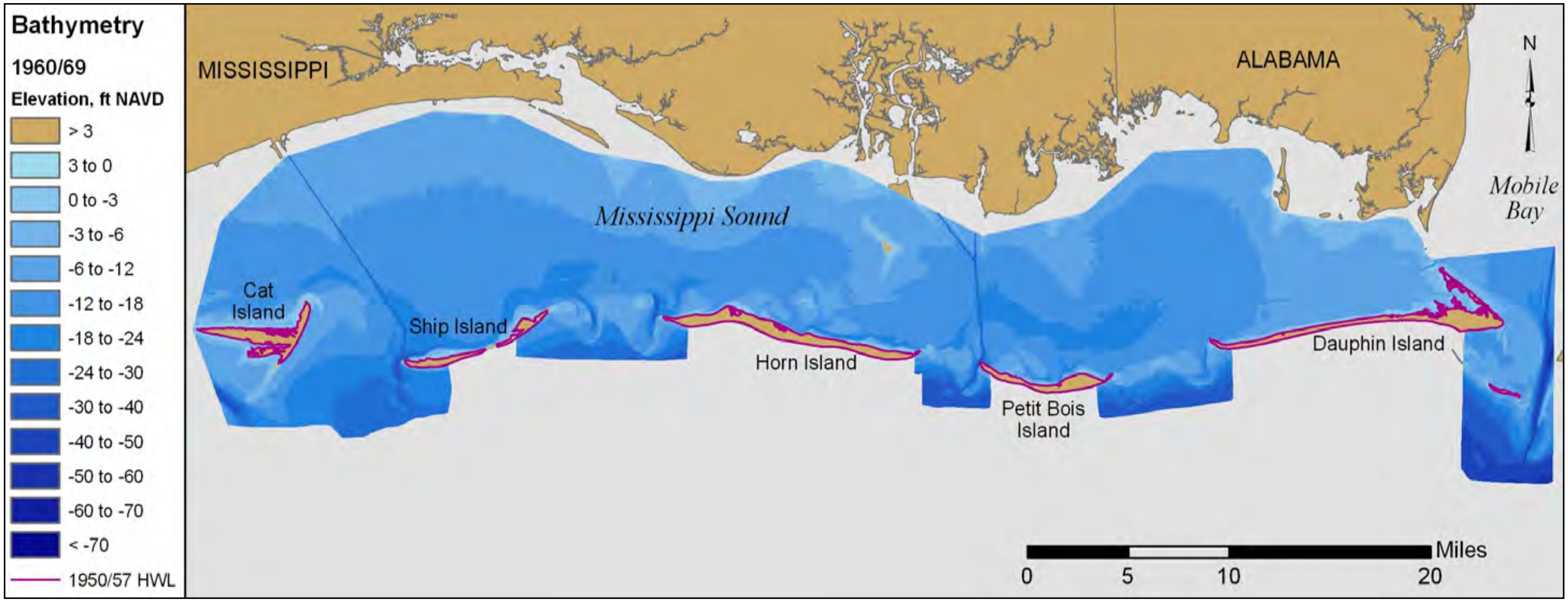

Figure 4.3. Regional bathymetric surface for the study area, 1960/69.

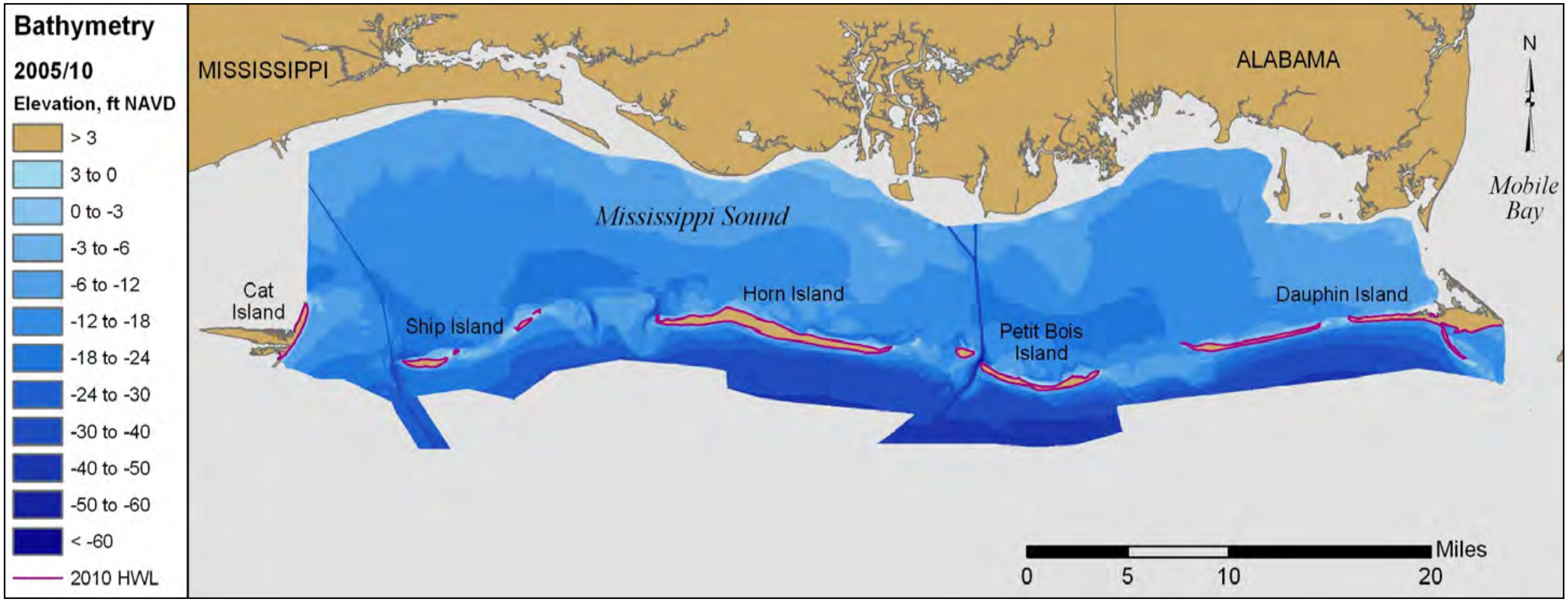

Figure 4.4. Regional bathymetric surface for the study area, 2005/10.

Chapter 3). A similar response was recorded for Petit Bois, Horn, and Ship Islands; however, the presence of well-maintained navigation channels at Horn Island Pass and Ship Island Pass controlled the degree to which natural island growth could occur. Third, as Dauphin Island expanded to the west, it appeared that gradual infilling of the channel created a broad, shallow entrance that may enhance natural westward island growth and downdrift sand transport to Mississippi barrier islands. Lastly, westward growth of Horn Island into Dog Keys Pass caused channel infilling and westward migration, which in turn resulted in erosion and dispersion of Dog Island and the deepening of Little Dog Keys Pass. Growth of the ebb shoal at Little Dog Keys Pass illustrated net deposition at the entrance, reducing the magnitude of sand transport to Ship Island.

One drawback of the 1960/69 seafloor surface is that much of the offshore was not surveyed. The Mississippi Sound and inlet environments were well surveyed but adjacent areas fronting the islands were absent. Because much of the most active portion of the littoral zone illustrates consistent geomorphology for prior time periods, it is expected that only minor differences in nearshore morphology would be recorded in areas of greatest island changes (adjacent to inlets and at central Ship Island where a breach from the 1947 hurricane was mapped). Westward island growth and erosion on the east margins of the barriers continued between 1917/20 and 1960/69, although the rate of change appeared to decrease after about 1950 (see Chapter 3, Spatial and Temporal Trends). Regardless of whether an island is abutting a maintained navigation channel or a natural channel, the rate of island and inlet change appears reduced relative to historical surfaces.

4.4.4 2005/10 Bathymetric surface

A number of significant geomorphologic changes were recorded by the 2005/10 bathymetry surveys. Most obvious was that associated with island breaching on Ship and Dauphin Islands (Figure 4.4). The largest tropical cyclones in the area were recorded between 1960/69 and 2005/10, so large changes in island and inlet shoals would be expected. From east to west, westward island growth of Dauphin Island effectively closed the main channel at Petit Bois Pass. The entrance remains as wide as it was in 1960/69, but flow within the entrance must have diminished as the main channel became filled in response to dominant west-directed longshore sediment transport. Although the eastern end of Petit Bois continued to erode, the western end of the island maintained position relative to 1960/69 because it abuts the Pascagoula navigation channel at Horn Island Pass (Figure 4.4). Littoral sand transported to and dredged from the channel was placed primarily in the littoral zone west of the channel since 1960/69. The small island west of the channel has been a primary dredged material disposal site for decades and slowly feeds sand west toward Horn Island. Placement records also indicate that dredged sand has been placed elsewhere on the ebb shoal that eventually supplies sediment to eastern Horn Island.

Although the eastern end of Horn Island continued to erode between 1960/69 and 2005/10, subaerial deposition along the west end of the island did not keep pace. Westward growth of the island continued to shoal the inlet and push the channel west, invoking a switch in channel flow dominance at Dog Keys Pass. The 2005/10 bathymetric surface illustrates that Little Dog Keys Pass is now deeper and more dominant than at any time in the historical survey record (Figure 4.4). The ebb shoal at Dog Keys Pass remains large, but the shoal at little Dog Keys Pass has grown substantially since 1847, implying that it has become a sink to littoral sand transport from the east. Consequently, sand transport to Ship Island has been reduced, resulting in a net deficit in sand bypassing to eastern Ship Island.

As a result of inlet shoal and channel dynamics at Dog Keys Pass, Ship Island has experienced greatest changes between 1960/69 and 2005/2010. The eastern half of the island is close to becoming a shoal as the island responds to a deficit in sand from Dog Keys Pass and the brunt of a series of devastating tropical cyclones since 1969. Transport dynamics naturally are reduced toward Ship Island as the direction of open-gulf wave energy becomes more restricted west of Horn Island in the shadow of the St. Bernard delta.

Although Horn Island Pass has been on a relatively routine maintenance dredging schedule since 1917/20, the outer margin of the ebb shoal has remained relatively consistent since this time, suggesting that channel deepening may not have had a significant impact on shoal evolution or channel hydraulics at the seaward extent of the ebb shoal. This finding is in contrast to the impact of jetty construction on ebb-shoal evolution at structured entrances (e.g., Dean and Perlin, 1977; Kraus, 2000; Byrnes and Baker, 2003; Byrnes et al. 2007). Apparently, as long as most littoral sand dredged from the channel is placed in the littoral zone downdrift of the channel, engineering impacts to transport processes can be mitigated.

4.4.5 Island and channel migration

Evolution of the Mississippi Sound barrier island chain has been controlled by net westward migration of islands and entrances, primarily in response to tropical cyclones and normal incident coastal processes. Mariners, engineers, and scientists have recognized the natural westward shift of the islands and channels since the earliest historical records. Physical parameters, such as entrance width between islands, channel depth, and shoal dynamics, control the exchange of sediment in the littoral zone between islands and entrances. Changes in inlet morphology document factors that may have significant impact on the historical evolution of the Mississippi Sound barrier islands. Inlet cross-sections were compiled to document changes in shoal and channel characteristics that influence the quantity of sediment bypassing entrances to downdrift beaches.

Figure 4.5 illustrates transect locations for each cross-section year at Petit Bois Pass. Island configuration and changes required separate transect locations for documenting channel and shoal evolution. However, the westernmost location for each transect terminates at a similar longshore position, providing a means for comparing island and channel migration, changes in inlet width, and seafloor elevations between 1848 and 2009. In 1848, the eastern side of the pass was approximately 24,500 ft east of its present location, channel depth was about 17.5 ft deep, and inlet width was approximately 9,800 ft (Figure 4.6; Table 4.5). Over the following 69 years, westward littoral transport from Dauphin Island transported large quantities of sand toward Petit Bois Pass, promoting island growth (sand spit development), inlet migration, and erosion along the eastern end of Petit Bois Island.

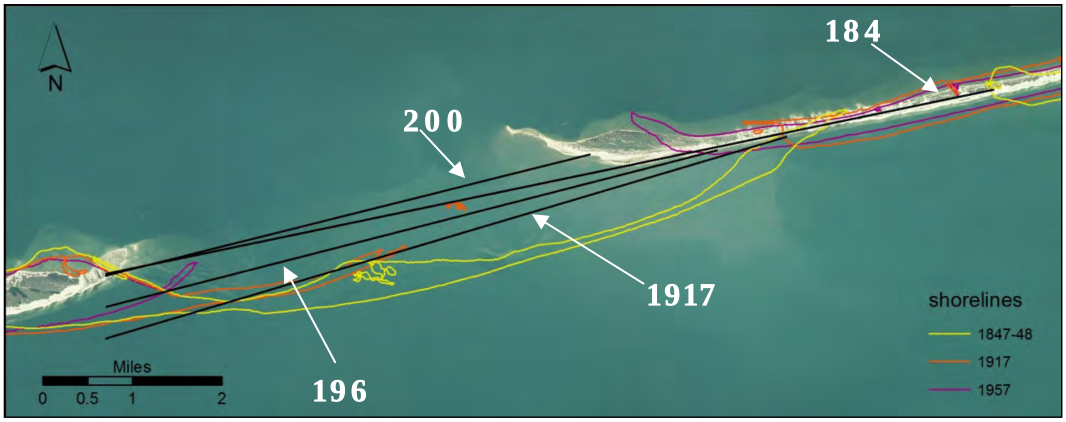

Figure 4.5. Transect locations for illustrating historical inlet cross-sections for Petit Bois Pass.

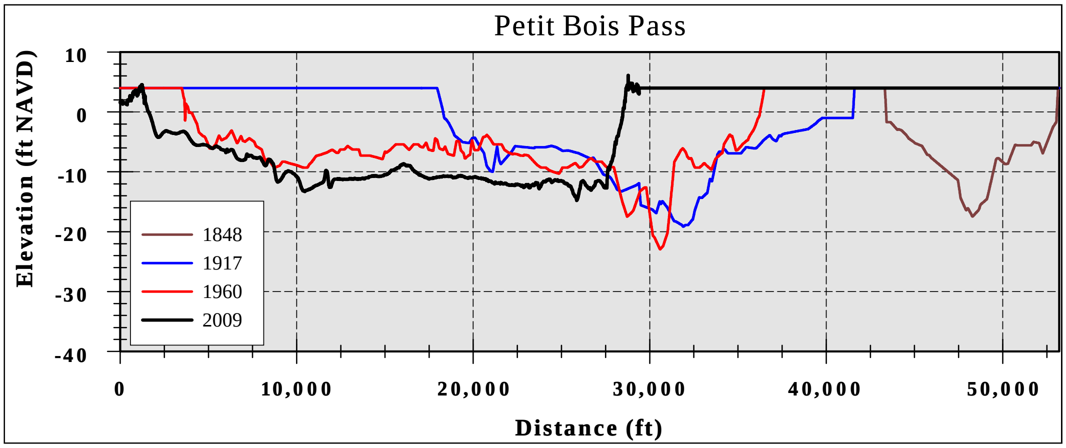

Figure 4.6. Historical inlet cross-sections for Petit Bois Pass illustrating changes in seafloor shape, 1848 to 2009.

By 1917, one year after the intense hurricane of 1916, the eastern end of Petit Bois Island had eroded and migrated approximately 42,000 ft west of its location in 1848, resulting in an inlet about 23,700 ft wide. Maximum channel depth along the cross-section increased to about 19 ft and channel location was approximately 16,400 ft west of its location in 1848. The trend of westward spit growth, channel migration, and erosion along the eastern end of Petit Bois Island continued through 1960 when the dominant inlet channel reached it greatest depth (-22.9 ft) and inlet width was about 33,000 ft. By 2009, west-directed island growth on Dauphin Island had filled the entrance channel, decreasing inlet width by about 5,600 ft and creating a broad and relatively shallow entrance area (Figure 4.6). A well-defined channel for exchange of water and sediment between the Mississippi Sound and the Gulf of Mexico was no longer present, perhaps signaling a change in inlet hydraulics that may promote more efficient bypassing of sand between Dauphin and Petit Bois Island in the future.

Inlet shoal and channel dynamics at Horn Island Pass were documented for each historical time period along the transect illustrated in Figure 4.7. Like Petit Bois Pass, westward island migration forced the channel and eastern Horn Island to the west as Petit Bois Island filled much of the historical footprint of the pass as it existed in 1853 (Figure 4.8). The western end of Petit Bois Island extended approximately 16,000 ft into the pass while the eastern end of Horn Island eroded and shifted about 19,600 ft west by 2009 (Table 4.5). Channel and island migration of Horn Island Pass ceased as of the 1961/62 bathymetric survey due to the presence of a fixed and maintained navigation channel abutting western Petit Bois Island; however, eastern Horn Island continued to erode and migrate westward during this time (Figure 4.8).

Table 4.5. Historical entrance and channel dimensions for passes within the Mississippi Sound barrier island system.

Petit Bois Pass

Bathymetry Survey Year	West Shoreline	Cumulative Shoreline Movement	East Shoreline	Cumulative Shoreline Movement	Channel Width	Channel Elevation	Channel Location[1]	Channel Migration
1848	43,315	0	53,139	0	9,825	-17.48	48,285	0
1917	17,943	25,372	41,605	11,534	23,662	-19.16	31,910	16,374
1960	3,495	39,820	36,494	16,645	32,999	-22.94	30,589	17,695
2009	1,285	42,030	28,686	24,454	27,401	-14.77	25,866	22,418

Horn Island Pass

Bathymetry Survey Year	West Shoreline	Cumulative Shoreline Movement	East Shoreline	Cumulative Shoreline Movement	Channel Width	Channel Elevation	Channel Location[1]	Channel Migration
1853	20,907	0	41,872	0	20,965	-17.48	37,142	0
1917/18	15,449	5,458	28,119	13,753	12,670	-19.16	26,004	11,138
1961/62	8,700	12,207	25,619	16,252	16,920	-22.94	24,989	12,152
2009	1,285	19,622	25,918	15,953	24,633	-14.77	24,938	12,203

Dog Keys Pass

Bathymetry Survey Year	West Shoreline	Cumulative Shoreline Movement	East Shoreline	Cumulative Shoreline Movement	Entrance Width	Little Dog Keys Pass			Dog Keys Pass		
						Channel Elevation	Channel Location[1]	Channel Migration	Channel Elevation	Channel Location[1]	Channel Migration
1853/55	5,345	0	47,421	0	42,076	-19.25	13,744	0	-20.89	35,392	0
1917/18	3,540	1,805	35,590	11,831	32,050	-33.57	14,885	-1,141	-28.69	31,310	4,082
1967/68	2,015	3,330	33,110	14,311	31,095	-32.20	14,480	-736	-34.61	30,835	4,557
2008	450	4,895	31,422	15,999	30,972	-35.89	14,709	-965	-29.21	29,032	6,359

Ship Island Pass

Bathymetry Survey Year	West Shoreline	Cumulative Shoreline Movement	East Shoreline	Cumulative Shoreline Movement	Channel Width	Channel Elevation	Channel Location[1]	Channel Migration
1847/48	1,905	0	36,463	0	34,558	-38.96	34,693	0
1917	1,160	745	33,872	2,592	32,712	-37.81	32,102	2,591
1968/69	250	1,655	31,652	4,811	31,402	-34.68	30,907	3,786
2008/2010	0	1,905	31,652	4,811	31,652	-38.40	29,207	5,486

Note: All measurements units are in feet.; [1] **Deepest part of the channel.**

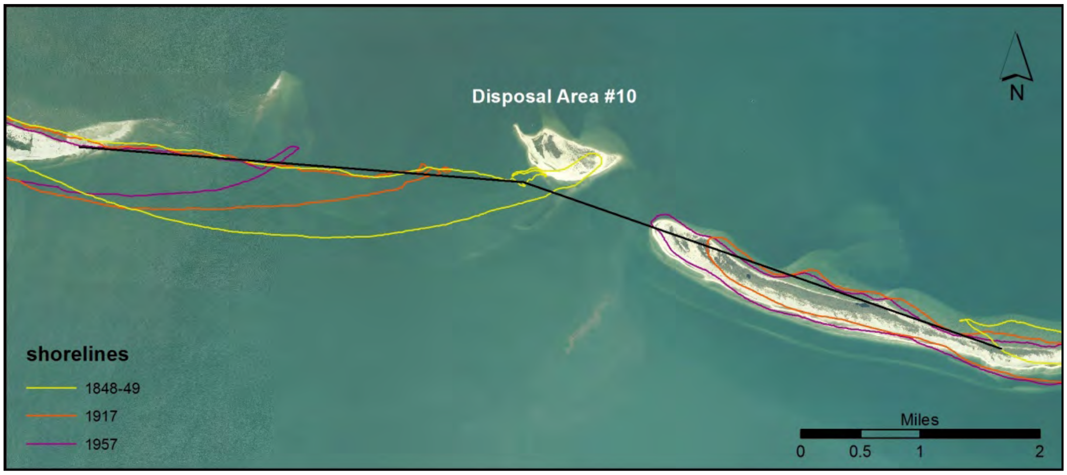

Figure 4.7. Transect location for illustrating historical inlet cross-sections for Horn Island Pass.

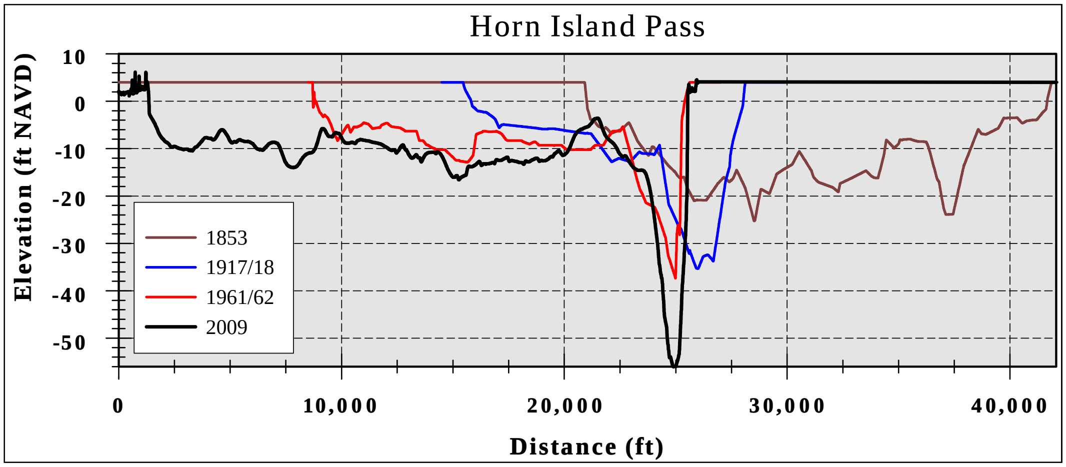

Figure 4.8. Historical inlet cross-sections for Horn Island Pass illustrating changes in seafloor shape, 1853 to 2009.

Two primary changes occurred at and near the channel between 1961/62 and 2009. First, channel depth along the transect increased to about 56 ft, far greater than that associated with authorized channel modifications (38 ft deep and 325 ft wide in 1962 to 44 ft deep and 550 ft wide in 1995; see Appendix A). Second, much of the sand dredged from the channel was placed just west of the channel in Disposal Area #10 (DA-10) (Figure 4.7). The location of the sand disposal area created a boundary to flow to and from the gulf that has apparently resulted in flows capable of scouring the channel to depths far greater than authorized.

To test this hypothesis, bathymetry data for 1961/61 and 2009 were scrutinized in greater detail with regards to scour areas in and near the navigation channel. Figure 4.9 highlights depths greater than 45 ft to outline the extent of scour by currents prior to placement of dredged sand from the channel in Disposal Area #10 (DA-10). Channel depths do indicate that scour occurs adjacent to the western end of Petit Bois Island where littoral sand accumulates via longshore drift. However, the scour area appears to be isolated to a small region within the navigation channel and maximum depths are about 55 ft (NAVD).

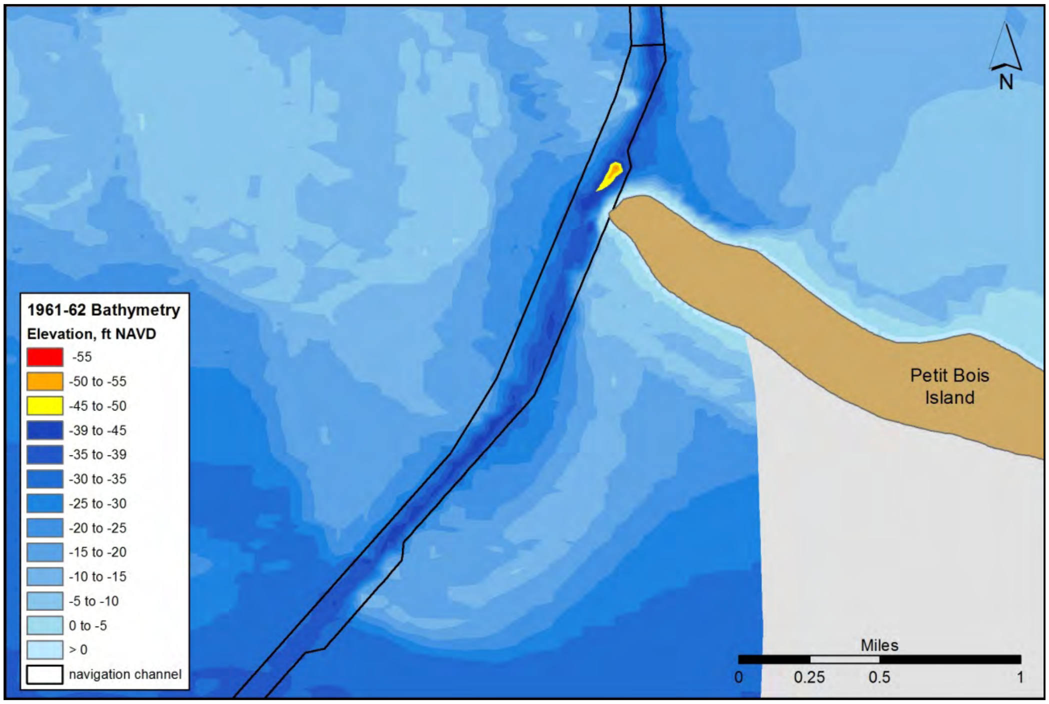

Figure 4.9. 1961/62 bathymetry illustrating the location of a small scour hole adjacent to the western end of Petit Bois Island, presumably the result of increased current flow near the channel boundary.

Between 1962 and 2009, changes in channel configuration were implemented and placement of littoral sand dredged from the channel in DA-10 was prevalent. The idea was to re-introduce littoral material transported into and dredged from the channel to the littoral zone west of the channel as a means of sand bypassing. However, the sand placement soon became subaerial as the amount of sand leaving the disposal area via littoral transport could not keep pace with the amount of material being placed at the site. Consequently, a new island beach was established as a boundary along the western side of the navigation channel.

Figure 4.10 highlights water depths greater than 44 ft (authorized channel depth) to document the presence of scour in and around the navigation channel in 2009. Image scale is the same as that presented in Figure 4.9. The green area represents authorized channel dredging in 2009. The yellow to red zone illustrates areas of scour with elevations lower than -60 ft NAVD in an area adjacent to the northwest margin of Petit Bois Island and DA-10 to the west of the channel. This scour area has developed to encompass the entire width of the channel and beyond to depths up to 20 ft deeper than those authorized for the channel. Perhaps the location of DA-10 provides a mechanism by which flow through the entrance, particularly ebb flows, accelerate in response to the short distance between islands. Increased conveyance of sand and water through the channel has resulted in seaward expansion of the eastern lobe of the ebb shoal and the need for a sediment trap on the eastern side of the channel where the outer bar meets the channel (compare Figures 4.9 and 4.10).

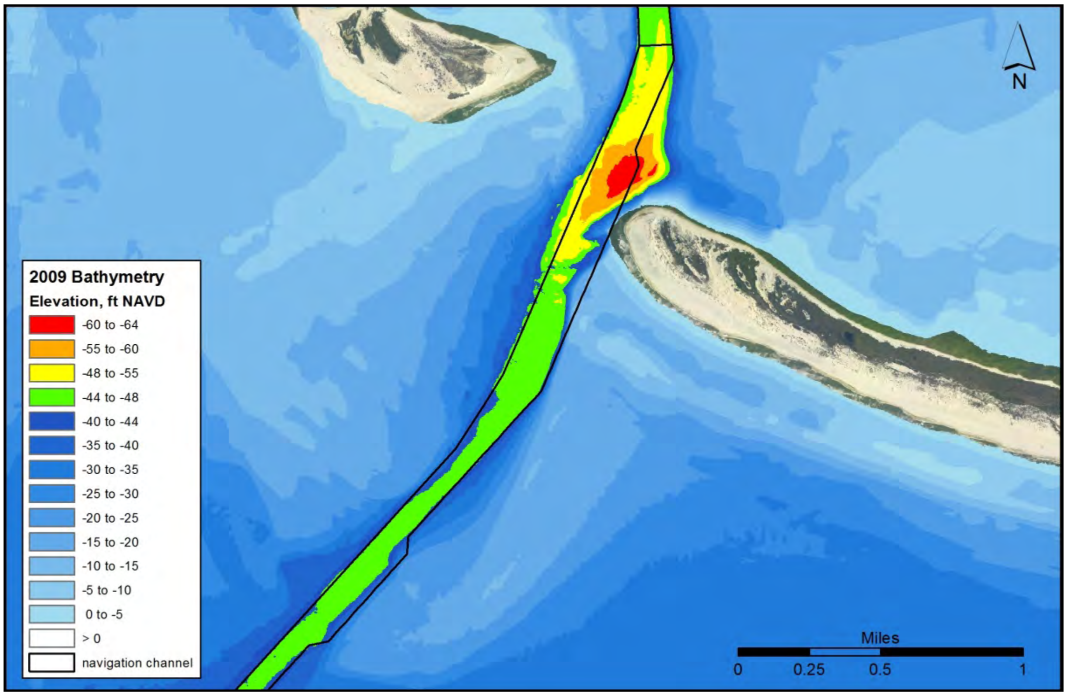

Figure 4.10. 2009 bathymetry illustrating the location of an extensive scour zone adjacent to the western end of Petit Bois Island, presumably the result of increased currents in the area of constricted flow between DA-10 and western Petit Bois Island.

Sand eroded from the eastern end of Horn Island is transported west to create a sand spit where the western end of Horn Island meets Dog Keys Pass. Figure 4.11 illustrates the location of a transect used to document cross-sectional changes in inlet morphology between 1853/55 and 2008. Dog Keys Pass is the largest entrance in the Mississippi barrier island chain and has a width of about 6 miles. The pass also contains two well-developed natural channels. Like island and inlet systems to the east, growth of western Horn Island filled the original location of Dog Keys Pass, and the inlet channel migrated west (Figure 4.12). For the period of record, westward growth of Horn Island (about 16,000 ft) exceeded erosion on eastern Ship Island, resulting in an entrance 11,000 ft narrower than in 1853/55. As such, flow entering and exiting the pass has been constricted; resulting in the development of a dual-channel inlet (Little Dog Keys Pass on the west side and Dog Keys Pass in the east).

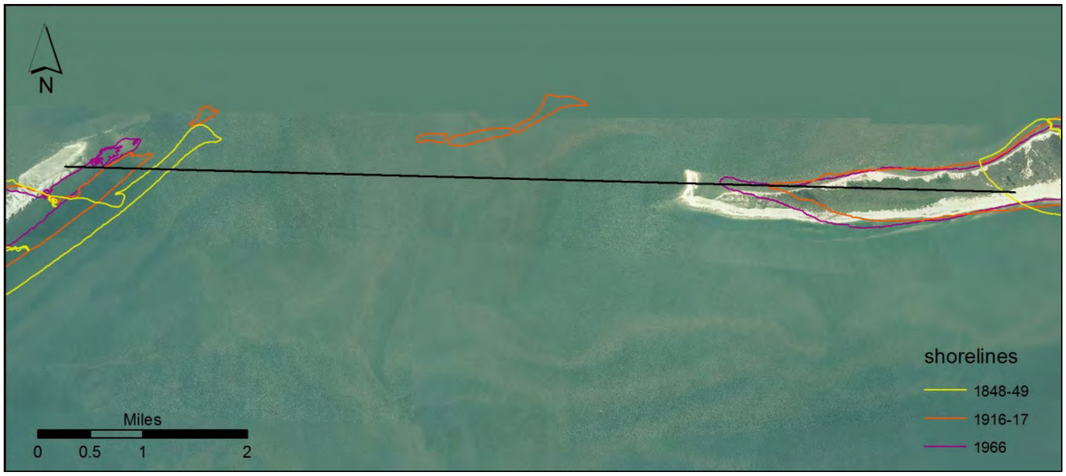

Figure 4.11. Transect location for illustrating historical inlet cross-sections for Dog Keys Pass.

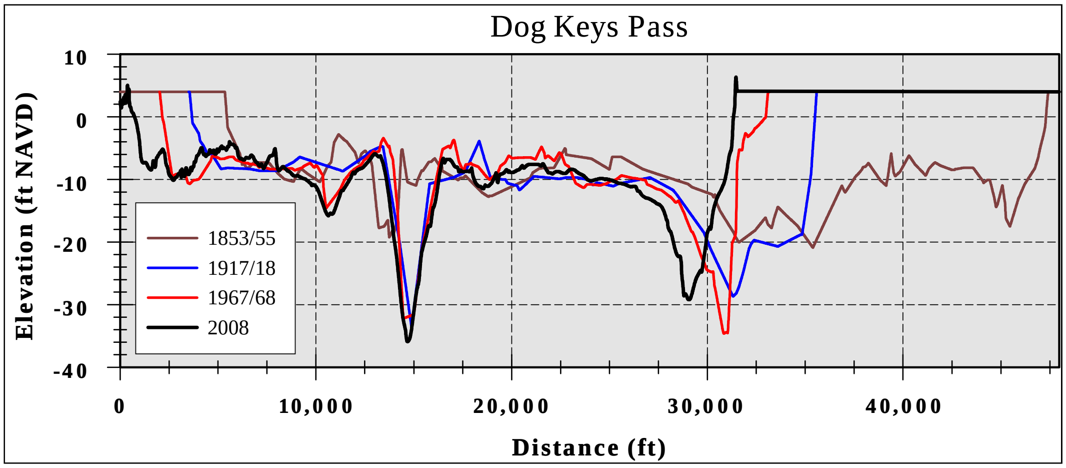

Figure 4.12. Historical inlet cross-sections for Dog Keys Pass illustrating changes in seafloor shape, 1853/55 to 2008.

Originally, Dog Keys Pass was the primary channel for flow to and from the gulf, but since 1967/68, Little Dog Keys Pass evolved into the dominant channel in terms of depth (36 versus 29 ft deep at the transect location; Table 4.5). Although both channels are well-defined, as sand continues to stream from Horn Island to Dog Keys Pass, the channel at Little Dog Keys Pass may become the channel of preference. The stability of Little Dog Keys Pass is well-documented on Figure 4.12, whereas channel migration to avoid infilling is a perpetual occurrence at Dog Keys Pass (6,400 ft since 1853/55).

Ship Island Pass has illustrated the same pattern of westward island growth and channel migration as inlet systems to the east. Figure 4.13 shows the transect location for cross-sections between Ship Island and Cat Island for the period 1847/48 and 2008/10. One marked difference between geomorphic changes at this pass versus those to the east is the absence of seafloor change west of the navigation channel disposal areas to Cat Island (Figure 4.14). Cat Island documents beach retreat expected for a transgressive barrier island; however, exchange of sediment between West Ship and Cat Islands appears non-existent. There is no measureable change in seafloor elevation between the islands for the entire 160 years of historical record, and this is unique for the Mississippi Sound barrier islands. Littoral transport to the west effectively stops at Ship Island Pass; it is the terminal point to longshore transport. Perhaps this dramatic change in dominant

Figure 4.13. Transect location for illustrating historical inlet cross-sections for Ship Island Pass.

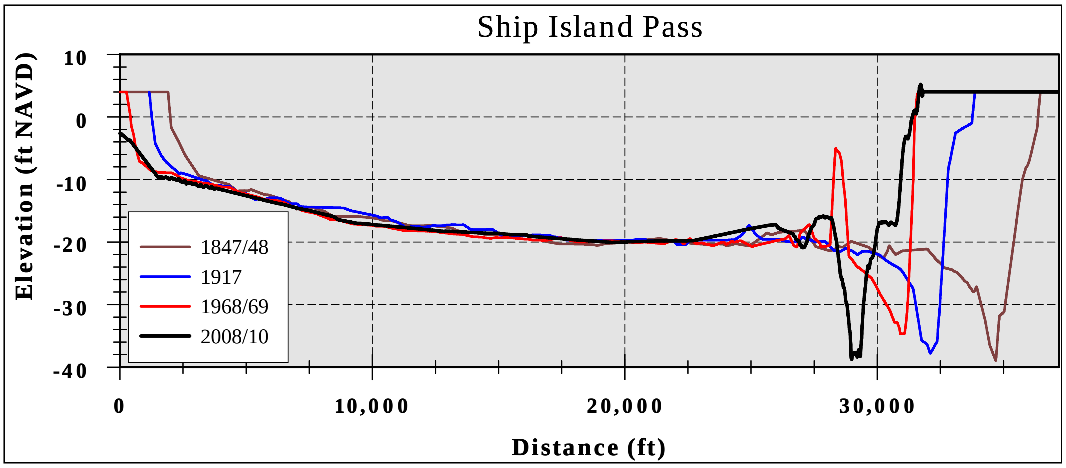

Figure 4.14. Historical inlet cross-sections for Ship Island Pass illustrating changes in seafloor shape, 1847/48 to 2008/10.

westward sand transport throughout the barrier island chain is a function of decreasing wave energy as the system became sheltered by the St. Bernard and Mississippi River deltas. Deltaic deposits adjacent to West Ship and Cat Islands have created a broad and shallow shelf surface that dissipates energy normally incident to island beaches east of this area.

Lastly, channel characteristics along the transect at Ship Island Pass have been very consistent throughout the historical record. Ship Island was named as such in the late 1690s because it had a naturally deep channel and expansive harbor of refuge behind the western end of the island. Channel depth changed very little between 1847/48 (39 ft deep) and 2008/10 (38.5 ft deep) along the transect. Channel depths through the outer bar (not along the transect) are maintained for navigation, but shoaling rates are relatively small compared with maintained channels to the east (see Section 2 and Appendix B). These observations are consistent with a decrease in wave energy toward the end of the littoral transport system.

4.5 Regional sediment transport dynamics

Comparison of bathymetric surfaces for the same geographic area but different time periods documents erosion and deposition patterns that reveal net sediment transport pathways. Erosion and deposition volumes define the magnitude of sediment exchange associated with these transport pathways. Together, these data describe the sediment budget for an area, constrained by import and export estimates (e.g., longshore transport) at the boundaries. Regional changes in seafloor topography were documented for the periods 1847/55 to 1917/20, 1917/20 to 1960/69, 1960/69 to 2005/10, and 1917/20 to 2005/10. These data provided a regional context under which specific changes within the Mississippi Sound barrier island system were evaluated for determining short-term (1917/18 to 1961/68) and long-term (1917/18 to 2005/10) sediment budgets.

The natural movement of sand within the Mississippi coastal zone is controlled predominantly by east-to-west directed waves and currents, hydraulics associated with passes between the islands, and the availability of sand sources east of the study area. Although differences exist between the 1847/55 and 1917/20 bathymetric surfaces in specific areas, both shelf surfaces appear similar upon initial inspection. An analytical comparison of bathymetry data yields a difference plot that isolates areas of erosion and deposition for documenting sediment transport patterns and quantifying trends (Figure 4.15). The most significant changes occurring during this

70-yr interval were associated with erosion along Dauphin, eastern Petit Bois, eastern Horn, and eastern Ship Islands; deposition along the western ends of the islands (sand spit development); and shoal deposition (and erosion) in the entrances, where sand transport to and from inlets is unbalanced as channels and shoals evolve toward equilibrium with incident wave and current energy.

Fluid flow and sediment transport at and adjacent to the Mississippi Sound barrier islands results in relatively predictable seafloor changes. Littoral zone transport is dominated by west-directed waves and currents; however, minor and localized areas of transport reversal do exist at the very eastern ends of the islands. Polygons of yellow to red (erosion) and green to blue (deposition) in channels and on the shoals of the ebb-tidal deltas illustrate the dynamic nature of these features as waves and currents transport and redistribute sediment from east to west throughout the system (Figure 4.15). Overall, sand eroded from the seafloor and island beaches supply sand for spit growth and inlet shoal formation, which in turn forces inlet channels and entrance boundaries to migrate westward in a conveyor-like process. Most coastal systems experience significant reversals in sand flux that redistribute sediment more evenly along beaches and at entrances, but for the Mississippi Sound barrier island system, net sand transport to the west is nearly equal to gross transport (addition of east- and west-directed transport). As such, long-term transport patterns are quite predictable and reliable for developing sediment budget estimates.

Sand sources and sinks are readily identified on bathymetric change figures as red and blue zones (respectively) along the islands. The continuous red zone along Dauphin and eastern Petit Bois Islands reflects the impact of the 1916 hurricane that crossed this area (see Byrnes et al. 2010). Deposition landward and downdrift of this area is from storm overwash processes and longshore transport. Western Petit Bois Island and the ebb shoal at Horn Island Pass experienced widespread accretion during this time. As Horn Island Pass was forced westward by spit growth, eastern Horn Island experienced large-scale erosion, mobilizing millions of cubic yards of sand transported west by littoral currents to create the sand spit on western Horn Island and shoal deposition in Dog Keys Pass. Most sand provided by beach erosion along eastern Ship Island sourced westward expansion of west Ship Island and sand shoal deposition at Ship Island Pass. Figure 4.15 clearly illustrates that sand transport between Ship and Cat Islands is not measureable, meaning Ship Island Pass marks the end of longshore transport along the barrier islands.

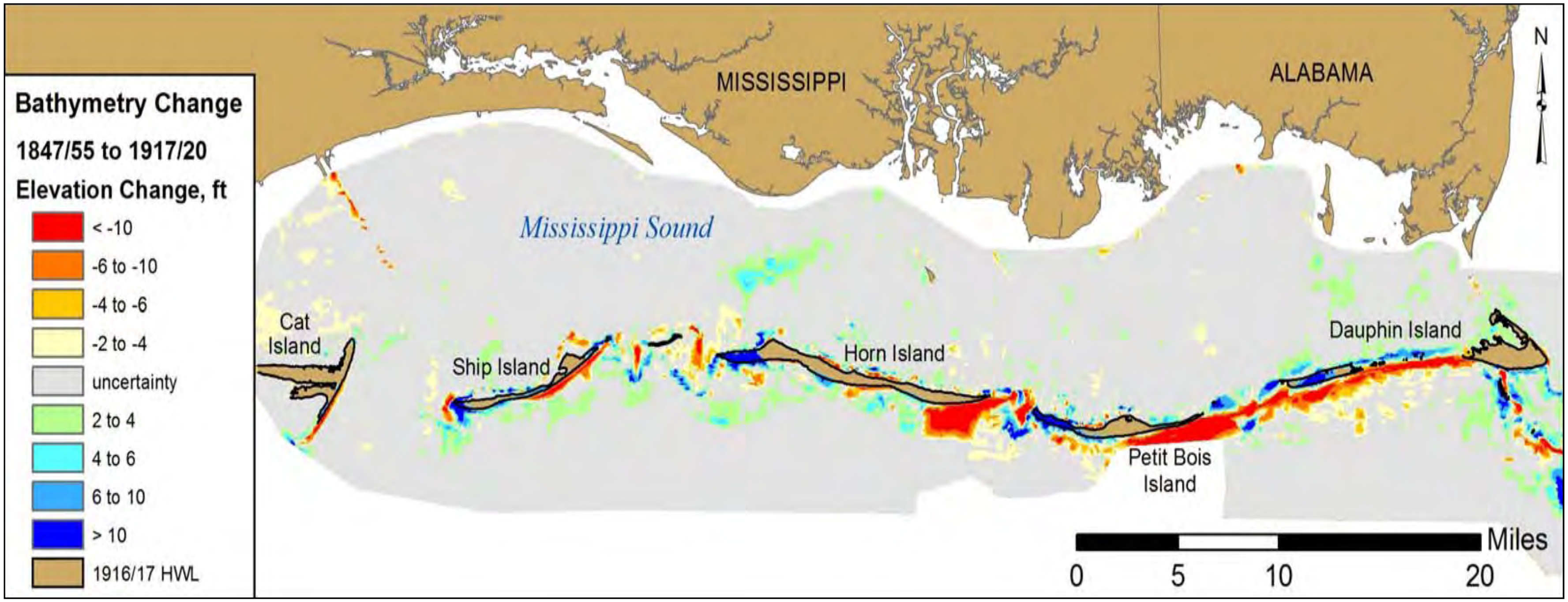

Figure 4.15. Bathymetric change between 1847/55 and 1917/20 for the Mississippi Sound barrier islands. Hot colors represent erosion (yellow to red) and cool colors represent deposition (green to blue).

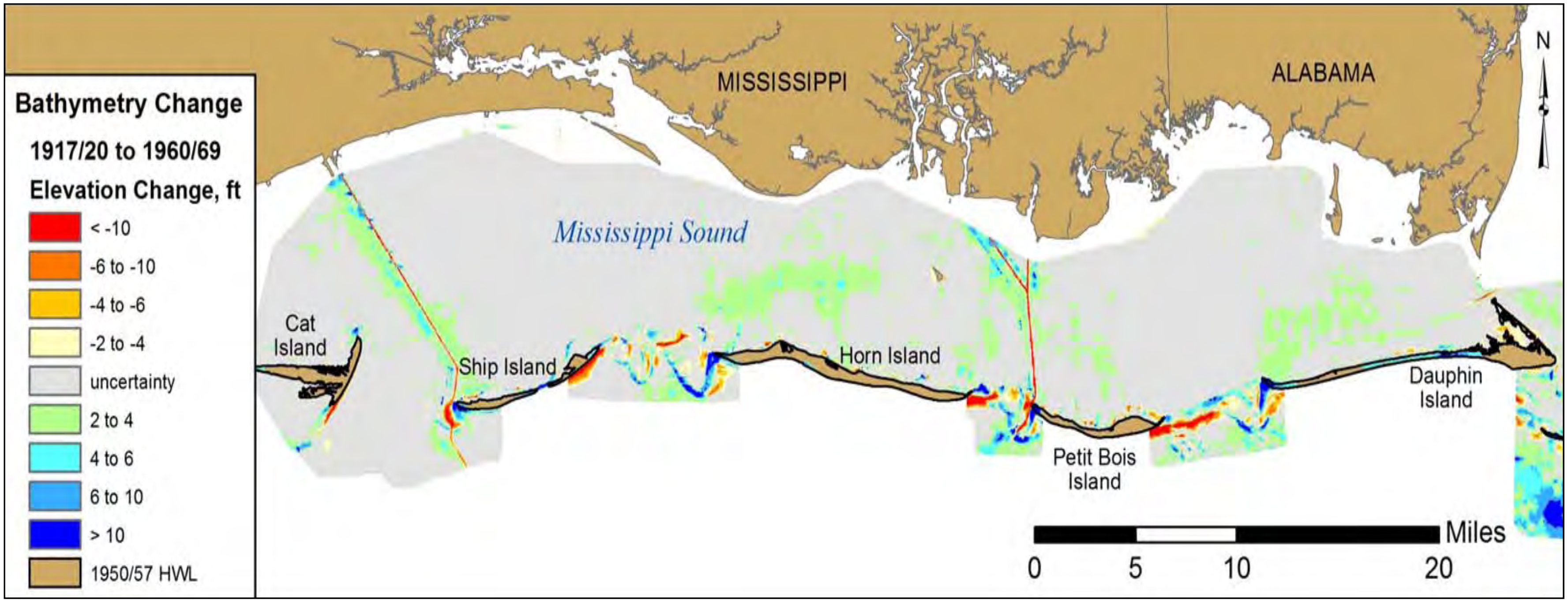

Figure 4.16. Bathymetric change between 1917/20 and 1960/69 for the Mississippi Sound barrier islands. Hot colors represent erosion (yellow to red), and cool colors represent deposition (green to blue).

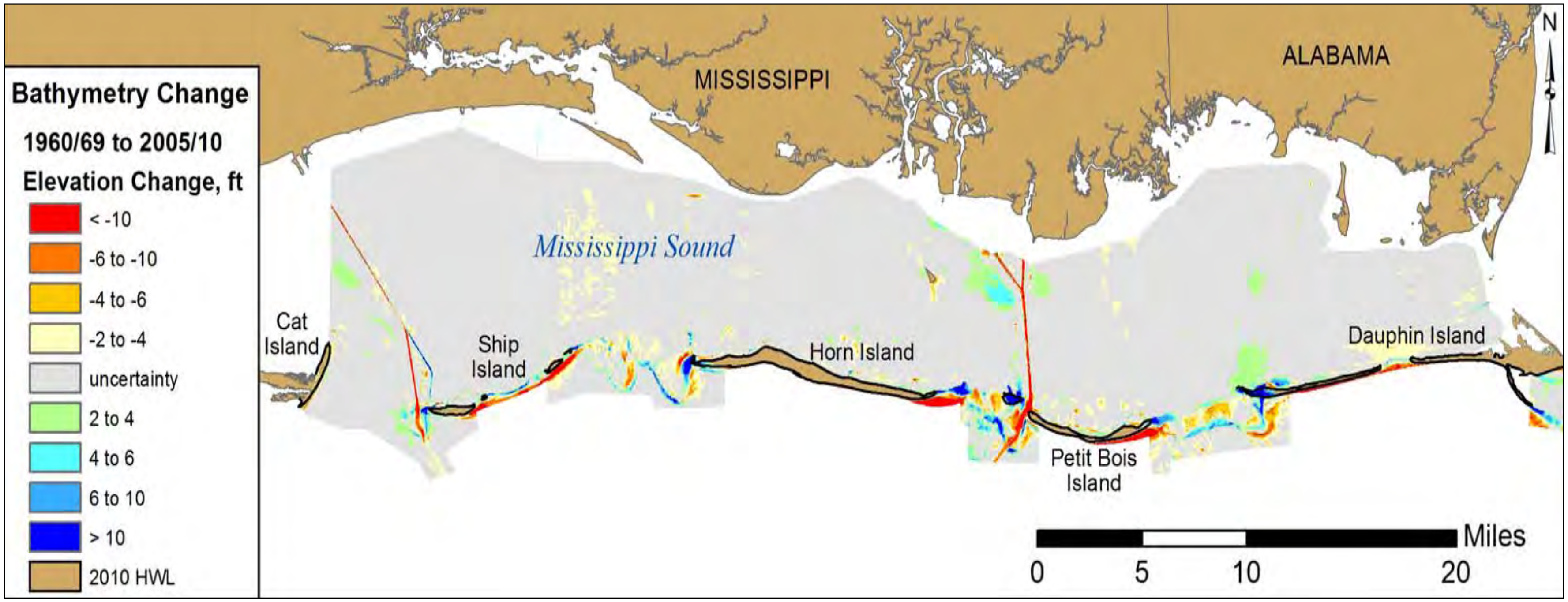

Figure 4.17. Bathymetric change between 1960/69 and 2005/10 for the Mississippi Sound barrier islands. Hot colors represent erosion (yellow to red), and cool colors represent deposition (green to blue).

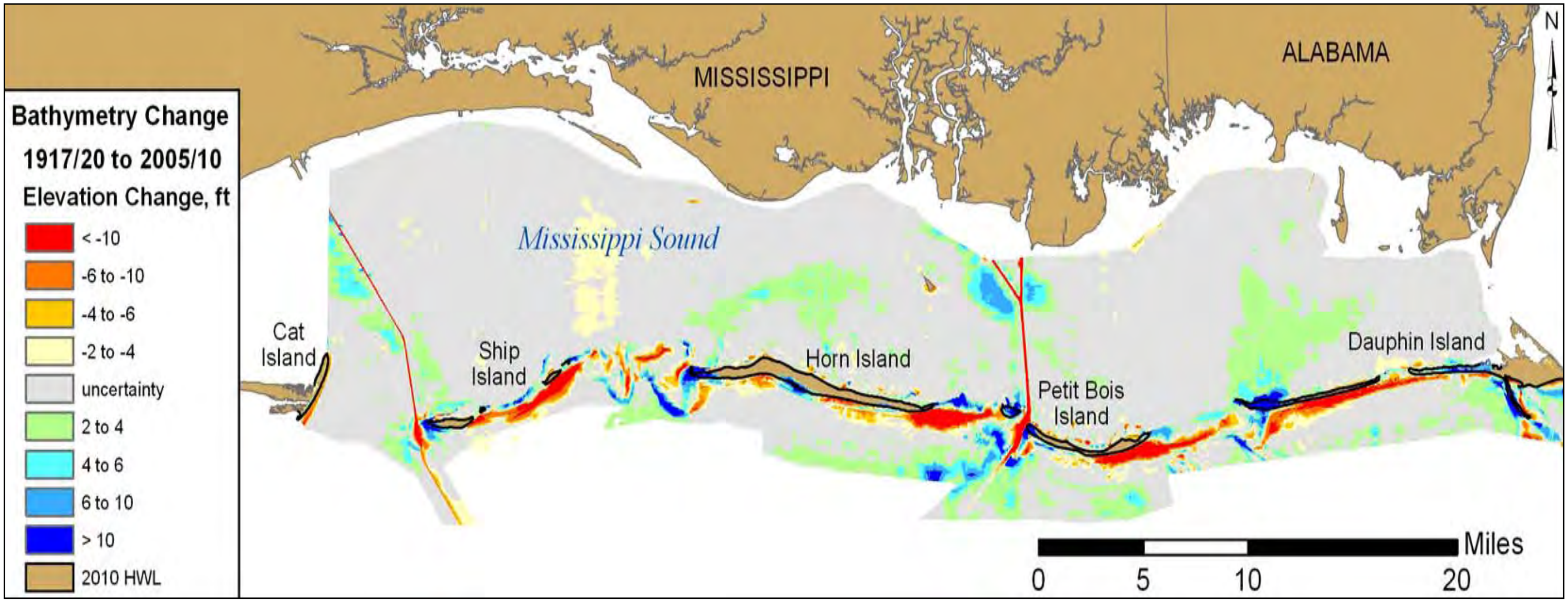

Figure 4.18. Bathymetric change between 1917/20 and 2005/10 for the Mississippi Sound barrier islands. Hot colors represent erosion (yellow to red), and cool colors represent deposition (green to blue).

Between 1917/20 and 1960/69, similar patterns of erosion and deposition occurred throughout the study area. However, gaps in data coverage along gulf coast island beaches made it difficult to compare areas that showed the greatest change over the previous 60 years. Entrance surveys again recorded deposition along the western ends of the islands and shoal deposition throughout the entrances (Figure 4.16). As the navigation channels continued migrating to the west in response to spit growth, erosion along the eastern ends of the islands supplied sand to downdrift beaches. Although data coverage does not provide for complete measurement of gulf beach erosion areas, shoreline positions for comparison time periods provide a proxy to estimate volume changes associated with shoreline recession based on erosion trends (volume changes) recorded for areas with complete shoreline and bathymetry data coverage.

By 1960/69, the navigation channels at Gulfport and Pascagoula were well-defined. Few changes were recorded for the Mississippi Sound except adjacent to sound channels where dredged material disposal sites existed. As illustrated in the previous discussion on entrance cross-sections, spit growth on the western ends of the islands, and associate channel and inlet shoal migration, were supplied by sand eroded from the eastern ends of the islands. All parts of the littoral zone near entrances were active during this period as islands and inlets responded to storm and normal processes. Similar to change comparisons for the period 1847/55 to 1917/20, the area between western Ship Island and Cat Island showed no measureable change, indicating that west-directed longshore transport terminates at Ship Island Pass (Figure 4.16). Sand transport along Cat Island beaches is north and south of a position just north of central Cat Island, and sand deposition at the ends of the island is sourced by local beach erosion. There is no apparent external source of sand to Cat Island beaches.

The pattern of beach erosion and deposition illustrated between 1960/69 and 2005/10 is similar to that recorded for the previous period. Very little change was recorded within the sound, except that associated with dredged material disposal from the sound channels (Figure 4.17). The southern portion of the Gulfport Sound channel was realigned during this time, and the old channel location has partially filled. The 1960/69 data coverage controlled the surface comparison area along the islands. Beach erosion again dominated eastern island areas and shoal deposition in entrances and along the western ends of islands was pervasive. Shoal reworking within entrances was marked by updrift erosion of old shoals and downdrift deposition within the entrance. The pattern of sand movement from western Dauphin Island toward eastern Petit Bois Island best illustrates the dominant transfer of sand through entrances in the barrier island chain from east to west (Figure 4.17).

A similar pattern of sand transport is documented for the ebb shoals at Horn Island Pass and Dog Keys Pass. Greatest net beach changes occurred along East Ship Island, where erosion and storm washover deposition have reduced the island footprint to a fraction of its original size. Unless restored, this island is expected to dissipate within the next decade or two, resulting in a much wider entrance at Dog Keys Pass and less sand bypassing to East Ship Island.

Quantifying change trends throughout the Mississippi Sound barrier island system was completed for the period 1917/20 to 2005/10 to develop a long-term sediment budget. Continuous data coverage was available for both periods from the sound seaward to the 35- to 40-ft depth contour in the gulf. As a result, detailed analysis of volume changes throughout the system provided a method for quantifying patterns of change recognized for all time periods.

Erosion along the western half of Dauphin Island provided vast quantities of sand for westward island growth, washover deposition, and development of subaqueous shoals within the entrance at Petit Bois Pass (Figure 4.18). Westward sediment transport along Petit Bois Island was supplied by beach erosion along the eastern end of the island and transport from Petit Bois Pass (about 440,000 cy/yr). Much of this sand was deposited in the navigation channel at Horn Island Pass (about 270,000 cy/yr), but substantial quantities also were deposited on the eastern lobe of the ebb shoal and at the western end of Petit Bois Island (Figure 4.18).

Beach erosion along eastern Horn Island supplied sand for spit growth at the western end of the island and shoal deposition at Dog Keys Pass. As the entrance channel and shoals were forced westward, the easternmost portion of the old ebb shoal eroded and supplied sand to new shoals west of its location. This trend continued along Ship Island where beach erosion along East Ship Island provided a source of sediment to West Ship Island and for storm washover deposits on the north side of the island. Overall, sand transport patterns within the Mississippi Sound barrier island system exhibited consistent trends throughout the period of record, even in the presence of channel dredging activities at Horn Island Pass (Pascagoula Bar Channel) and Ship Island Pass (Gulfport Bar Channel).

4.6 Potential dredging impacts at Horn Island Pass and Ship Island Pass

As documented in Chapter 2, channel dredging commenced in Horn Island Pass and Ship Island Pass in the late 1890s to support local commerce. Original authorized depths were 21 and 26 ft, respectively, and channel width was to be 300 ft. By 2009, authorized channel depth at Horn Island Pass was 44-ft deep (550-ft wide), greater than that authorized for Ship Island Pass (38-ft deep, 400-ft wide). Both bar channels have accumulated millions of yards of littoral sand during this time (Horn ~ 24.9 million cy; Ship ~ 15.5 million cy), and new work extracted 9.4 million cy from Horn Island Pass and 9.8 million cy from Ship Island Pass. New work cannot be considered littoral sand for the period of analysis, but depending on placement location, it can add to the littoral sand budget.

Between 1917/18 and 2009 (long-term sediment budget timeframe), approximately 23.8 million cy (259,000 cy/yr) of sand were extracted from the Horn Island Pass navigation channel. During the same period, about 17.5 million cy of sand dredged from the channel were placed on the western lobe of the ebb shoal to be redistributed as littoral sand (see Chapter 2). This leaves an approximate 6.3 million cy deficit of littoral sand, which under natural channel conditions, would have a chance of being transported to downdrift beaches. Instead, it likely was disposed offshore as part of channel dredging activities. This implies that without channel dredging activities, approximately 6.3 million cy of littoral sand would have remained in the littoral system as islands and inlets migrated to the west. The direct impact of this net sand deficit to downdrift beaches is not apparent because the system is so dynamic and net transport quantities are large. Would it have deposited along the beach or as part of subaqueous shoals? The answer is unknown, but it is clear that littoral sand transport to the channel under incident wave and current processes likely was placed outside the littoral zone, resulting in a net deficit of about 6.3 million cy to the littoral sand transport system downdrift of Horn Island Pass.

Furthermore, although approximately 6.8 million cy of littoral sand from channel maintenance dredging was placed in DA-10 (the disposal site just west of the channel in the littoral zone) for westward transport to downdrift beaches, the disposal area appears to be primarily a depocenter for dredged material placement rather than an active source of sand to downdrift beaches. As such, this sequestered dredged channel sand should be considered a net deficit to downdrift beaches because dispersal of sand at the site is minimal. Overall, this implies that the littoral system west of Horn Island Pass has experienced a net deficit of about 13.1 million cy since 1917. Proposed barrier restoration west of the pass should consider sand deposited in DA-10 as a primary source for augmenting the littoral transport system.

Ship Island Pass is located at the western end of the longshore sand transport system. This implies that sand transport does not extend west of the bar channel. In fact, all bathymetric change results, including analysis of entrance cross-sections between West Ship Island and Cat Island, illustrate no measureable seafloor changes west of the channel until the Cat Island littoral zone is encountered. As such, littoral sand deposited in Ship Island Pass does not impact downdrift environments because westward drift ceases to be active at this point.

5 Sediment Budget

Sediment budget determination for the coastal zone involves application of the principle of conservation of mass to littoral and offshore sediment (Bowen and Inman, 1966; Rosati and Kraus, 1999; Rosati, 2005). Development of sediment budgets for the Mississippi Sound barrier islands requires quantitative evaluation of various sediment sources to and losses from the study area, and a comparison of net gains or losses with observed rates of erosion or accretion. The USACE Sediment Budget Analysis System (SBAS; Rosati, 2005) was applied to analyze transport pathways and sediment volume fluxes.

Sediment erosion and accretion volumes were quantified for the periods 1917/18 to 1961/68 (short-term budget) and 1917/18 to 2005/10 (long-term budget) by differencing bathymetric survey data. Zones of erosion and accretion were identified throughout the sediment budget control areas based on bathymetric change analysis (see Chapter 4). Overall, ebb shoals at all entrances were net depositional (sediment sinks). Beach and nearshore environments along the east ends of the islands were net erosional (sediment sources). The dominant direction of littoral transport is from east to west, and sand from beaches and nearshore areas along the western Florida and Alabama coast supply material to downdrift barrier beaches fronting the Mississippi Sound. Net west-directed transport deposits sand along the east side of passes as elongated sand spits and shoal deposits in the entrances. Much of the sand dredged from Horn Island Pass has been placed on the west lobe of the ebb shoal, transferring littoral sand derived from beaches east of the navigation channel to the downdrift littoral zone. However, it was determined from dredging records that approximately 6.3 million cy of littoral sand (68,000 cy/yr) dredged from the channel between 1917/18 and 2009 was not returned to the littoral zone west of the channel, resulting in a net long-term deficit to the sand budget.

5.1 Sediment sources and sinks

In recent geologic time, the primary source of sediment to barrier islands and entrances fronting the Mississippi Sound has been sand transported west from western Florida and coastal Alabama beaches. As Otvos and Giardino (2004) suggested, local sources of sediment to the barrier islands are derived from eastern Dauphin Island and the Mobile Pass ebb shoal complex. Byrnes et al. (2010) document the historical flow of sand in coastal Alabama, including the quantity of sediment exiting the transport system along western Dauphin Island. Analysis of historical data from this study indicates that present-day sand supplied to the Mobile Pass ebb shoal is derived primarily from beach and nearshore sediment east of Mobile Pass (Stone et al, 2004). The coast and shelf east of the pass is sand rich from the 80-ft depth contour north into upland deposits (McBride and Byrnes, 1995); it is the primary source of sand for all beaches and tidal shoals west and into Mississippi. Transport quantities presented in the Byrnes et al. (2010) were derived from survey data collected prior to the passage of Hurricane Katrina, so post-hurricane hydrographic data collected by NOAA was used to update the Byrnes et al. (2010) sediment budget along western Dauphin Island for consistency with recent survey data evaluated in the present study (2005/10).

As illustrated and discussed throughout this report, barrier islands fronting Mississippi Sound historically have been growing and migrating to the west in the dominant direction of littoral transport (Byrnes et al. 1991; Morton, 2008). Inlets and their ebb shoals act as conduits (and sand sinks) for sand transport to the west. Islands become local sources of sediment as well, as sand is eroded from their eastern ends and transported to the west to be redeposited. This process is not occurring on Dauphin Island because the eastern end of the island is a relict Pleistocene barrier ridge (Otvos, 1981). However, this stable portion of the island provides a location from which large volumes of littoral sand from the Mobile Pass ebb shoal can be transported west, sourcing the barrier islands and inlet shoals of western Alabama and Mississippi (Otvos and Giardino, 2004). Furthermore, Dauphin Island and the Mississippi barrier islands continue to extend westward as sand spits (sediment sinks) as littoral sand is supplied to beaches via channel and shoal migration and beach erosion along the eastern ends of the islands (sediment sources).

Storm overwash and island breaching have provided beach sand to back-barrier environments during landward migration of low lying island segments. As sand is transported across a barrier island, the gulf shoreline migrates to the north due to beach erosion. However, this sand is not permanently lost from the beach. Along low lying portions of all the Mississippi Sound barrier islands, sand from the front side of the island often is recycled to the backside of the island as the island migrates landward. This process is termed barrier rollover because a portion of the island migrates landward in response to storm processes. As such, the gulf side of barrier islands can be considered a local source of sand for landward island migration and lateral island growth.

5.2 Channel shoaling rates and offshore disposal

Channel dredging history for Horn Island Pass and Ship Island Pass was discussed in Chapter 2. Appendices A and B contain detailed information on new work and maintenance dredging quantities for both channels. However, because Ship Island Pass is the terminal point in the west-directed longshore transport system, only dredging data for the channel at Horn Island Pass is relevant to littoral sediment dynamics. Furthermore, as described in Chapter 4, only maintenance dredging quantities can be used for estimating channel shoaling rates. Summarizing maintenance dredging data, one can derive an average shoaling rate for the outer bar channel for the period under which sediment budgets have been developed (1917/18 to 1961/68 and 1917/18 to 2005/10). Maintenance dredging records indicate that approximately 87,000 cy/yr was extracted from Horn Island Pass between 1917/18 and 1961/62 (short-term budget), and between 1917/18 and 2007/10 (long-term budget), 259,000 cy/yr of sand was extracted from the Pass channel.

Although the exact location for disposal of all channel maintenance dredging is not known, bathymetric changes offshore the Horn Island Pass ebb shoal indicate large areas of deposition just west of the navigation channel (Figure 5.1). These areas appear to be sites for offshore dredged material disposal from the channel that exists seaward of the littoral transport zone. Other disposal areas located on the west lobe of the ebb shoal and within the littoral zone include DA-10, littoral zone, and deposition near the outer margin of the ebb shoal. Prior to 1960 (before disposal site designations), it appears that sand dredged from the pass channel was placed west of the channel and just south of the outer margin of the ebb shoal (Figure 5.1A). Prior to analyzing bathymetric changes in this area, it was not known whether dredged material deposited offshore was contributing to net sediment accumulation and transport on the ebb-tidal delta. It is possible that sand deposited offshore of the western lobe of the ebb shoal as a result of channel dredging migrated shoreward during storms, but evidence for this process is generally absent from the 1961/62 to 2007/10 bathymetric change surface (Figure 5.2; minor zone of erosion where the deposition polygon was present on the 1917/18 to 1961/62 change surface). Furthermore, a bathymetric low exists between the outer edge of the ebb shoal and the offshore disposal mound, indicating limited exchange of sediment (if any) between these depositional features. As such, sediment at disposal areas seaward of the ebb shoal do not appear to be within the littoral zone.

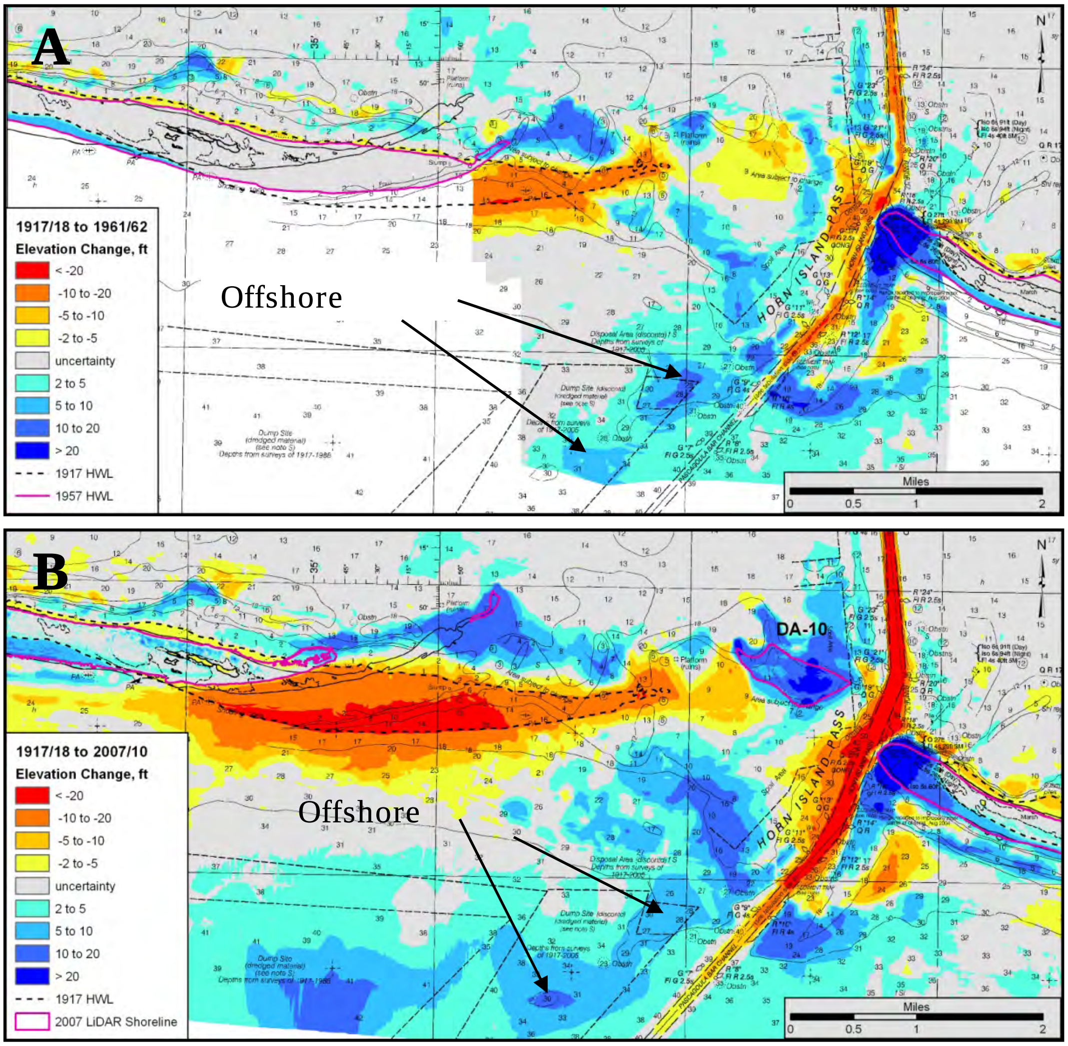

Figure 5.1. Bathymetric change at Horn Island Pass illustrating the location of disposal areas relative to change on the ebb shoal. A – illustrates 1917/18 to 1960 change surface overlaying NOAA digital nautical chart 11374_1 (2009); B - illustrates 1917/18 to 2005/10 change surface overlaying NOAA digital nautical chart 11374_1 (2009).

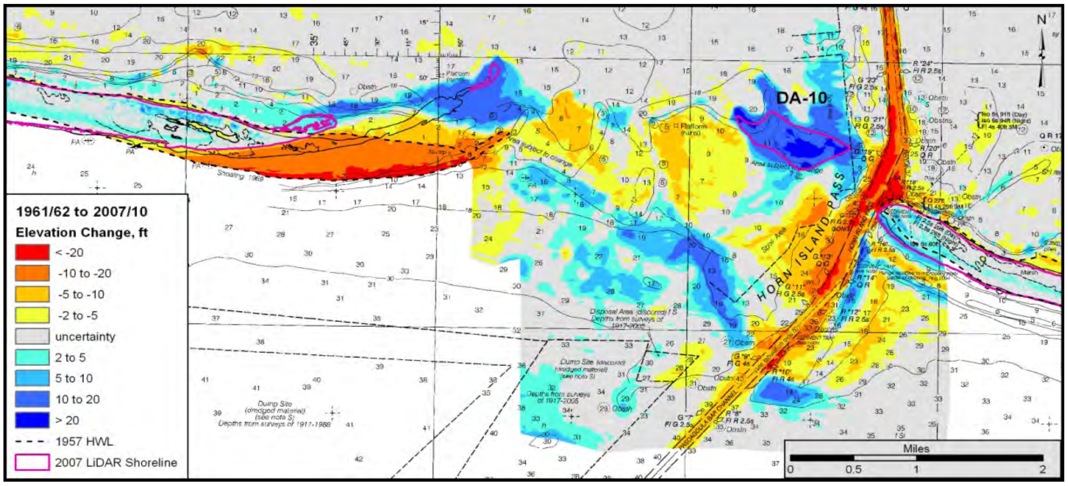

Figure 5.2. Bathymetric change between 1961/62 and 2007/10 at Horn Island Pass illustrating minor changes seaward of the western lobe of the ebb shoal in the location of offshore disposal areas identified in Figure 5.1. The change surface is overlaying NOAA digital nautical chart 11374_1 (2009).

New work and maintenance dredging records provided quantities of sand dredged from the bar channel that were placed offshore and in disposal sites between 1917 and 2009 (Table 2.3). The annual maintenance dredging rate was about 259,000 cy, and the annual new work rate was about 94,000 cy. The quantity of new work and maintenance dredging placed in DA-10 was approximately 109,000 cy/yr, while the amount placed in the designated site called Littoral Zone was about 24,000 cy/yr. Sand placement in the Pre-1992 Open Water site was about 57,000 cy/yr, and the amount of maintenance estimated to have been placed offshore the west lobe of the ebb shoal prior to 1962 was 42,000 cy/yr. This suggests that about 190,000 cy/yr of sand dredged from the bar channel was placed on the west lobe of the ebb shoal, an area of active littoral transport. This analysis implies that approximately 6.3 million cy (68,000 cy/yr) of littoral sand was placed seaward of the littoral zone between 1917/18 and 2009.

5.3 Short-term sediment budget: 1917/18 to 1961/68

An initial sediment budget was established in Phase 1 of the MsCIP study to provide a technical basis for establishing an initial plan for restoring portions of the Mississippi barrier islands as the first line of defense against tropical storm and hurricane impacts. The hurricane of 1947 and Hurricane Camille created a shallow inlet at central Ship Island that was about to close when Hurricane Georges destroyed the narrow sand spit extending west from East Ship Island. By the time Hurricane Katrina approached the coast of Mississippi, a severely degraded Ship Island could only provide minimal relief to mainland Harrison County. A continuous Ship Island, like the one that existed in 1847, would have little impact on waves or storm surge for an event like Hurricane Katrina, but for the more common smaller events like tropical storms and Category 1 hurricanes, island continuity would be expected to provide added protection to the mainland by absorbing offshore wave energy.

The following discussion documents net sand transport processes for the Mississippi Sound barrier islands for the period 1917/18 to 1961/68 toward development of a barrier island restoration plan. One of the drawbacks of the 1960/69 data set is that survey data were not available for portions of the gulf-facing beaches along each of the islands. Because this area encompasses littoral transport along the islands, the data most critical for establishing a sediment budget for the barrier island system, estimates of sand flux in areas lacking bathymetry data were determined using shoreline change as a proxy for volume change based on the relationship between shoreline and bathymetry change adjacent to areas of missing data. In other words, if one knows the relationship between shoreline change and bathymetry change for a given area, and one agrees this relationship is valid for adjacent areas of coast where bathymetry data are absent, shoreline change for an adjacent area can be used to estimate associated volume change. This method was used to estimate volume changes in areas where bathymetry data were missing for the 1960/69 surface.

5.3.1 Macro-scale trends

Net deposition and erosion along the Mississippi Sound barrier islands for the period 1917/18 to 1961/68 were determined by differencing the 1917/20 and 1960/69 bathymetric surfaces to isolate polygons of erosion and accretion. This period encompasses a time when channel dredging at Horn Island Pass and Ship Island Pass was active. Furthermore, it includes the 1916 and 1947 hurricanes, both of which resulted in significant impacts along the Mississippi Sound barrier islands (see Chapter 3). Figure 5.3 illustrates the macro-scale sediment budget for the study area, which summarizes details from each of the five control areas along the coast for assessing net sediment flux throughout the system. Black arrows signify the direction of net sand movement and numbers reflect the magnitude of sediment flux in thousands of cubic yards per year. Red numbers document net additions or losses from each control area for the period of record. **P** is the volume of sand placed in the littoral zone as a result of maintenance dredging (**Rm**) and new work (**Rn**).

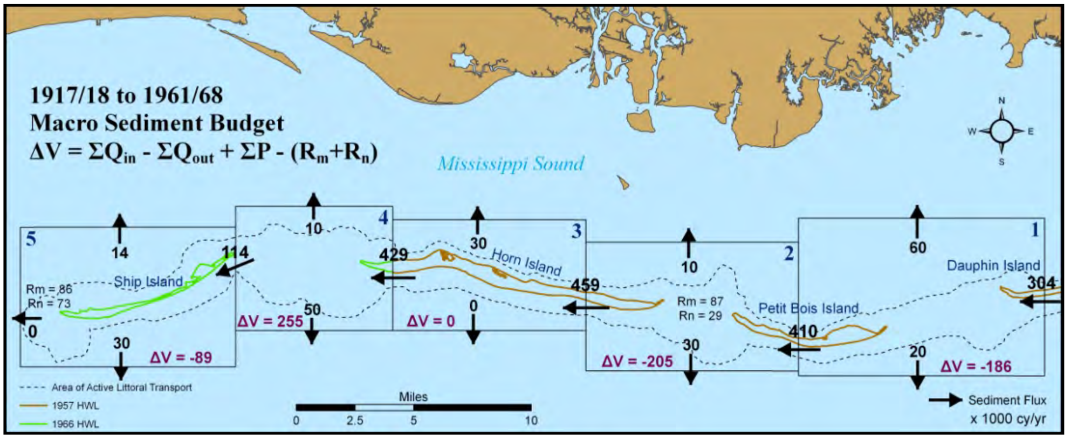

Figure 5.3. Macro-scale sediment budget for the Mississippi Sound barrier island chain, 1917/18 and 1961/68. Arrows illustrate the direction of sediment movement throughout the system and numbers reflect the magnitude of net sediment transport in thousands of cy/yr.

Starting at western Dauphin Island, net sand transport into sediment budget Box 1 is about 304,000 cy/yr. This value was determined using sand volume change and sediment budget information from Byrnes et al. (2010) for Dauphin Island. Overall, the area encompassed by Box 1 was a net source of sediment to downdrift beaches (410,000 cy/yr), the gulf (20,000 cy/yr), and the sound (60,000 cy/yr). West-directed sediment flux was by far the dominant direction of transport. Large quantities of sediment were deposited in Horn Island Pass channel (Box 2), but all of the maintenance dredging sand volume was placed seaward of the ebb shoal. Regardless, the flux of sand west to Box 3 was increased by about 49,000 cy/yr to 459,000 cy/yr. North and south sediment losses to the sound (10,000 cy/yr) and gulf (30,000 cy/yr) were relatively small, but total sand placement offshore as part of channel dredging added to net sand export from this control area and resulted in Box 2 being a significant sediment source (about 205,000 cy/yr; Figure 5.3).

Approximately 459,000 cy/yr of sand enters Box 3 from eastern Horn Island heading toward Dog Keys Pass. It was estimated that about 30,000 cy/yr of sand eroded from the back side of Horn Island was lost to the sound, but no sand from gulf-facing beaches in Box 3 was lost offshore. Sand flux to Dog Keys Pass (Box 4) is about 429,000 cy/yr, very consistent with transport magnitudes east of this area. Dog Keys and Little Dog Keys Pass is the largest entrance in the study area, and this dual inlet system is very active in terms of channel and shoal morphodynamics. Net sediment deposition for this period has enhanced shoal growth on both ebb shoals, creating a net sediment sink for this area (255,000 cy/yr). Furthermore, export of sand to the sound (10,000 cy/yr) and the gulf (50,000 cy/yr) have decreased the west-directed flux of sand illustrated east of Box 4. As a result, the flux of sand to Ship Island (114,000 cy/yr) is about 25 percent of west-directed sand transport entering Dog Keys Pass (429,000 cy/yr). The end result is chronic erosion along East Ship Island because the quantity of sediment eroded from the beach and nearshore in this area is about three times the quantity entering Box 5 from the east. Net erosion is the only possible result under these conditions.

As stated earlier in the report, the channel at Ship Island Pass represents the terminal point of the longshore sand transport system for the barrier island chain. West Ship Island is net depositional, but about 86,000 cy of littoral sand is deposited in the channel each year during this period. It is expected that maintenance and new work dredging material was placed west of the channel and out of the littoral transport system. It appears that only minor amounts of sediment were transported to backbarrier (14,000 cy/yr) and offshore (30,000 cy/yr) environments.

5.3.2 Detailed sediment budget

Five sediment budget boxes were identified in the previous section when describing net sand flux throughout the barrier island system from 1917/18 to 1961/68. Figure 5.4 illustrates net changes within Box 1 for the Petit Bois Pass area. Spit growth along the western end of Dauphin Island and shoal accretion at Petit Bois Pass absorbed about 78 percent of the sediment flux from Dauphin Island (304,000 cy/yr). It was estimated that approximately

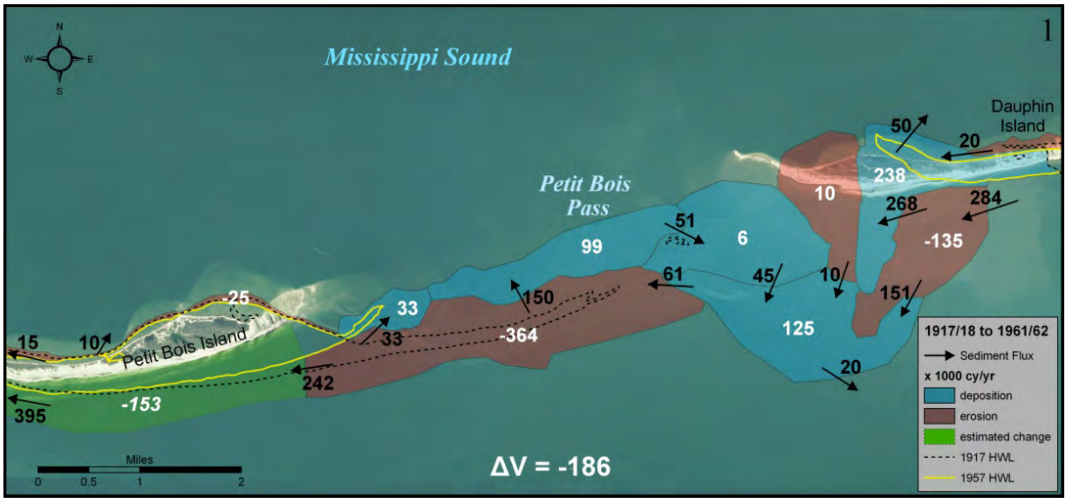

Figure 5.4. Detailed sediment transport pathways and quantities for Box 1 (Petit Bois Pass area) of the macro-scale sediment budget, 1917/18 and 1961/68. Arrows illustrate the direction of sediment movement and numbers reflect the magnitude of net sediment transport in thousands of cy/yr. Underlying image is from October 2008.

20,000 cy/yr of sand was transport offshore to the gulf, and 61,000 cy/yr of sand from the entrance combined with island erosion on the east end of Petit Bois Island to supply 410,000 cy/yr of sand toward the west end of the island. Washover deposition created a long subaqueous shoal north of the old location of the island in 1917/18 that was partially supplied by east-directed sand transport from eastern Petit Bois Island. Erosion along the north side of the island provided sand for shoal development soundward of the active littoral zone (10,000 cy/yr).

Sand flux to the western end of Petit Bois Island created an elongated sand spit that abutted the navigation channel at Horn Island Pass. Of the 410,000 cy/yr of the sediment transported from the east toward the channel, 87,000 cy/yr was dredged from the channel and 236,000 cy/yr was deposited on the eastern lobe of the ebb shoal (Figure 5.5). Another 10,000 cy/yr was transported into the sound, and 20,000 cy/yr was transported offshore to the gulf. Although only 29,000 cy/yr of new dredging work was recorded during this time, and additional 92,000 cy/yr of sand was eroded from the western margins of the channel and transported to the western lobe of the ebb shoal (Figure 5.5), along with 57,000 cy/yr of sand from the Petit Bois.

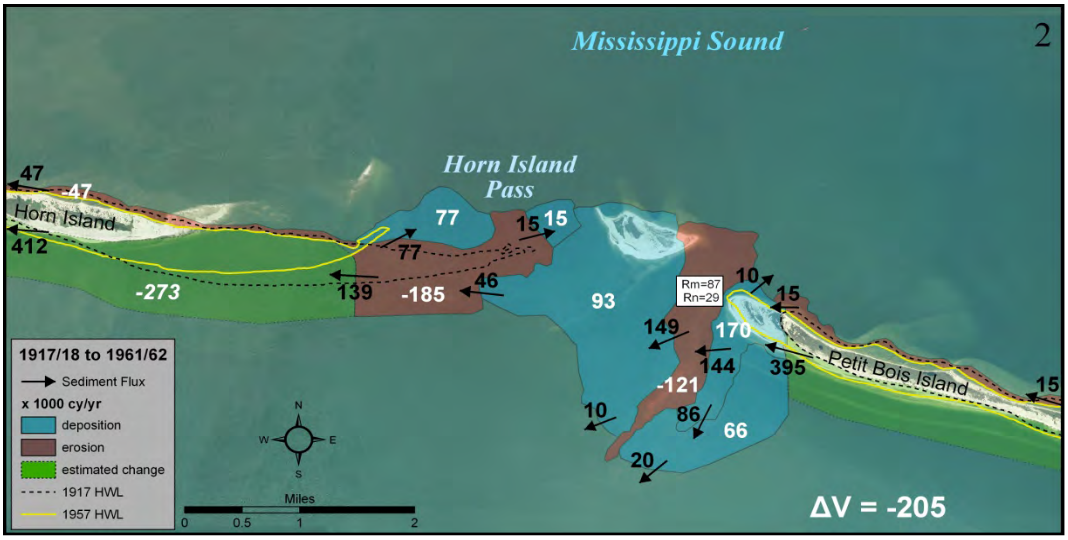

Figure 5.5. Detailed sediment transport pathways and quantities for Box 2 (Horn Island Pass area) of the macro-scale sediment budget, 1917/18 and 1961/68. Arrows illustrate the direction of sediment movement and numbers reflect the magnitude of net sediment transport in thousands of cy/yr. Underlying image is from October 2008.

Most sand transported to the western lobe of the ebb shoal deposited (93,000 cy/yr), but about 10,000 cy/yr was transported offshore and 46,000 cy/yr of sand was transported toward Horn Island. Approximately

92,000 cy/yr of sand eroded from the eastern end of Horn Island was transported into the sound as washover and east-directed transport from Horn Island to create an extensive subaqueous sand shoal on the western side of the pass. The remaining 459,000 cy/yr of sediment supplied by erosion of east Horn Island and transport through the inlet system moves westward along Horn Island (Figure 5.5).

Based on estimates of change along the beaches of central Horn Island, gulf beach sand flux was about 412,000 cy/yr. Change calculations for the sound side of the island indicated that erosion along the north side of the island provided about 30,000 cy/yr of sediment to the Mississippi Sound (Figure 5.6; Box 3). As such, net sand flux toward western Horn Island and Dog Keys Pass was about 429,000 cy/yr (Figure 5.6).

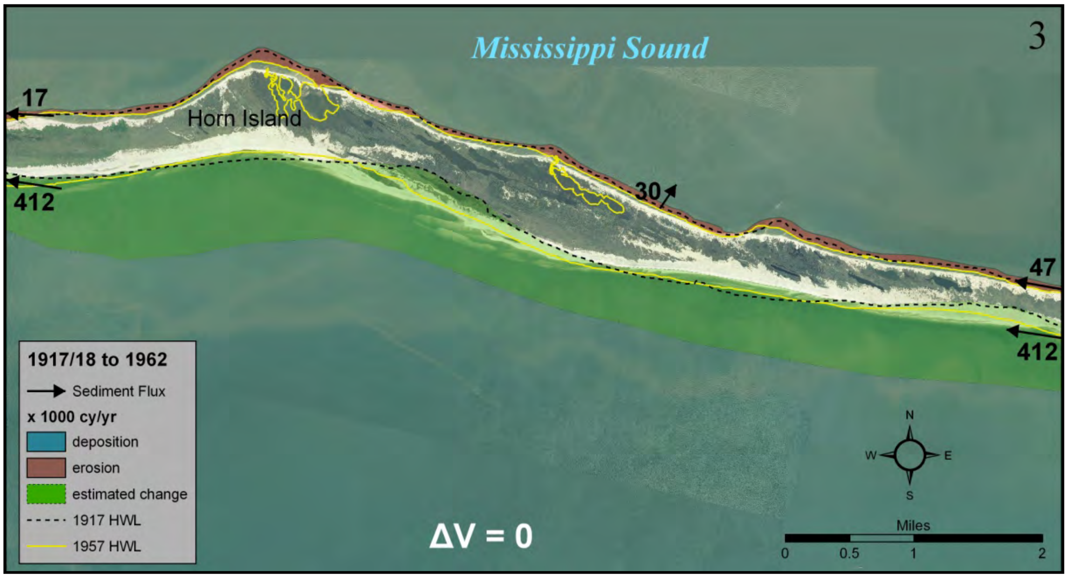

Figure 5.6. Detailed sediment transport pathways and quantities for Box 3 (Horn Island) of the macro-scale sediment budget, 1917/18 and 1961/68. Arrows illustrate the direction of sediment movement and numbers reflect the magnitude of net sediment transport in thousands of cy/yr. Underlying image is from October 2008.

Sand flux to the western end of Horn Island and into Dog Keys Pass resulted in about 304,000 cy/yr shoal deposition in Dog Keys Pass (about 70 percent of the total sediment flux; Figure 5.7). In addition, approximately 10,000 cy/yr was transported into the Mississippi Sound and an estimated 25,000 cy/yr was transported to the gulf. The remaining sand transported to the entrance (90,000 cy/yr) continued west toward Little Dog Keys Pass and East Ship Island. In 1917/18, Dog Island was an island in the entrance that remained subaerial until about 1932 (Rucker and Snowden, 1988). Although Dog Island and associated shoals were net

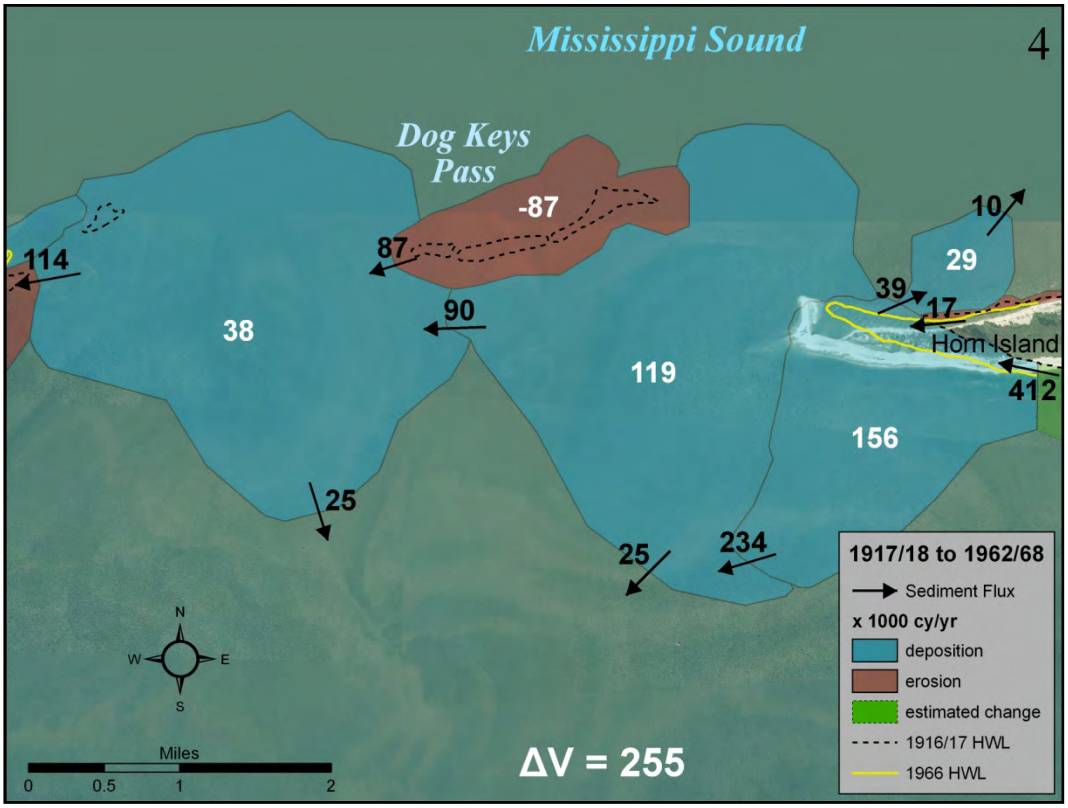

Figure 5.7. Detailed sediment transport pathways and quantities for Box 4 (Dog Keys Pass) of the macro-scale sediment budget, 1917/18 and 1961/68. Arrows illustrate the direction of sediment movement and numbers reflect the magnitude of net sediment transport in thousands of cy/yr. Underlying image is from October 2008.

erosional for the shortterm budget, deposition on the ebb shoal at Little Dog Keys Pass has been persistent during the historical record (Figure 5.7).

Net sand flux to Little Dog Keys Pass from Dog Island and Dog Keys Pass (177,000 cy/yr) was not adequate to meet the sand needs from eroding East Ship Island because it is estimated that approximately 25,000 cy/yr moves offshore to the gulf and 38,000 cy/yr deposited on the shoals at Little Dog Keys Pass. The net result was that East Ship Island only received 114,000 cy/yr of the 429,000 cy/yr flux of sand into Box 4, creating a sand deficit to East Ship Island (Figure 5.7).

The orientation of East Ship Island exposes low-lying sand beaches to direct attack by southeast waves. As such, a significant amount of sand eroded from the gulf-facing beaches is transported to the north side of the island during overwash events (about 131,000 cy/yr). Gulf beach erosion along East Ship Island mobilizes about 320,000 cy/yr of sediment for transport toward West Ship Island, almost three times the amount of sand being transported to the island from Little Dog Keys Pass. Island erosion is the only option under these circumstances (Figure 5.7).

The flux of sand to West Ship Island is approximately 303,000 cy/yr, of which 86,000 cy/yr deposits in the navigation channel; 63,000 cy/yr is transported to the sound, where it deposits as sand shoals inside the entrance (53,000 cy/yr) and the remainder is redistributed in the sound; and 168,000 cy/yr is deposited at the end of West Ship Island and on the ebb shoal east of the pass (Figure 5.8). Bathymetric change at the channel entrance indicates that approximately 74,000 cy/yr of sediment is transported from the eroding western margin of the channel to a depositional area west of this location. Approximately 30,000 cy/yr of sand is transported south of the shoal and 20,000 cy/yr appears to be migrating back to the channel by south-directed tidal currents.

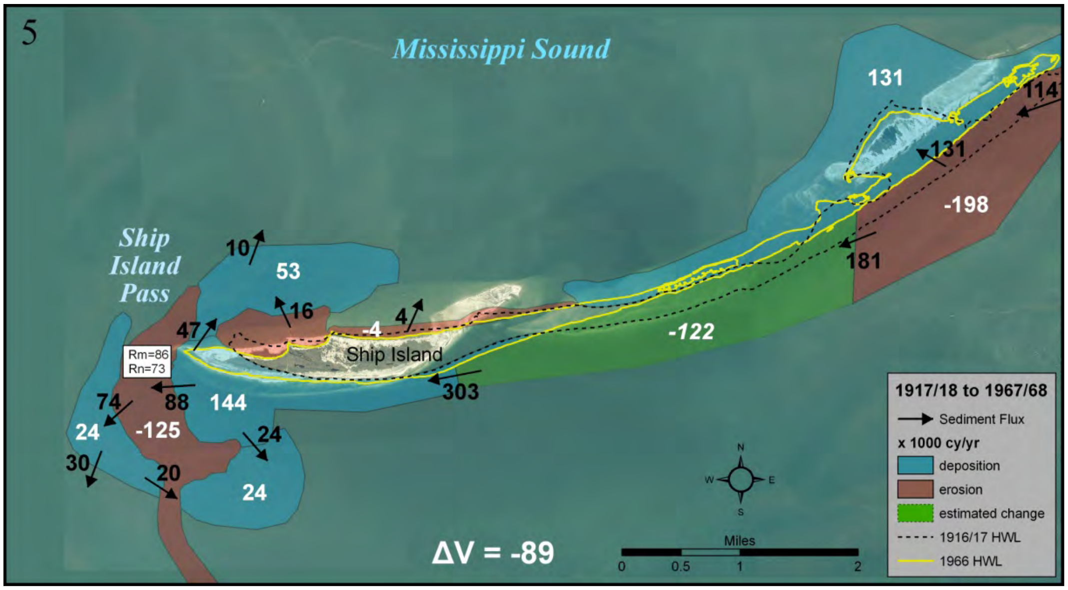

Figure 5.8. Detailed sediment transport pathways and quantities for Box 5 (Ship Island and Pass area) of the macro-scale sediment budget, 1917/18 and 1961/68. Arrows illustrate the direction of sediment movement and numbers reflect the magnitude of net sediment transport in thousands of cy/yr. Underlying image is from October 2008.

5.4 Long-term sediment budget: 1917/18 to 2005/10

Although the initial sediment budget developed during Phase 1 of the MsCIP barrier islands study provided comprehensive sediment transport results for evaluating system changes over a forty-year period, two primary observations were made regarding future updates to the sediment budget. First, bathymetry data gaps along the gulf-facing beaches of each of the islands for the 1960s surveys should be completed to enhance confidence in estimates derived for the existing sediment budget. Second, the 1960s bathymetry was surveyed prior to Hurricane Camille, meaning that modern survey data for the study area was not available for the period encompassing the two most significant hurricanes to impact the northern Gulf of Mexico. Based on these and other considerations, it was recommended that a modern bathymetric survey should be completed for the entire Mississippi barrier island system that covers the entire littoral sediment budget control area. The following discussion presents results of a long-term sediment budget developed using modern bathymetric and shoreline surveys collected as part of MsCIP. Data coverage throughout the sediment budget control area was complete, so change estimates were not required to evaluate net change for the period 1917/18 to 2005/2010.

5.4.1 Macro-scale trends

Net deposition and erosion along the Mississippi Sound barrier islands for the period 1917/18 to 2005/10 were determined by differencing the 1917/18 and 2005/10 bathymetric surfaces to isolate polygons of erosion and accretion. This period encompasses a time of significant channel dredging activity at Horn Island Pass and Ship Island Pass. Furthermore, it includes some of the most destructive hurricanes to impact the northern Gulf of Mexico (e.g., 1916 hurricane, 1947 hurricane, Hurricane Camille, and Hurricane Katrina). Figure 5.9 illustrates the macro-scale sediment budget for the study area, which summarizes details from each of the five control areas along the coast for assessing net sediment flux.

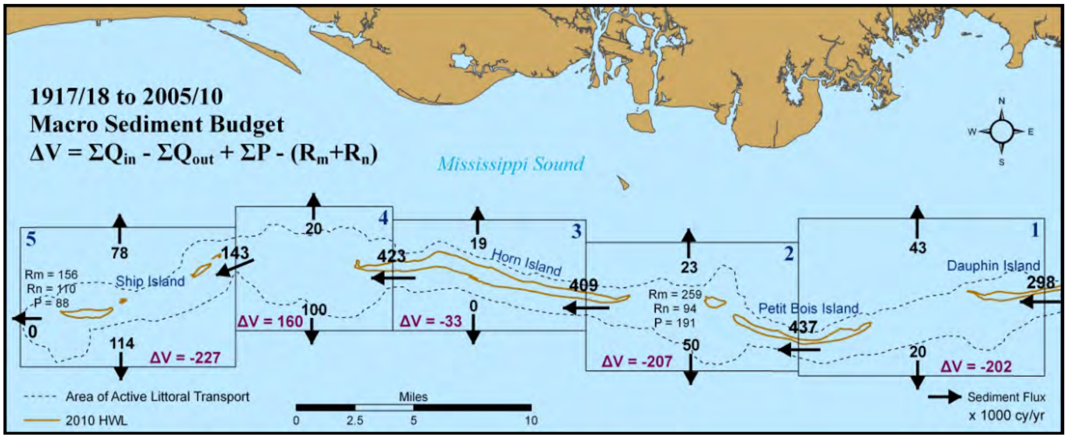

Figure 5.9. Macro-scale sediment budget for the Mississippi Sound barrier island chain, 1917/18 and 2005/10. Arrows illustrate the direction of sediment movement throughout the system and numbers reflect the magnitude of net sediment transport in thousands of cy/yr.

Starting at western Dauphin Island, net sand transport into sediment budget Box 1 is 298,000 cy/yr. This value was determined by updating the sediment budget of Byrnes et al. (2010) for Dauphin Island. Their original analysis used 2002 bathymetry data as the analysis endpoint. The endpoint for all bathymetry data along the Mississippi Sound barrier islands was after Hurricane Katrina, so the sediment budget of Byrnes et al. (2010) was updated to include post Katrina bathymetry and lidar surveys collected by NOAA and USGS. Detailed analysis of these recent data sets yielded the sand volume flux stated above as the input boundary condition at the eastern end of the barrier island sediment budget (Figure 5.9).

Overall, the area encompassed by Box 1 was a net source of sediment to downdrift beaches (437,000 cy/yr), the gulf (20,000 cy/yr), and the sound (43,000 cy/yr). West-directed sediment flux was by far the dominant direction of transport. Large quantities of sediment were deposited in Horn Island Pass channel (Box 2), but most of the maintenance dredging sand volume was restored to the west lobe of the ebb shoal. As such, the flux of sand west to Box 3 was reduced only by about 28,000 cy/yr to 409,000 cy/yr. North and south sediment losses to the sound (23,000 cy/yr) and gulf (50,000 cy/yr) were relatively small, but total sand placement offshore as part of channel dredging added to net sand export from this control area and resulted in Box 2 being a significant sediment source (about 207,000 cy/yr; Figure 5.9).

Approximately 409,000 cy/yr of sand enters Box 3 from the Horn Island Pass area heading toward Dog Keys Pass. About 19,000 cy/yr of sand eroded from the back side of Horn Island is lost to the sound, but it is estimated that no sand from gulf-facing beaches is lost offshore. Overall, Box 3 is a source of sand for downdrift beaches and Dog Keys Pass. Sand flux to Dog Keys Pass (Box 4) is about 423,000 cy/yr, very consistent with transport magnitudes east of this area. Dog Keys and Little Dog Keys Pass is the largest entrance in the study area, and this dual inlet system is very active in terms of channel and shoal morphodynamics. Changes in flow patterns throughout the inlet have enhanced shoal growth on both ebb shoals, creating a net sediment sink for this area (160,000 cy/yr). Furthermore, export of sand to the sound (20,000 cy/yr) and the gulf (100,000 cy/yr) have decreased the west-directed flux of sand illustrated east of Box 4. As a result, the flux of sand to Ship Island is about 35 percent of west-directed sand transport elsewhere in the system (143,000 cy/yr). As with the short-term sediment budget, the end result is chronic erosion along

East Ship Island because the quantity of sediment eroded from the beach and nearshore in this area is almost three times the quantity entering Box 5 from the east. Net erosion is the only possible result under these conditions.

West Ship Island is net depositional, but a substantial amount of littoral sand deposits in the channel (156,000 cy/yr). Some of the dredged sand is placed on the north side of the island, but a majority of it is placed west of the channel where longshore transport is nonexistent. Box 5 is also a major source of sediment to backbarrier (78,000 cy/yr) and offshore (114,000 cy/yr) deposits.

5.4.2 Detailed sediment budget

Five sediment budget boxes were used to describe macro-scale changes in net sediment flux throughout the Mississippi barrier island littoral zone. Figure 5.10 illustrates detailed changes in sand movement within Box 1 for the Petit Bois Pass area. Spit growth along the western end of Dauphin Island and shoal accretion at Petit Bois Pass absorbed all sediment transported from eastern Dauphin Island (298,000 cy/yr) and approximately 25 percent of the sand supplied by erosion of the eastern lobe of the relict ebb shoal at Petit Bois Pass. Approximately 20,000 cy/yr of sand was transport offshore to the gulf and an equal amount into the Mississippi Sound, and 37,000 cy/yr of sand from the entrance combined with island erosion on the east end of Petit Bois Island to supply 437,000 cy/yr of sand to the west end of the island (Figure 5.10). Washover deposition created a

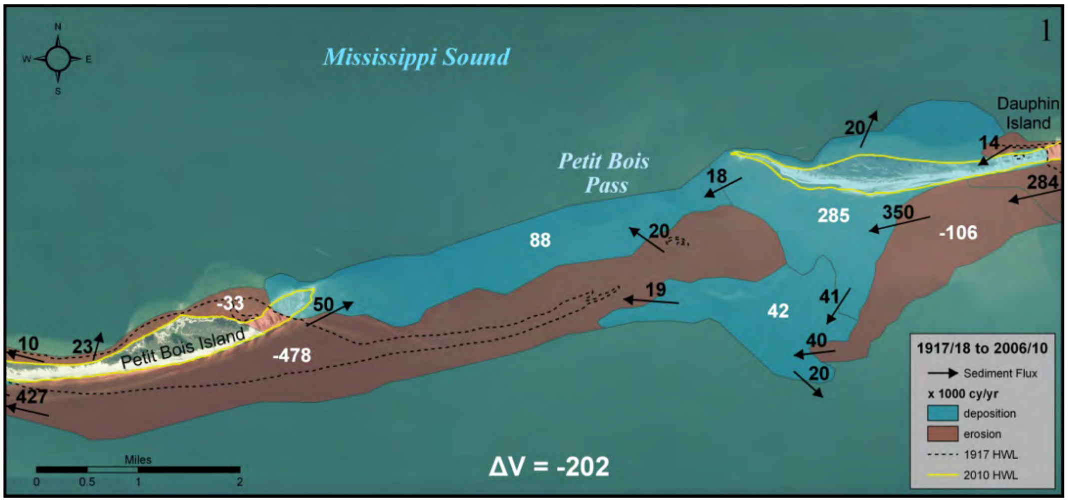

Figure 5.10. Detailed sediment transport pathways and quantities for Box 1 (Petit Bois Pass area) of the macro-scale sediment budget, 1917/18 and 2005/10. Arrows illustrate the direction of sediment movement and numbers reflect the magnitude of net sediment transport in thousands of cy/yr. Underlying image is from October 2008.

long subaqueous shoal north of the old location of the 1917 island shoreline that was partially supplied by east-directed sand transport from eastern Petit Bois Island. Erosion along the north side of the island provided sand for shoal development soundward of the active littoral zone (23,000 cy/yr).

Sand flux to the western end of Petit Bois Island created an elongated sand spit that abutted the navigation channel at Horn Island Pass. All sand excavated from the navigation channel during maintenance dredging (259,000 cy/yr; 1918 to 2009) was supplied by sand transport from the east and into the navigation channel (270,000 cy/yr; Figure 5.11). Another 13,000 cy/yr was transported into the sound, and 20,000 cy/yr was transported offshore to the gulf. This implied that about 134,000 cy/yr deposited along the spit and at entrance shoals east of the channel. Although only 94,000 cy/yr of new dredging work was recorded during this time, and additional 85,000 cy/yr of sand was eroded from the western margin of the channel and transported to the western lobe of the ebb shoal (Figure 5.11). Channel dredging also contributed approximately 82,000 cy/yr of sand to the west lobe of the ebb shoal, resulting in extensive shoal deposition and about a 30,000 cy/yr sediment export to the gulf. Channel dredging also contributed 109,000 cy/yr of sand to Disposal Area 10 (DA-10), presently recognized as a subaerial island adjacent to the channel west of western Petit Bois Island. Most sand placed in this area has remained, but about 52,000 cy/yr of sand is transported from the west lobe of the ebb shoal

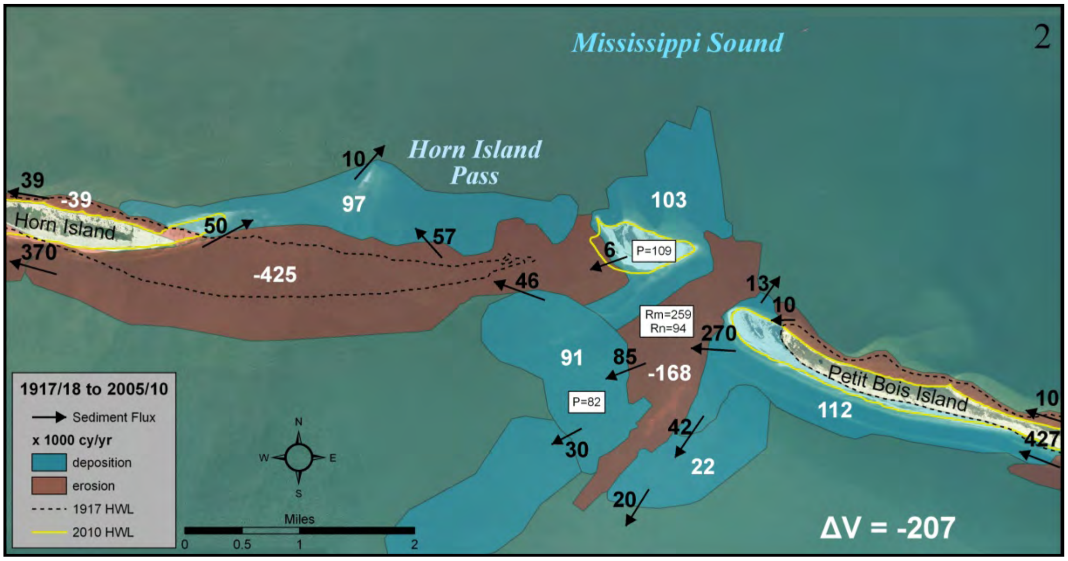

Figure 5.11. Detailed sediment transport pathways and quantities for Box 2 (Horn Island Pass area) of the macro-scale sediment budget, 1917/18 and 2005/10. Arrows illustrate the direction of sediment movement and numbers reflect the magnitude of net sediment transport in thousands of cy/yr. Underlying image is from October 2008.

toward Horn Island. Approximately 107,000 cy/yr of sand eroded from the eastern end of Horn Island is transported into the sound as washover and east-directed transport from Horn Island to create an extensive subaqueous sand shoal on the western side of the pass. It is estimated that 10,000 cy/yr of sediment was transported from this area into the sound. The remaining 409,000 cy/yr of sediment supplied by erosion of east Horn Island and transport through the inlet system moves westward along Horn Island (Figure 5.11). Although Box 2 is a net source of sediment to adjacent environments (207,000 cy/yr), most sediment exported the system via offshore placement of new work dredging (94,000 cy/yr) and maintenance dredging (68,000 cy/yr). Offshore placement of maintenance dredging sand is a net loss to the littoral system.

Erosion and accretion along the gulf side of central Horn Island resulted in the addition of 33,000 cy/yr of sediment to the littoral transport system (Figure 5.12; Box 3). However, it is estimated that erosion along the north side of the island provided about 19,000 cy/yr of sediment to the Mississippi Sound; no sand appeared to be transported seaward to the gulf. Sand flux was balanced fairly well in Box 3, although a small net gain in sand transport toward western Horn Island and Dog Keys Pass was documented (423,000 cy/yr; Figure 5.12).

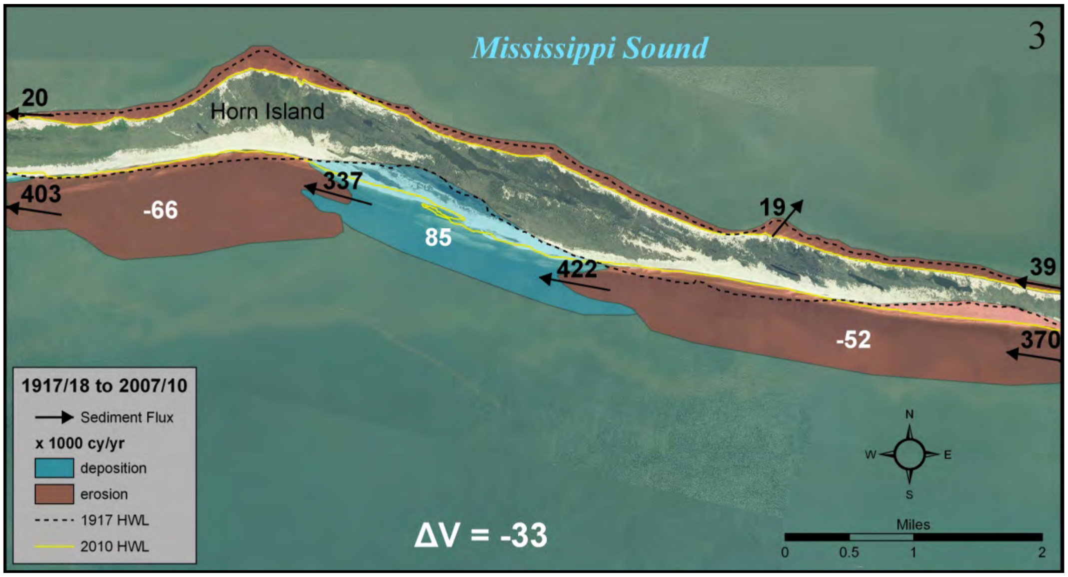

Figure 5.12. Detailed sediment transport pathways and quantities for Box 3 (Horn Island) of the macro-scale sediment budget, 1917/18 and 2005/10. Arrows illustrate the direction of sediment movement and numbers reflect the magnitude of net sediment transport in thousands of cy/yr. Underlying image is from October 2008.

Sand flux to western Horn Island and into Dog Keys Pass resulted in about 243,000 cy/yr of shoal deposition in Dog Keys Pass (about 55 percent of the total sediment flux; Figure 5.13). In addition, approximately 20,000 cy/yr of sediment was transported into the Mississippi Sound and an estimated 50,000 cy/yr was transported to the gulf. The remaining sand transported to the entrance (110,000 cy/yr) continued west toward Little Dog Keys Pass and East Ship Island. In 1916, Dog Island was a beach in the entrance that remained subaerial until about 1932 (Rucker and Snowden, 1988). Although deposition on the ebb shoal at Little Dog Keys Pass has been persistent during the historical record, erosion of Dog Island and other entrance shoals during inlet evolution resulted in a net loss of sand from the area (11,000 cy/yr; Figure 5.13). As such, net sand flux to Little Dog Keys Pass from Dog Island and Dog Keys Pass (182,000 cy/yr) was not adequate to meet the sand needs from eroding East Ship Island, given that approximately 50,000 cy/yr of sediment exited Little Dog Keys Pass to the gulf. Even though Little Dog Keys Pass is net erosional between 1917/18 and 2007/10, only 143,000 cy/yr of the 423,000 cy/yr flux of sand into Box 4 is transported to East Ship Island (Figure 5.13).

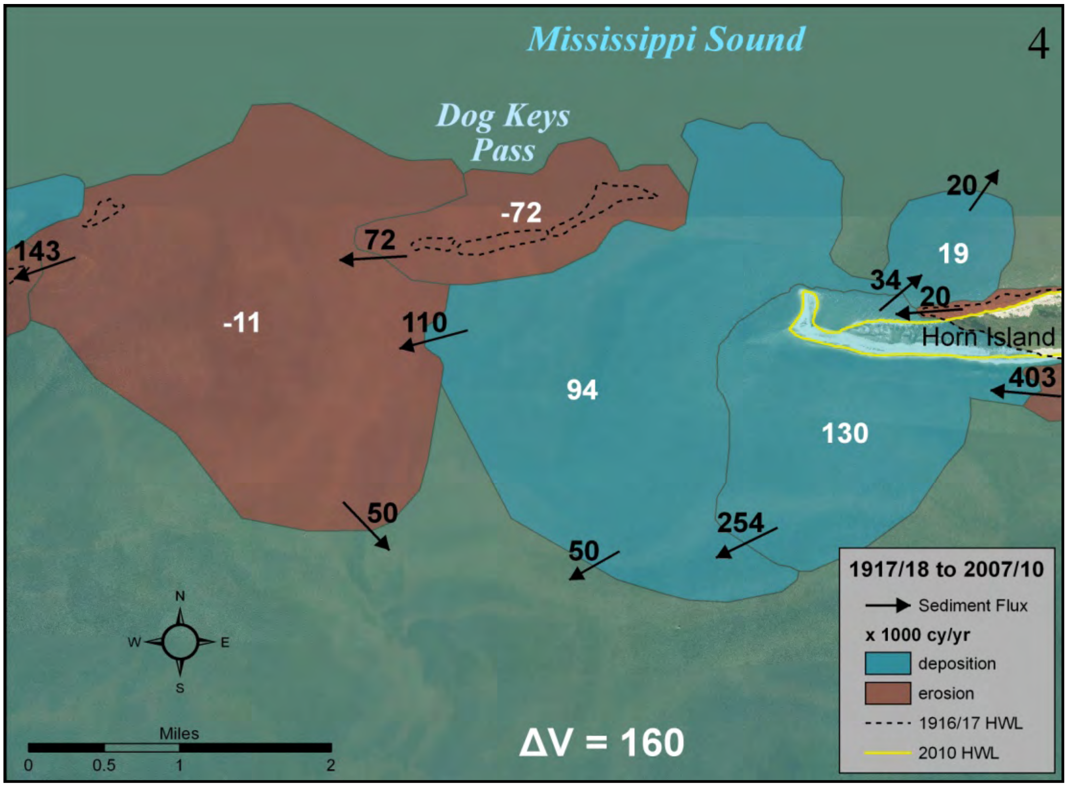

Figure 5.13. Detailed sediment transport pathways and quantities for Box 4 (Dog Keys Pass) of the macro-scale sediment budget, 1917/18 and 2005/10. Arrows illustrate the direction of sediment movement and numbers reflect the magnitude of net sediment transport in thousands of cy/yr. Underlying image is from October 2008.

The orientation of East Ship Island exposes low-lying sand beaches to direct attack by southeast waves. As such, a significant amount of sand eroded from the gulf-facing beaches is transported to the north side of the island during overwash events (about 79,000 cy/yr). Rapid beach erosion along the gulf side of East Ship Island (see Figure C34) has exposed old interior marsh and fine-grained backbarrier deposits that are estimated to contribute approximately 60,000 cy/yr of fine-grained sediment to offshore and sound environments. Long-term erosion along East Ship Island mobilizes about 400,000 cy/yr of sediment from the beaches, almost three times the amount of sand transported to the island from Little Dog Keys Pass. The island can only erode under these circumstances, as it has throughout the historical record (Figure 5.14).

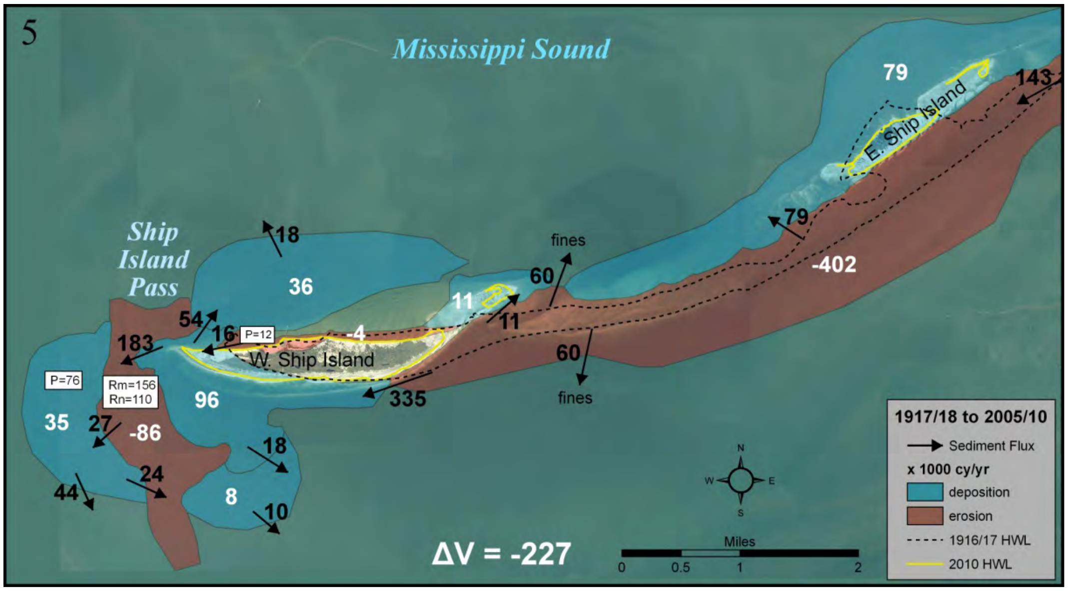

Figure 5.14. Detailed sediment transport pathways and quantities for Box 5 (Ship Island and Pass area) of the macro-scale sediment budget, 1917/18 and 2005/10. Arrows illustrate the direction of sediment movement and numbers reflect the magnitude of net sediment transport in thousands of cy/yr. Underlying image is from October 2008.

The flux of sand to West Ship Island is approximately 335,000 cy/yr, of which 183,000 cy/yr deposits in the navigation channel; 54,000 cy/yr is transported to the sound, where it deposits as sand shoals inside the entrance (36,000 cy/yr) and the remainder is redistributed in the sound; and 104,000 cy/yr is deposited at the end of West Ship Island and on the ebb shoal east of the pass (Figure 5.14). A portion of sand deposited west of the channel in the littoral zone placement area (24,000 cy/yr) appears to be migrating back toward the channel by south-directed tidal currents, although it is estimated that 44,000 cy/yr is transported offshore. Because

Ship Island Pass marks the terminal point for longshore sand transport along the Mississippi barrier islands, future placement of dredged channel sand on the north side of the island may be a more effective use of littoral sediment from a sand management perspective.

5.5 Choosing an operational sediment budget

Planning and design for barrier island restoration must rely on an operational sediment budget for defining pathways and magnitudes of change. A comparison of short-term and long-term sediment budgets reveals remarkable consistency with transport patterns and magnitudes. As such, it is recommended that the 1917/18 to 2005/10 sediment budget formulation be used for all barrier island restoration planning and design considerations. It encompasses the longest period of record for including the impact of major storm events (e.g., hurricanes Camille and Katrina, and many others), and channel dredging and placement quantities are well-documented for the entire period of record. Furthermore, all survey data sets are continuous and require no estimates of change where data gaps existed in the short-term sediment budget.

6 Conclusions and Recommendations

The Comprehensive Barrier Island Restoration Plan Appendix (H) of the Mississippi Coastal Improvements Program Comprehensive Plan Integrated Feasibility Report (MsCIP, 2009) provided technical documentation and recommendations regarding the goal to restore portions of the Mississippi barrier island system to enhance littoral sand transport for mitigating historical coastal erosion trends and maintaining contiguous island systems to reduce salt water intrusion from the gulf. When completed, island restoration would have the added benefit of providing “first line of defense” protection to mainland habitat against the impact of hurricanes and tropical storms. Proposed sand placement sites were identified in the plan based on an initial analysis of historical survey data sets and numerical modeling. The intent of the present study was to update existing analyses based on modern surveys collected as part of the engineering and design phase of the barrier island restoration project. Furthermore, it was anticipated that scientific results generated from the present study would be used to optimize initial restoration plans based on defined sediment transport trends.

A series of devastating hurricanes over the past century has significantly reduced the width and elevation of barrier island beaches, exposing mainland beaches, infrastructure, and navigation channels to increasing storm damage. The Mississippi Sound barrier islands provide the first line of defense for mainland habitat and navigation channels, serving to decrease gulf wave energy in their shadow and potentially modify the timing and magnitude of storm surge. The primary goal of this component of the MsCIP study was to quantify net sediment volume changes associated with the historical evolution of nearshore morphology and adjacent beaches for the period 1917/20 to 2005/10. Net sediment transport pathways and quantities derived from these analyses provided the framework upon which island restoration quantities and geometries were designed.

Shoreline and beach evolution for the barrier islands fronting the Mississippi Sound is driven by longshore transport processes associated with storm and normal wave and current conditions. Although beach erosion and washover deposition are processes that have influenced island changes, the dominant mechanism by which sand is redistributed along the barrier islands and in the passes is by longshore currents generated by wave approach from the southeast. Geomorphic changes along the islands illustrate the dominance of net sand transport from east to west (see Chapters 3 and 4).

Sediment erosion and accretion volumes were quantified for the period 1917/18 to 2005/10 for developing an operational sediment budget. Zones of erosion and accretion were identified throughout sediment budget control areas based on bathymetric and shoreline change analysis. Overall, ebb shoals at all entrances were net depositional (sediment sinks). Beach and nearshore environments along the east ends of the islands were net erosional (sediment sources). The dominant direction of littoral transport is from east to west, and sand from beaches and nearshore areas along the western Florida and Alabama coast supply material to downdrift barrier beaches fronting Mississippi Sound. Net west-directed transport deposits sand along the east side of passes as elongated sand spits and shoals in the entrances. Much of the sand dredged from Horn Island Pass has been placed on the west lobe of the ebb shoal, transferring littoral sand derived from beaches east of the navigation channel to the downdrift littoral zone. However, it was determined from dredging records that approximately 6.3 million cy of littoral sand dredged from the channel between 1917/18 and 2009 was not returned to the littoral zone west of the channel, creating a net long-term deficit to the sand budget. Furthermore, approximately 6.8 million cy of sand from channel maintenance dredging was placed in DA-10, from which minimal sand has been supplied to the active littoral zone. The following specific conclusions were most germane to the overall goal of the study:

1. Beach erosion along the eastern ends of islands supplied sediment to downdrift depositional zones along the western margins of islands and as subaqueous deposition in adjacent inlets.
2. Cross-shore beach changes (north-to-south) were present along eastern Petit Bois and Ship Islands, but the dominant direction of transport was alongshore (east-to-west).
3. As islands migrated westward, inlet channels did the same, except where navigation channels were established and maintained at Horn Island Pass and Ship Island Pass. However, both navigation channels have been repositioned to the west of their original locations since channel dredging commenced, reflecting the dominance of west-directed littoral transport and its impact on channel maintenance operations.

4. Western Ship Island is at the terminal position of the Mississippi barrier island littoral transport system, and as such, has been the most vulnerable barrier island to erosion processes within the system.
5. Although all barrier islands along the Mississippi coast have been subjected to breaching during storm events, only Ship Island has been breached multiple times during the historical record and continuously since Hurricane Camille.
6. Given historical rates of shoreline recession (15 to 20 ft/yr) and associated beach erosion (~400,000 cy/yr) along East Ship Island, the island is expected to become a subaqueous shoal within the next decade unless restoration measures are undertaken.
7. Inlet systems are primary sediment sinks to longshore sediment transport.
8. Sediment flux along the barrier islands fronting the Mississippi Sound ranges from 300,000 to 400,000 cy/yr, with greatest net sand transport rates along Horn Island.
9. The channel at Petit Bois Pass has been filling since the 1960s, potentially providing a more efficient pathway for sand transport from Dauphin Island to Petit Bois Island.
10. For the navigation channel at Horn Island Pass, the difference between littoral zone placement and maintenance dredging (1917 to 2009) is about -6.3 million cy (net deficit to the littoral sand budget). Furthermore, maintenance dredging sand placed in DA-10 (about 6.8 million cy) primarily has accumulated in the northern portion of the littoral zone where transport to eastern Horn Island is limited. This implies that the littoral system west of Horn Island Pass has experienced a net deficit of about 13.1 million cy since 1917.
11. Placement of dredged sand from Horn Island Pass at DA-10 has enhanced channel flow velocities between eastern Petit Bois Island and DA-10, resulting in increased scour in and near the channel up to 20-ft deeper than authorized. Increased flows in the channel entrance may pose a hazard to navigation.
12. Although the channel at Dog Keys Pass has been shoaling since the 1960s, the channel at Little Dog Keys Pass (west in the entrance) has become dominant and deeper, maintaining the wide entrance as a natural sediment trap to sand bypassing between Horn and East Ship Islands.
13. Offshore placement of maintenance dredging material from Horn Island Pass (south and west of the channel) was identified in bathymetric change results and may be a possible source of sand for island restoration.
14. Littoral sand deposited at DA-10 from channel dredging is an ideal source of restoration sand for downdrift beaches. Although the dredged material

was placed in the active littoral zone of Horn Island Pass, the rate of westward transport from the disposal area is slow compared with average net transport processes. Proposed barrier restoration west of the pass should consider sand deposited in DA-10 as a primary source for augmenting the littoral transport system.

15. Given the long-term stability of littoral sand in DA-10, future channel maintenance dredging from Horn Island Pass should be placed in a more active location on the western lobe of the ebb shoal to maintain natural westward movement of littoral sand.
16. The difference between littoral zone placement and maintenance dredging at Ship Island Pass is about -5.7 million cy (1917 to 2009). Because Ship Island Pass is the terminal position for littoral sand transport along the Mississippi barrier shoreline, sand placement cannot be considered a net loss to the natural transport system from channel dredging. However, future placement of dredged channel sand along the north side of the island may be a more effective use of littoral sediment from a sand management perspective.

Based on study results, it is recommended that initial littoral zone placement sites and volumes identified for eastern Petit Bois and Ship Islands should be modified to reflect priority littoral sand needs within the system. If the intent of restoration is to enhance littoral zone sand transport for mitigating coastal erosion trends in critical loss areas, then all island restoration efforts should be focused on the Ship Island barrier system. Ship Island is the most degraded barrier island along the Mississippi coast and is farthest from original sand sources. Historically, littoral sand trapped in Dog Keys Pass has diminished sand transport to East Ship Island, the most rapidly deteriorating island in coastal Mississippi. Once East Ship Island becomes a subaqueous shoal, beach erosion processes will shift westward because the primary source of sand for beach deposition and island migration to the west will have dispersed.

The original plan to restore the central portion of Ship Island to an island configuration consistent with conditions prior to Hurricane Camille is warranted based on historical data; however, sediment budget results suggest that significant sand should be placed along East Ship Island to mitigate historical erosion trends and enhance the littoral transport system that provides approximately 75 percent of littoral sand to downdrift beaches. Based on sand transport rates derived from the sediment budget, addition of 5 to 6 million cy of compatible beach sand along East Ship

Island is expected to supplement existing littoral transport for about 20 to 30 years. Additionally, the large restoration area (up to 16 million cy of sand) between East and West Ship Islands (downdrift of East Ship Island) will benefit directly from sand placed along East Ship Island, enhancing the longevity of littoral sand transport in the area.

Implementation of these changes would require abandoning placement of sand in the littoral zone along eastern Petit Bois Island. Based on the long-term sediment budget, littoral sand transport in this area is less degraded than that along East Ship Island. In fact, there is evidence that the channel at Petit Bois Pass is naturally filling, enhancing bypassing of sand from Dauphin Island to Petit Bois Island. Under these circumstances, it would be inappropriate to place sand at this site at the expense of restoration where a more immediate need exists. All scientific analyses indicate that the Ship Island barrier system is the area of greatest restoration need.

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Appendix A: Channel Dredging History – Horn Island Pass (Pascagoula Bar Channel)

Navigation Channel History for Horn Island Pass: 1881 to 2009					
Date	Authority	Description	New Work (cy)	Maintenance (cy)	Source
March 3, 1881	River and Harbor Act	Examination of the pass at Horn Island from the harbor in Mississippi Sound to the Gulf of Mexico was conducted by Thomas L. Harrison, Assistant Engineer in August and September of 1881. “There is a depth of 22 feet in the harbor, and a least depth of 16.5 feet at mean low-water in the pass.” “The chief desire of the mill men and timber merchants is to obtain 21 to 22 feet through this pass at mean low-water, thus enabling vessels drawing more than 17 to 18 feet to come in and load, and saving the cost of a long, expensive, and dangerous tow to Ship Island ...” “The improvement can be made by dredging and probably would be reasonably permanent, as the pass appears to be slowly deepening from year to year, from natural causes.” "A short dumping ground (say one-half mile distant from the line of dredging) can be obtained. Soft digging through the Horn Island Pass, of blue mud and sand, mixed; on the outer bar, about 60 to 100 feet wide, hard sand." Estimated excavation for a channel 6,200 feet long, 21 feet deep and 100 feet wide would be 86,000 cubic yards at a cost of about $43,000.			S. Ex. Doc. 131, 47th Cong., 1st Sess.; ARCE, 1882; p. 1324-1325;
July 5, 1884	River and Harbor Act	An appropriation of $5,000 was made for improvement of the pass. However, no project was submitted, as the amount was deemed inadequate to undertake the work. The appropriation was held until more funds became available.			ARCE, 1885; p. 1361-1362
December 4, 1894		Report by Maj. A.N. Damrell, Corps of Engineers, on “The bar recently formed in Horn Island Pass, Mississippi” authorized by the River and Harbor Act of August 17, 1894. Maj. Damrell stated “The bar formation took place during and after the storm of August 18, 1888, and was reported on, after a personal examination, February 2, 1893”. He further states “This pass, in my opinion, is worthy of improvement by the General Government”; however, “I am unable to recommend the work until a careful survey has been made to determine whether the work when done will be reasonably permanent.”			H. Ex. Doc. 104, 53rd Cong., 3rd Sess.; ARCE, 1895; p. 1714

Navigation Channel History for Horn Island Pass: 1881 to 2009					
Date	Authority	Description	New Work (cy)	Maintenance (cy)	Source
June 3, 1896	River and Harbor Act	A survey for the improvement of Horn Island Pass was made in October, 1896, in compliance with the River and Harbor Act of June 3, 1896. "The project adopted was to dredge a channel 21 feet deep at mean low water through the pass, at a cost not to exceed $8,000."			ARCE, 1897; p. 1693
Dec. 31, 1896		Report of Maj. W.T. Rossell, Corps of Engineers, on a survey of Horn Island Pass and the passage leading from said pass to the anchorage inside Horn Island, with a view to obtaining a channel 23 feet deep at low tide. This would require the excavation of 410,000 cy for a width of 300 feet. To improve this channel to a depth of 21 feet and width of 300 feet, 85,332 cy would need to be excavated. The material to be dredged was a mixture of about 2 parts sand to 1 part mud which packed quite hard and would not be easy to dredge. At the time of the survey, the depth in the pass had increased from 16.5 feet in 1881 to 19 feet in 1896 due to natural causes. The position of the channel also changed; the eastern end of Horn Island had receded and the western end of Petit Bois Island had advanced (at a much faster rate than Horn Island). If a channel was dredged across the bar, it would not be permanent. It was concluded that Horn Island Harbor and Pass were not worthy of improvement. (See map accompanying H. Doc. 200)			H. Doc. 200, 54th Cong., 2nd Sess.; ARCE, 1897, p. 1716-1717
February 11, 1897		Contract was entered into with the Rittenhouse Moore Dredging Company of Mobile, AL, for the removal of a shoal in what was known as the outer bar in Horn Island Pass. The area was 200 feet wide and 1,300 feet long, and there was a least depth of 18.7 feet mean low water. The contractor was paid 40 cents per cubic yard bin measurement. “Dredging operations were commenced on March 8, 1897, with the suction dredge *Jumbo*, attended by the steam tug *U.S. Grant*, and were completed on April 17, 1897, by the removal of 18,616 cubic yards of very fine white sand, and the result was a cut 200 feet wide and 1,300 feet long, with an average depth of 20.5 feet mean low water”.	18,616		ARCE, 1897; p. 1694

Navigation Channel History for Horn Island Pass: 1881 to 2009

Date	Authority	Description	New Work (cy)	Maintenance (cy)	Source
May 7, 1898	River and Harbor Act	Report of Maj. W.T. Rossell, Corps of Engineers, on a survey of Horn Island Harbor and Pass, Mississippi “with a view of ascertaining the extent to which the channel leading to and from the pass should be dredged and improved to meet the necessities of commerce”. Maj. Rossell stated that “there was a depth of 19 feet mean low water over the shoal at the outer bar, but that the channel there cannot be permanently improved by dredging.” "The material composing the bar is fine white sand, easily moved." However, Rossell does believe that improvement of the anchorage area is warranted.			H. Doc. 51, 55th Cong., 3rd Sess.; ARCE, 1899; p. 1784-1786
March 3, 1899	River and Harbor Act	An appropriation of $50,000 was made for Pascagoula River and Horn Island Harbor, and contracts authorized in the amount of $267,600.			ARCE, 1900; p. 352
July 21, 1899		Contract awarded to Albert G. Delmas, of Scranton, Mississippi, to excavate a channel 150 feet wide and 4,000 feet long to a project depth of 20 feet across the “bulkhead” in Horn Island Harbor (outer bar) where the depth was previously about 17.5 feet. Dredging operations commenced on September 27, 1899 with a clam-shell patent dredge, three scows, two steam tugs, and a coal tender. Dredging was completed in the anchorage of Horn Island Harbor on May 7, 1900.	50,064		ARCE, 1900; p. 2211
March 25, 1901		Dredging commenced and by June 30, 116,658 cubic yards had been excavated from the Horn Island anchorage, chiefly compact sand, and the cut of 150 feet wide by 20 feet deep was widened to 400 feet for the 4,000 feet length of channel.	116,658		ARCE, 1901; p. 1842
February 28, 1902		From July 1, 1901, when the contract was dated, to February 28, 1902, the channel at Horn Island Harbor was widened from 400 to 500 feet through the length of 4,000 feet to a depth of 20 feet. In addition, a channel was dredged through the shoal in Horn Island Harbor known as the "Neck," 20 feet deep, 500 feet wide, and 1,250 feet long. Dredging was completed by Albert Demas.	66,665		ARCE, 1902; p. 302 & 1305

Navigation Channel History for Horn Island Pass: 1881 to 2009					
Date	Authority	Description	New Work (cy)	Maintenance (cy)	Source
February 2, 1904		Pursuant to a requirement of the River and Harbor Act of June 13, 1902, a preliminary examination and survey of Horn Island Pass, Mississippi, with a view of securing a channel 25 feet deep and 300 feet wide across the outer bar, was completed by Captain Craighill on November 7, 1903 and reported by the Office of the Chief of Engineers. The depth of Horn Island Pass was found to be 18 feet. The pass consisted of an outer bar and an inner bar separated by a deeper pocket immediately between the ends of the adjacent islands. From an examination of the shores of Horn Island, it was concluded that the island was cutting away on the south side and building up on the north side. It was believed that the natural deepening over the years of Horn Island Pass was due to the contraction of the pass opening, a result of the steady growth of Petit Bois Island to the west. In 1860 the opening between these 2 islands was over 3 miles, in 1896 it was 1.75 miles.			H. Doc. 506, 58th Cong., 2nd Sess.; ARCE, 1904; p. 1863-1867
March 3, 1905	River and Harbor Act	Provides for obtaining a 21-foot channel through the outer and inner bars of the Pass and channel widths of 300 feet across the outer bar and 200 feet elsewhere.			ARCE, 1905; p. 1421-1422
August 15, 1906		The U.S. dredge *Charleston*, borrowed from the Charleston District, began dredging the inner and outer bars at Horn Island Pass to dimensions authorized by the March 3, 1905 River and Harbor Act.	353,230		ARCE, 1907; p. 1390
July 1, 1907		"During the past fiscal year, the U.S. dredge *Charleston* removed 184,017 cubic yards of material from this channel…". The work completed resulted in full depth and widths authorized by the project. "The channel shoals rapidly and requires constant attention to maintain it."	184,017		ARCE, 1908; p. 1447
Fiscal Year 1909		No dredging was completed during the fiscal year. A shoal had formed on the crest of the outer bar.			ARCE, 1909, p. 1430
August 1 to October 10, 1909		The U.S. *Charleston* removed all shoals in the channel through Horn Island Pass, restoring it to its project depth and width.		158,470	ARCE, 1910; p. 1581

Navigation Channel History for Horn Island Pass: 1881 to 2009					
Date	Authority	Description	New Work (cy)	Maintenance (cy)	Source
August 17, 1909		Report of a preliminary examination of "Horn Island Pass, from the outer bar in Gulf of Mexico through and across Dago shoals, in Mississippi Sound, by the most direct and practicable route, to the 21-foot depth north of Petit Bois Island" by Maj. Henry Jervey, Corps. of Engineers, was submitted according to the River and Harbor Act of March 3, 1909. Commercial interests desired additional anchorage and loading basin north of Petit Bois Island. Dago shoals were located northward of Horn Island Pass, had depths from 14 to 18 feet, and formed a hard bottom. The advantages were that the channel leading from Pascagoula would be straighter and a little shorter, and the channel connecting it with the pass would be more direct than that leading to Horn Island Basin. However, disadvantages included the proposed work including a cut of from 3 to 7 feet in depth through an exposed reach which would be subject to rapid deterioration during storm periods; and the location being more exposed than that of Horn Island. It was concluded that a channel through Dago shoals to the basin north of Petit Bois Island was not worthy of being undertaken by the General Government.			H. Doc. 314, 61st Cong., 2nd Sess.
Sept. 30, 1910 & Dec. 27, 1911		Report of preliminary examination and survey of mouth of Pascagoula River, with a view to securing increased depth in a continuous channel from the upper limits of the present project in Dog River to deep water in the Gulf of Mexico, was submitted according to the River and Harbor Act of June 25, 1910. The investigation covered Pascagoula River and its tributary, Dog River, and Horn Island Pass. It was recommended that the existing projects for Pascagoula River and Horn Island Pass be combined in a single project for Pascagoula Harbor. The estimated amount to be dredged for a channel across Horn Island Bar 5,800 feet long, 25 feet deep, and 300 feet wide, was 243,000 cy. There was a deep water pocket between the lower end of the inner channel and Horn Island outer bar 4,600 feet long. The favorable project included a channel 300 feet wide and 25 feet deep across the outer bar.			H. Doc. 682, 62nd Cong., 2nd Sess.

Navigation Channel History for Horn Island Pass: 1881 to 2009

Date	Authority	Description	New Work (cy)	Maintenance (cy)	Source
Fiscal Year 1911		No dredging completed during the fiscal year.			ARCE, 1911; p. 1722
Fiscal Year 1912		No dredging completed during the fiscal year.			ARCE, 1912; p. 1943
March 4, 1913	River and Harbor Act	Provided for a 300 foot wide and 25 foot deep channel through the outer bar at Horn Island, provided local interests contribute $100,000 and furnish space for public wharves in Pascagoula River.			ARCE, 1913, p. 689
January 30 to February 14, 1913		The U.S dredge *Charleston* removed shoals from Horn Island Pass (1,702 cubic yards) and the outer bar channel (23,565 cubic yards).		25,267	ARCE, 1913; p. 2165
February 7 to March 19, 1914		The U.S dredge *Charleston* worked on maintenance dredging in the Horn Island Pass outer bar channel. A depth of 21 feet was obtained for the length of the outer bar channel (0.6 miles).		37,807	ARCE, 1914; p. 2208-2209
March 4, 1915	River & Harbor Act	Provided for amendment of present project by waiving the requirement that as a condition precedent to further improvement a contribution of $100,000 be made by local interests and by limiting the authorized first cost to $283,000, to be expended in securing a through channel of such dimensions as might be obtained, but not to exceed 25 feet deep, by the expenditure of that sum.			ARCE, 1915, p. 776
Fiscal Year 1915		No dredging completed during the fiscal year. At the end of the fiscal year there a maximum low-water draft of 21 feet across the bar at Horn Island.			ARCE, 1915; p. 777 & 2552
Fiscal Year 1916		No dredging completed during the fiscal year. On June 30, 1916, the controlling depth in the channel across the bar 21 feet.			ARCE, 1916; p. 827 & 2399
Fiscal Year 1917		No dredging completed during the fiscal year. On June 30, 1917, the controlling depth in the channel across the bar 20 feet.			ARCE, 1917; p. 854 & 2493

Navigation Channel History for Horn Island Pass: 1881 to 2009					
Date	Authority	Description	New Work (cy)	Maintenance (cy)	Source
August 22 to October 2, 1917; April 2-22, 1918		The U.S. dredge *Charleston* dredged shoals from Horn Island Pass and outer bar channel. On June 30, 1918, the controlling depth across the bar was 20 feet.		79,643	ARCE, 1918; p. 888 & 2543
Fiscal Year 1919		No dredging completed during the fiscal year. On June 30, 1919, the controlling depth across the bar 19.4 feet.			ARCE, 1919; p. 935 & 2629
Fiscal Year 1920		No dredging completed during the fiscal year. On June 12, 1920, the controlling depth in the Horn Island Pass Channel 18.5 feet. The Horn Island Pass Channel shoaled at a rate of approximately 20,000 cy per annum.			ARCE, 1920; p. 907-908 & 2364
Fiscal Year 1921		Maintenance dredging was conducted in Horn Island Pass to bring the project to 300 feet wide by 21 feet deep; only able to complete maintenance dredging over one-third the channel length.		27,811	ARCE, 1921; p. 906
Fiscal Year 1922		Maintenance work "resulted in the removal of 52,819 cubic yards of material from the Horn Island Pass Channel and 28,756 cubic yards of material from Mississippi Sound on Dago Shoals, securing a depth of 21 feet over the project width in the Horn Island Pass Channel."		81,575	ARCE, 1922; p. 933
Fiscal Year 1923		No dredging completed during the fiscal year. As of June 5, 1923, the controlling depth in Horn Island Pass channel 21 feet.			ARCE, 1923; p. 809
Fiscal Year 1924		No dredging completed during the fiscal year. On June 12, 1924, the controlling depth of Horn Island Pass 20 feet.			ARCE, 1924; p. 804
Fiscal Year 1925		No dredging completed during the fiscal year. In June 1925, the controlling depth of Horn Island Pass 20 feet.			ARCE, 1925; p. 787
Fiscal Year 1926		No dredging completed during the fiscal year. In June 1926, the controlling depth of Horn Island Pass 20 feet.			ARCE, 1926; p. 794
Fiscal Year 1927		No dredging completed during the fiscal year. In June 1927, the controlling depth of Horn Island Pass 20 feet.			ARCE, 1927; p. 819-820
Fiscal Year 1928		No dredging completed during the fiscal year. In June 1928, the controlling depth of Horn Island Pass 20 feet.			ARCE, 1928; p. 854

Navigation Channel History for Horn Island Pass: 1881 to 2009					
Date	Authority	Description	New Work (cy)	Maintenance (cy)	Source
Fiscal Year 1929		No dredging completed during the fiscal year. In June 1929, the controlling depth of Horn Island Pass 20 feet.			ARCE, 1929; p. 855-856
Fiscal Year 1930		No dredging completed during the fiscal year. In June 1930, the controlling depth of Horn Island Pass 19 feet.			ARCE, 1930; p. 926
Fiscal Year 1931		No dredging completed during the fiscal year. In June 1931, the controlling depth of Horn Island Pass 19 feet.			ARCE, 1931; p. 924
Fiscal Year 1932		No dredging completed during the fiscal year. In June 1932, the controlling depth of Horn Island Pass 19 feet.			ARCE, 1932; p. 824
Fiscal Year 1933		No dredging completed during the fiscal year. In June 1933, the controlling depth of Horn Island Pass 19 feet.			ARCE, 1933; p. 496
Fiscal Year 1934		No dredging completed during the fiscal year. In June 1934, the controlling depth of Horn Island Pass 19 feet.			ARCE, 1934; p. 581
Fiscal Year 1935		No dredging completed during the fiscal year. In June 1935, the controlling depth of Horn Island Pass 19.0 feet.			ARCE, 1935; p. 674
Fiscal Year 1936		No dredging completed during the fiscal year. In June 1936, the controlling depth of Horn Island Pass 19.0 feet.			ARCE, 1936; p. 661-662
Fiscal Year 1937		No dredging completed during the fiscal year. In June 1937, the controlling depth of Horn Island Pass 19 feet.			ARCE, 1937; p. 702
Fiscal Year 1938		No dredging completed during the fiscal year. In June 1938, the controlling depth of Horn Island Pass 19 feet.			ARCE, 1938; p. 741-742
Fiscal Year 1939		No dredging completed during the fiscal year. In June 1939, the controlling depth of Horn Island Pass 17 feet.			ARCE, 1939; p. 817-818
April 22 to May 1940		The U.S. hopper dredge *Benyaurd* dredged the channel at Horn Island Pass to the authorized depth of 21 feet and a width of 300 feet.		313,131	ARCE, 1940; p. 811-812
February 11, 1897 to May 1940	Existing River and Harbor Acts	Total dredging completed under the River and Harbor Acts of 1896 and 1905.	789,250	723,704	

Navigation Channel History for Horn Island Pass: 1881 to 2009					
Date	Authority	Description	New Work (cy)	Maintenance (cy)	Source
May to June 15, 1940		The U.S. hopper dredge *Benyaurd* dredged the channel at Horn Island Pass to the maximum authorized depth of 25 feet and a width of 300 feet, as authorized by the March 1915 Rivers and Harbors Act.	291,515		ARCE, 1940; p. 811-812
Fiscal Year 1941		No dredging completed during the fiscal year. In June 1941, the controlling depth of Horn Island Pass 24 feet.			ARCE, 1941; p. 775
July 21 to August 7, 1941; January 7-28, 1942		The U.S. hopper dredge *Benyaurd*, operating in Horn Island Pass channel, removed 527,419 cubic yards of material to maintain an authorized channel depth of 25 feet and a width of 300 feet.		527,419	ARCE, 1942; p. 687
May 11-29, 1943		The U.S. hopper dredge *Benyaurd*, operating in Horn Island Pass channel, removed 152,077 cubic yards of material to maintain an authorized channel depth of 25 feet and a width of 300 feet.		152,077	ARCE, 1943; p. 621
Fiscal Year 1944		No dredging completed during the fiscal year. At the end of the FY, the controlling depth of Horn Island Pass 25 feet.			ARCE, 1944; p. 607
Fiscal Year 1945		No dredging completed during the fiscal year. At the end of the FY, the controlling depth of Horn Island Pass 25 feet.			ARCE, 1945; p. 846
January 14, 1946		The U.S. hopper dredge *Benyaurd*, operating in Horn Island Pass channel, removed 1,037 cubic yards of material. At the end of the FY, the controlling depth of Horn Island Pass was 22.5 feet.		1,037	ARCE, 1946; p. 913
September 29 to October 12, 1946		The U.S. hopper dredge *San Pablo* dredged 59,938 cy of material from the Horn Island Pass channel. At the end of the FY, the controlling depth of Horn Island Pass was 24 feet.		59,938	ARCE, 1947; p. 894-895
February 9-21 and March 15-20, 1948		The U.S. hopper dredge *Lyman* dredged material from the Horn Island Pass channel. In April 1948, the controlling depth of Horn Island Pass was 25 feet.		169,200	ARCE, 1948; p. 989
February 11, 1897 to March 20, 1948	Existing River and Harbor Acts	Total dredging completed under the River and Harbor Acts of 1896, 1905, 1913 and 1915.	1,080,765	1,633,375	

Navigation Channel History for Horn Island Pass: 1881 to 2009					
Date	Authority	Description	New Work (cy)	Maintenance (cy)	Source
May 2 to June 16, 1949		The U.S. hopper dredge *Langfitt*, with contributed funds, dredged 966,300 cubic yards of new material from the Horn Island Pass channel from about Buoy No. 9 to the 35-foot contour in the Gulf of Mexico. The controlling depth in Horn Island Pass in June, 1949, was 32 feet, far deeper than that authorized by the 1913 and 1915 River and Harbor Acts (controlling legislation). According to the 1948 ARCE (p. 989), the controlling depth in Horn Island Pass in April, 1948, was 25 feet. This apparent unauthorized modification was explained in the 1956 ARCE (p. 562): “The project was modified by local interest, at their expense, to provide a channel 35 feet deep and 325 feet wide through Horn Island Pass.”	966,300		ARCE, 1949; p. 891
Fiscal Year 1950		No dredging completed during the fiscal year. In Feb. 1950, the controlling depth of Horn Island Pass 30 feet.			ARCE, 1950; p. 899
Fiscal Year 1951		No dredging completed during the fiscal year. In May 1951, the controlling depth of Horn Island Pass 30 feet.			ARCE, 1951; p. 730-731
Fiscal Year 1952		No dredging completed during the fiscal year.			ARCE, 1952; p. 687
Fiscal Year 1953		No dredging completed during the fiscal year. The controlling depth for the channel in April, 1953, 25 feet.			ARCE, 1953; p. 642
Fiscal Year 1954		No report submitted for Pascagoula Harbor/Horn Island Pass this fiscal year. Listed under "Inactive Navigation Projects."			ARCE, 1954; p. 413 & 448
September 3, 1954	River and Harbor Act	Authorized modification of the existing project in accordance with plans on file in the office of the Chief of Engineers. Provides for the Federal Government to assume maintenance of the existing project at Pascagoula Harbor as modified by local interests in 1949, at their expense, to provide a channel 35 feet deep and 325 feet wide. The President, in approving the project, stated that no appropriations would be requested prior to a favorable report on the project.			ARCE, 1958; p. 508; H. Doc. 98, 86th Cong., 1st Sess.
Fiscal Year 1955		No dredging completed during the fiscal year. In Aug. 1954, the controlling depth of Horn Island Pass 25 feet.			ARCE, 1955; p. 436

Navigation Channel History for Horn Island Pass: 1881 to 2009

Date	Authority	Description	New Work (cy)	Maintenance (cy)	Source
September 21-25, 1955		The U.S. hopper dredge *Langfitt* removed material from the Horn Island Pass bar channel. In June 1956, the controlling depth of Horn Island Pass was 25 feet.		84,080	ARCE, 1956; p. 562-563
Fiscal Year 1957		No dredging completed during the fiscal year. In June 1957, the controlling depth of Horn Island Pass 25 feet.			ARCE, 1957; p. 557-559
Fiscal Year 1958		No dredging completed during the fiscal year. In Jan. 1958, the controlling depth of Horn Island Pass 25 feet.			ARCE, 1958; p. 508-509
July 14-31, 1958		The U.S. hopper dredge *Mackenzie* agitated 968,229 cubic yards in Horn Island Pass channel. In May 1959, the controlling depth of Horn Island Pass was 25 feet.			ARCE, 1959; p. 532
Jan. 22, 1959		Report submitted included a study of the engineering and economic feasibility of the plans authorized in the River and Harbor Act approved Sept. 3, 1954, and an investigation to determine whether additional project modifications may be advisable at the time. It was found economically justified and recommended that the Government restore and maintain the Horn Island Pass dimensions obtained by local interests in 1949, a channel 2.75 miles long, 35 feet deep and 325 feet wide. The estimated amount to be removed for the restoration of this channel was 881,000 cy (including 2 feet of overdepth) and the average annual maintenance was estimated to be 230,000 cy. The average annual maintenance of the present project (25 feet deep and 300 feet wide) was 100,000 cy.			H. Doc. 98, 86th Cong., 1st Sess.
March 1 to April 23, 1960		The U.S. hopper dredge *Mackenzie* removed material from the Horn Island Pass channel to maintain channel dimensions dredged in 1949 (paid for by local interests) in accordance with the 1954 River and Harbor Act authorization. In June 1960, the channel depth at Horn Island Pass was 33 feet.		927,015	ARCE, 1960; p. 519-520
June 9, 1960		The Chief of Naval Operations requested that the Chief of Engineers initiate and sponsor a project modification which would lead to congressional action providing for a 38 foot sea channel from Horn Island Pass to the sea.			H. Doc. 65, 87th Cong., 1st Sess.

Navigation Channel History for Horn Island Pass: 1881 to 2009

Date	Authority	Description	New Work (cy)	Maintenance (cy)	Source
July 14, 1960	River and Harbor Act	Authorized deepening of the Horn Island Pass channel from 35 feet (as authorized in 1954) to 38 feet and 325 feet wide for a distance of about 2.8 miles, from the 38-ft depth contour in the Gulf of Mexico through Horn Island Pass to Mississippi Sound. An immediate study was called for to determine if these modifications of the existing navigation project were warranted.			ARCE, 1961; p. 571-572; H. Doc. 65, 87th Cong., 1st Sess.
July 1-22, 1960		The U.S. hopper dredge *Mackenzie* performed "new work" in Horn Island Pass channel as per the 1954 River and Harbor Act. However, volume dredged was classified as maintenance material because the channel was dredged to 35 feet in 1949 by local interests. In March 1961, the controlling depth of Horn Island Pass was 35 feet.		438,165	ARCE, 1961; p. 572
July 25-29 and August 3-12, 1960		The U.S. hopper dredge *Langfitt* performed "new work" in Horn Island Pass channel as per the 1954 River and Harbor Act. However, volume dredged was classified as maintenance material because the channel was dredged to 35 feet in 1949 by local interests. In March 1961, the controlling depth of Horn Island Pass was 35 feet.		457,150	ARCE, 1961; p. 572
October 1-30, 1960		The U.S. hopper dredge *Hyde* removed material from the Horn Island Pass channel to maintain project dimensions authorized in 1954.		333,718	ARCE, 1961; p. 572
Nov. 3, 1960		Report submitted in response to River and Harbor Act of July 14, 1960, to determine if further modification of the 1954 Act was warranted. The Navy desired a channel 38 feet deep and 325 feet wide across the bar at Horn Island Pass. This work, including 2-feet overdepth, would require the removal of about 1,100,000 cy. It was concluded that this additional depth was warranted by the needs of naval vessels.			H. Doc. 65, 87th Cong., 1st Sess.
March 16-25 and April 1-10, 1961		The U.S. hopper dredge *Gerig* removed 169,010 cubic yards of material from the Horn Island Pass channel to maintain project dimensions and agitated an additional 1,334,598 cubic yards. Horn Island Pass had a controlling depth of 35 feet in March 1961		169,010	ARCE, 1961; p. 572

Navigation Channel History for Horn Island Pass: 1881 to 2009

Date	Authority	Description	New Work (cy)	Maintenance (cy)	Source
February 11, 1897 to April 10, 1961	Existing River and Harbor Acts	Total dredging completed under the River and Harbor Acts of 1896, 1905, 1913, 1915, and 1954 (channel depth of 35 feet and width of 325 feet).	2,047,065	4,042,513	
May 10 to June 13, 1962		The U.S. hopper dredge *Gerig* performed new work in Horn Island Pass channel as per the 1960 River and Harbor Act. In May 1962, when the existing project was completed, the controlling depth was 38 feet.	1,049,220		ARCE, 1962; p. 582-583
Aug. 31, 1962		Report was submitted on a review of reports on Pascagoula Harbor, with a view to determining whether the existing project should be modified in any way, with particular reference to providing additional channel depths in Horn Island Pass. Local interests desired increased depths and widths, as great as 45 feet deep and 400 feet wide in Horn Island Pass, in view of the trend towards the use of larger vessels. The Chief of Engineers recommended modification of the existing project to provide for an entrance channel from deep water in the Gulf of Mexico through Horn Island Pass, 3 miles long, 40 feet deep, and 350 feet wide, including an impounding area for littoral drift 40 feet deep, 200 feet wide, and about 1,500 feet long adjacent to the channel at the west end of Petit Bois Island. The purpose of the impounding area was to trap littoral drift between maintenance dredging operations before it encroached on the channel. Dredging would be performed by hopper dredge and the spoils would be deposited in deep water in the Gulf of Mexico to the west of the channel. The estimated amount to be removed was 4,123,000 cy of material. Initial dredging would provide for 2 feet additional depth as an advanced maintenance measure plus 2 feet as an allowable tolerance. To ensure full project dimensions at all times, it was proposed to commence each maintenance dredging operation as soon as practicable after the channel had shoaled to project depth, and to provide additional depth as advance maintenance during each operation.			H. Doc. 560, 87th Cong., 2nd Sess.
October 1-18, 1962		The U.S. hopper dredge *Langfitt* removed material from the Horn Island Pass channel to maintain project dimensions at a cost of $87,087.		569,714	ARCE, 1963; p. 520

Navigation Channel History for Horn Island Pass: 1881 to 2009

Date	Authority	Description	New Work (cy)	Maintenance (cy)	Source
October 23, 1962	River and Harbor Act	Authorized enlarging Horn Island Pass channel to 40 feet deep and 350 feet wide, including an impounding area for littoral drift, 40 feet deep, 200 feet wide, and about 1,500 feet long adjacent to the western end of Petit Bois Island.			ARCE, 1963; p. 519-520
February 10 to March 6, 1964		The U.S. hopper dredge *Hyde* removed material from the Horn Island Pass channel to attain project dimensions.		192,949	ARCE, 1964; p. 472
January 2-16, 1965		The U.S. hopper dredge *Langfitt* removed material from the Horn Island Pass channel to attain project dimensions. In Jan. 1965, the controlling depth was 38 feet.		435,439	ARCE, 1965; p. 463
February 11, 1897 to January 16, 1965	Existing River and Harbor Acts	Total dredging completed under the River and Harbor Acts of 1896, 1898, 1905, 1913, 1915, 1954, and 1960 (channel depth of 38 feet, width of 325 feet, and length of 2.8 miles).	3,096,285	5,240,615	
April 21 to May 28, 1965		The U.S. hopper dredge *Gerig* performed new work in Horn Island Pass channel as per the 1962 River and Harbor Act.	997,462		ARCE, 1965; p. 463
July 30 to August 12, 1965		The U.S. hopper dredge *Gerig* performed new work in Horn Island Pass channel as per the 1962 River and Harbor Act. Existing project was completed in Aug. 1965.	308,127		ARCE, 1966; p. 500
October 2-28, 1965		The U.S. hopper dredge *Gerig* removed material from the Horn Island Pass channel to attain project dimensions. Controlling depth in March 1966 was 40 feet.		507,385	ARCE, 1966; p. 500
October 20 to November 18, 1966		The U.S. hopper dredge *Gerig* removed material from the Horn Island Pass channel to attain project dimensions. In Dec. 1966, the controlling depth was 39.0 feet.		704,210	ARCE, 1967; p. 490
March 26 to April 26, 1968		Contractor's pipeline dredge *Fritz Jahncke* removed sand from the Horn Island Pass channel to attain project dimensions.		717,836	ARCE, 1968; p. 375; Mobile District O&M
Fiscal Year 1969		No dredging completed during the fiscal year.			ARCE, 1969; p. 357
September 1 to October 15, 1969		The U.S. hopper dredge *McFarland* removed material from the Horn Island Pass channel on an emergency basis related to channel shoaling from Hurricane Camille.		1,994,454	ARCE, 1970; p. 342

Navigation Channel History for Horn Island Pass: 1881 to 2009					
Date	Authority	Description	New Work (cy)	Maintenance (cy)	Source
January 27 to February 14, 1970		The U.S. hopper dredge *Gerig* removed material from the Horn Island Pass channel on an emergency basis related to channel shoaling from Hurricane Camille.		445,477	ARCE, 1970; p. 342
December 6-22, 1970		The U.S. hopper dredge *Gerig* removed sediment from the Horn Island Pass outer bar channel to attain project dimensions (40 feet deep by 350 feet wide).		342,542	ARCE, 1971; p. 10-13
Fiscal Year 1972		No dredging completed during the fiscal year.			ARCE, 1972; p. 10-12
August 26 to September 22, 1972		Contractor’s pipeline dredge *Tom James* removed sediment from the Horn Island Pass Impoundment Area to attain project dimensions. Dredged material placed as BN (beach nourishment).		681,111	ARCE, 1973; p. 10-13; Mobile District O&M
July 10-24, 1974		The U.S. hopper dredge *Gerig* removed sediment from the Horn Island Pass bar channel to maintain authorized project dimensions. Dredged material placed in ocean D/A (disposal area).		150,067	Mobile District O&M
March 18-31, 1975		The U.S. hopper dredge *Davison* removed sediment from the Horn Island Pass bar channel to maintain authorized project dimensions. Dredged material placed in ocean D/A.		309,676	ARCE, 1975; p. 10-11; Mobile District O&M
December 1-15, 1975		Contractor's pipeline dredge *Paul F. Jahncke* removed sediment from Horn Island Pass channel and impoundment basin. Dredged material placed in D/A #10 BN.		511,397	Mobile District O&M
June 14-30, 1976		The U.S. hopper dredge *Gerig* removed sediment from the Horn Island Pass bar channel to maintain authorized project dimensions. Dredged material placed in ocean D/A.		810,231	ARCE, 1976; p. 10-11; Mobile District O&M
April 30 to May 15, 1977 and June 14-21, 1977		The U.S. hopper dredge *McFarland* removed sediment from the Horn Island Pass bar channel to maintain authorized project dimensions. Dredged material placed in ocean D/A.		558,632	ARCE, 1977; p. 10-12; Mobile District O&M

Navigation Channel History for Horn Island Pass: 1881 to 2009					
Date	Authority	Description	New Work (cy)	Maintenance (cy)	Source
February 17-27, 1978		The U.S. hopper dredge *McFarland* removed sediment from the Horn Island Pass bar channel to maintain authorized project dimensions. Dredged material placed in ocean D/A.		331,699	ARCE, 1978; p. 10-13; Mobile District O&M
August 31 to October 11, 1978		Contractor's pipeline dredge *Pontchartrain* removed sediment from the Horn Island Impoundment Area. Dredged material placed as BN (#10).		407,147	Mobile District O&M
October 5-15, 1979		The U.S. hopper dredge *Langfitt* removed sediment from the Horn Island Pass bar channel at a cost of $297,975. Dredged material placed in ocean D/A.		220,870	ARCE, 1980; p. 10-12; Mobile District O&M
October 10 to November 18, 1979		Contractor's pipeline dredge *Blackburn* removed sediment from the Horn Island Impoundment Area. Dredged material placed as BN (#10).		85,070	Mobile District O&M
February 18 to March 4, 1981		The U.S. hopper dredge *Langfitt* removed sediment from the Horn Island Pass bar channel to maintain authorized project dimensions. Dredged material placed in ocean D/A.		168,134	Mobile District O&M
September 14-25, 1981		Contractor's pipeline dredge *Fritz Jahncke* removed sediment from the Horn Island Impoundment Area. Dredged material placed as BN (#10).		137,290	ARCE, 1981; p. 10-12; Mobile District O&M
September 12 - November 19, 1982		Contractor's hopper dredge *Mermentau* removed sediment from the Horn Island Pass bar channel to attain project dimensions. Dredged material placed in ocean D/A.		610,047	Mobile District O&M
June 4-22, 1983		Contractor's pipeline dredge *Buster Bean* removed sediment from the Horn Island Impoundment Area. Dredged material placed as BN (#10).		389,552	Mobile District O&M
November 9-December 10, 1983		Contractor's hopper dredge *Atchafalaya* removed sediment from the Horn Island Pass bar channel to attain project dimensions. Dredged material placed in ocean D/A.		493,175	Mobile District O&M
Dec. 10 to 28, 1984		Contractor's pipeline dredge *Port Arthur* removed sediment from the Horn Island Impoundment Area. Dredged material placed in D/A #10.		201,499	Mobile District O&M

Navigation Channel History for Horn Island Pass: 1881 to 2009					
Date	Authority	Description	New Work (cy)	Maintenance (cy)	Source
July 24 to August 19, 1985		Contractor's hopper dredge *Sugar Island* removed sediment from the Horn Island Pass bar channel to attain project dimensions. Dredged material placed in ocean D/A.		598,500	Mobile District O&M
October 1985 to January 1986		Contractor's pipeline dredge *Port Arthur* removed sediment from the Horn Island Pass Bar Channel and the Impoundment Area. Dredged material placed in D/A #10.		536,926	Mobile District O&M
November 17, 1986	Water Resources Development Act	Authorized Pascagoula Bar Channel to 44 feet deep by 550 feet wide, Horn Island Pass channel to 44 feet deep by 600 feet wide, and relocating the Pass channel about 500 feet westward.			ARCE, 1987, see Table 10-B
October 31, 1986 to January 3, 1987		Contractor's hopper dredge *Mermentau* removed sediment from the Horn Island Pass bar channel to attain project dimensions. Dredged material placed in ocean D/A.		481,788	Mobile District O&M
September 14-19, 1987		Contractor's pipeline dredge *Tom James* removed sediment from the Horn Island Impoundment Basin to attain project dimensions. Dredged material placed in D/A #10.		179,946	Mobile District O&M
December 28, 1989 to January 10, 1990		Contractor's dredge *Blackburn* removed sediment from the Horn Island Pass bar channel to attain project dimensions. Dredged material placed in D/A #10.		254,152	Mobile District O&M
November 1-17 and 23-26, 1990		Contractor's dredge *Manhattan Island* removed sediment from the Horn Island Pass bar channel to attain project dimensions. Dredged material placed in ocean D/A.		535,333	Mobile District O&M
September 29-30, 1992		Contractor's dredge *Missouri H* removed sediment from the Horn Island Impoundment Area. Dredged material placed in D/A #10. Dredging dates: January 1-5, 10-14, 17-18, 1991; September 17-18, 29-30, 1991.		248,113	Mobile District O&M
September 7-15, 1993		Contractor's dredge *Manhattan Island* removed sediment from the Horn Island Pass bar channel to attain project dimensions. Dredged material placed in ocean D/A ODMDS.		697,093	Mobile District O&M

Navigation Channel History for Horn Island Pass: 1881 to 2009					
Date	Authority	Description	New Work (cy)	Maintenance (cy)	Source
February 11, 1897 to September 15, 1993	Existing River and Harbor Acts	Total dredging completed under the River and Harbor Acts of 1896, 1905, 1913, 1915, 1954, 1960, and 1962 (channel depth of 40 feet, width of 350 feet, and impoundment area along the western end of Petit Bois Island).	4,401,874	19,549,967	
September 19 to October 12, 1995		Pascagoula Harbor Improvements, Phase I: New work was conducted in the lower sound channel (176+40 to 219+35) using contractor's dredge *George D. Williams*. Dredged material placed in OW D/A #10 and Horn Island OW D/A BN.	710,304		Mobile District O&M
September 16 to November 24, 1995		Pascagoula Harbor Improvements, Phase I: Contractor's dredge *Tom James* removed sediment from the Lower Sound, Horn Island Pass, and Bar channels. Dredged material placed in D/A #10 and as BN.	2,411,260		Mobile District O&M
August 14-24, 1997		Contractor's pipeline dredge *Missouri H* removed sediment from Horn Island Pass (258+00 to 268+00). Dredged material placed in D/A #10.		151,489	Mobile District O&M
October 12-29, 1998		Contractor's pipeline dredge *Meridian* removed sediment from Horn Island Pass (258+00 to 278+00) to attain project dimensions. Dredged material placed in D/A #10.		659,256	Mobile District O&M
Nov. 1, 1999 to Jan. 28, 2000		Pascagoula Harbor Improvement Phase 2: Contractor's dredge *Meridian* removed sediment from the Horn Island Pass bar channel to attain project dimensions. Dredged material was placed in the Littoral Zone D/A.	1,858,476		Mobile District O&M; Pascagoula Harbor GDM (1992)
April 7-27, 2002		Contractor's pipeline dredge *George D. Williams II* removed sediment from Horn Island Pass (246+59.31 to 280+00 and 298+00 to 303+00) to attain project dimensions. Dredged material was placed in OW D/A # 10.		531,403	Mobile District O&M
Dec. 11 to 18, 2003 & Jan. 2 to 14, 2004		Contractor's (USACE) pipeline dredge *McFarland* removed sediment from the Pascagoula Bar sediment trap. Disposal Area was not provided on dredging history card.		325,392	Mobile District O&M
March 11 to April 2, 2004		Contractor's pipeline dredge *Meridian* removed sediment from Horn Island Pass (257+00 to 302+39.46). Dredged material was placed in OW D/A # 10 as beach nourishment.		715,548	Mobile District O&M

Navigation Channel History for Horn Island Pass: 1881 to 2009					
Date	Authority	Description	New Work (cy)	Maintenance (cy)	Source
September 17 to October 1, 2005		Contractor's pipeline dredge *Missouri H* removed sediment from Horn Island Pass (257+00 to 274+75) to attain project dimensions (44 feet deep by 550 feet wide). Dredged material placed in OW D/A # 10.		252,708	Mobile District O&M
October 9-21, 2005		Contractor's hopper dredge *Newport* removed sediment from the Horn Island Pass bar channel (305+00 to 340+00) to attain project dimensions. Dredged material was placed in Ocean D/A.		120,901	Mobile District O&M
October 13 to November 5, 2005		Contractor's pipeline dredge *Missouri H* removed sediment from the Horn Island Impoundment Area. Dredged material was placed in OW D/A # 10.		555,407	Mobile District O&M
April 27 to 30, 2007		Contractor's hopper dredge *Newport* removed sediment from Horn Island Pass (279+00 to 308+00). Dredged material was placed in the Littoral Zone.		77,141	Mobile District O&M
Sept. 2 to 10, 2007		Contractor's pipeline dredge *E.W. Ellefsen* removed sediment from Horn Island Pass (259+45 to 272+45). Dredged material was placed in OW D/A # 10.		355,543	Mobile District O&M
Sept. 5 to 6, 2008		Contractor's hopper dredge *Glenn Edwards* removed sediment from Horn Island Pass (257+00 to 287+00) as part of emergency dredging for Pascagoula. Dredged material was placed in the Pascagoula Open Water D/A.		45,437	Mobile District O&M
Sept. 7 to 10, 15 to 16, & 23 to Oct. 3, 2008		Contractor's hopper dredge *Glenn Edwards* removed 967,359 cy of sediment from Horn Island Pass and the bar channel (297+00 to 480+00) as part of emergency dredging for Pascagoula. Approximately 36% was removed from the area of littoral zone infilling. Dredged material was placed in Pascagoula Open Water D/A.		343,597	Mobile District O&M
Oct. 8 to 20, 2008		Contractor's hopper dredge *Newport* removed sediment from Horn Island Pass (257+00 to 387+00) as part of emergency dredging for Pascagoula. Dredged material was placed in the Littoral Zone.		232,929	Mobile District O&M

Navigation Channel History for Horn Island Pass: 1881 to 2009

Date	Authority	Description	New Work (cy)	Maintenance (cy)	Source
Oct. 21 to 23 and 26 to 27, 2008		Contractor's hopper dredge *Newport* removed sediment from Horn Island Pass and Pascagoula Bar Channel (300+00 to 322+00 and 360+00 to 414+00) as part of emergency dredging for Pascagoula. Dredged material was placed in the Littoral Zone.		73,202	Mobile District O&M
Sept. 19 to Nov. 7, 2009		Contractor's pipeline dredge *G.D. Morgan* removed sediment from Horn Island Pass (257+25 to 290+90). Dredged material was placed in OW D/A # 10.		959,539	Mobile District O&M
1897 to 2009		Total dredging in the Horn Island Pass Bar Channel	9,381,914	24,949,459	
1908 to 2009		Average Channel Infilling Rate (cy/yr)		245,000	

Appendix B: Channel Dredging History – Ship Island Pass (Gulfport Bar Channel)

Navigation Channel History for Ship Island Pass: 1841 to 2009

Date	Authority	Description	New Work (cy)	Maintenance (cy)	Source
Feb. 5, 1841		Report on ship channel at Ship Island, Gulf of Mexico. "The bar makes a regular curve, starting from the shore of Ship Island, near the western point, to its junction with the sand bank projecting from Cat Island. It is one mile distant from the western point of Ship Island, and is a narrow ridge of sand about seven hundred feet in breadth, enclosing a basin of water thirty and forty feet deep on the inner side, and shoaling rapidly to deep water seaward." "The bar and banks are formed of sand, hard and firm, but all the inside soundings are soft, the bottom being a blue marl."			H. Doc. 80, 29th Cong., 1st Sess.
April 26, 1842		Report of Lieutenant L.M. Powell, of the survey of the coast of the Gulf of Mexico, from Appalachicola to the mouth of the Mississippi, was referred to the Committee on Naval Affairs. "The bar of Ship Island pass was found to have barely 20 feet at ordinary low water over the best part of it; the western point of Ship Island, bearing north-northeast, will, on this course, carry a ship over in the deepest water. This bar has no dangers, so that a vessel of 17 or 18 feet draught may run in on any course, and find shelter on the north side of Ship Island, six or eight hundred yards from any part of it."			H. Doc. 220, 27th Cong., 2nd Sess.
March 3, 1881	River and Harbor Act	Examination of the outlet and harbor of Ship Island was conducted by Thomas L. Harrison, Assistant Engineer in the summer of 1881. “After careful examination of the various channels, I find nothing less than 23 to 24 feet over the bar, with 4 to 5 fathoms inside at mean low-water.” “After consultation with the pilots and several prominent citizens of Biloxi, I do not think there is anything at this pass, at present, requiring improvement.”			S. Ex. Doc. 131, 47th Cong., 1st Sess.; ARCE, 1882; p. 1321-1322
July 13, 1892	River and Harbor Act	Provided for an examination of Mississippi Sound outside the range of islands of the Mississippi coast, with a view of making an entrance for vessels. The main channel had a depth of 22 feet on the crest of the bar at mean low-water. The desired depth was 24 feet. A.N. Damrell (Major of Engineers) states “the depth can be obtained by dredging, and probably the channel thus obtained would maintain itself, as there seems to be a gradual deepening from natural causes.” “The bar is composed of coarse, compact sand and the distance between the 24-foot curve inside and out is very short.” “The harbor is, in my opinion, worthy of improvement for the reason that the commerce is large and the cost is small.”			ARCE, 1893; p. 1783

Navigation Channel History for Ship Island Pass: 1841 to 2009					
Date	Authority	Description	New Work (cy)	Maintenance (cy)	Source
June 3, 1896	River and Harbor Act	Provided for a preliminary examination of Ship Island Pass, Mississippi, “with a view of obtaining a channel twenty-six feet deep at low tide in said pass between the Gulf of Mexico and Ship Island Harbor, with a view of dredging a channel five hundred feet wide and twenty-five feet deep to connect Ship Island Harbor with the railroad pier at Gulfport.” Concluded that the channel was not worthy of improvement by the General Government.			H. Doc. 84, 54th Cong., 2nd Sess.; ARCE, 1897; p. 1708-1710
June 16, 1898	River and Harbor Act	A survey was ordered to “determine a plan and estimate for a channel 26 feet deep at mean low water through Ship Island Pass, Mississippi.” The proposed channel would require the removal of 160,000 cy of material at 25 cents per cubic yard, making the cost $40,000. "The bar seems to be composed of a comparatively stiff clay, and there seems to be a probability that the channel, if dredged, will be reasonably permanent." William T. Rossel, who conducted the survey Dec. 17, 1898, believed that it was advisable to do the work.			H. Doc. 120, 55th Cong., 3rd Sess.; ARCE, 1899; p. 1723
March 3, 1899	River and Harbor Act	“complete a channel through Ship Island Pass, with a depth of 26 feet, in accordance with the report and estimate printed in House Document No. 120, fifty-fifth Congress, third session, $40,000.” Proposal for dredging was advertised on April 25, 1899, and bids were opened on May 25, 1899. Contract was awarded to the National Dredging Company of Wilmington, DE, at 22.5 cents per cubic yard on June 12, 1899.			ARCE, 1899; p. 1723
November 23, 1899 to March 13, 1900		Work commenced on deepening and widening the channel at Ship Island Pass. Chiefly compact white sand, a little clay, and bluish sticky mud, was excavated from a channel 26 feet deep and 4,000 feet long across the outer bar at Ship Island Pass.	163,401		ARCE, 1900; p. 2217
Fiscal Year 1901		No dredging took place during the FY. A survey of the channel was made in May 1901 and showed that it had "shoaled slightly in one place to a depth of 25.6 feet, and had deepened in another."			ARCE, 1901; p. 375
Fiscal Year 1902		No dredging took place during the FY.			ARCE, 1902; p. 308
Fiscal Year 1903		No annual report submitted.			

Navigation Channel History for Ship Island Pass: 1841 to 2009					
Date	Authority	Description	New Work (cy)	Maintenance (cy)	Source
Fiscal Year 1904		No annual report submitted.			
Fiscal Year 1905		No annual report submitted.			
Fiscal Year 1906		No annual report submitted.			
Oct. 16, 1905 & June 27, 1906		A preliminary examination and a survey of Ship Island Pass was made in compliance with the River and Harbor Act of March 3, 1905, with the object being to determine accurately existing conditions of Ship Island Pass and to secure necessary data for an estimate of the cost of securing and maintaining a channel of the recommended depth of 26 feet. The channel dredged in 1899-1900 had since shoaled so that in some places the depth was less than 22 feet. It was estimated that a channel 300 feet wide and 26 feet deep would require the removal of 365,000 cy of material from a cut 10,600 feet long. The annual fill and cost of maintenance for the locality was not expected to exceed 20% per annum. "It is to be noted that the results of this survey are somewhat at variance with previous examinations of this locality..." "...the variation is believed to be probably due to error in the plane of mean low water used in connection with former examinations rather than to changed conditions." It was concluded that this improvement was worthy of being undertaken by the General Government.			H. Doc. 184, 59th Cong., 2nd Sess.
March 2, 1907	River and Harbor Act	Combined Ship Island Pass and Gulfport Harbor projects.			ARCE, 1907; p. 1392
Fiscal Year 1907		No dredging took place during the FY.			ARCE, 1907; p. 1392
Fiscal Year 1908		No dredging took place during the FY.			ARCE, 1908; p. 415
March 3, 1909	River and Harbor Act	Approved $10,000 for the maintenance work of dredging with the U.S. dredge *Charleston* in Ship Island Pass.			ARCE, 1909; p. 1432

Navigation Channel History for Ship Island Pass: 1841 to 2009

Date	Authority	Description	New Work (cy)	Maintenance (cy)	Source
Fiscal Year 1909		No dredging took place during the FY.			ARCE, 1909; p. 1432
October 11, 1909 to Jan. 24, 1910; April 21 to June 30, 1910		The U.S. dredge *Charleston* removed 398,079 cubic yards of sand from Ship Island Pass, all maintenance dredging. At the end of the FY there was an available draft of from 24 to 25 feet at MLW.		398,079	ARCE, 1910; p. 482, 1582-1583
Fiscal Year 1911		No dredging was completed during the fiscal year. The minimum low-water draft was 24 feet.			ARCE, 1911; p. 518, 1725
Fiscal Year 1912		No dredging was completed during the fiscal year. "The maximum draft that can be carried over the shoalest part of the improvement at Ship Island Pass is 23 feet mean low water."			ARCE, 1912; p. 638, 1945
Fiscal Year 1913		No dredging was completed during the fiscal year. "The maximum draft that can be carried over the shoalest part of the improvement at Ship Island Pass is 23 feet mean low water."			ARCE, 1913; p. 700, 2171
Nov. 7, 1913 to Feb. 6, 1914		The U.S dredge *Charleston* dredged Ship Island Pass and outer bar channel to maintain authorized dimensions. The work resulted in deepening of the channel to from 24.5 to 26 feet over its full project width of 300 feet. The dredged channel was about 1.9 miles long.		232,157	ARCE, 1914; p. 714, 2215
Fiscal Year 1915		No dredging was completed during the fiscal year. The Ship Island Pass channel had been completed. At the end of the FY, this channel had a depth of 23.5 feet.			ARCE, 1915; p. 786, 2557
Fiscal Year 1916		No dredging was completed during the fiscal year. On June 30, 1916, due to shoals, the controlling depth was 22.6 feet.			ARCE, 1916; p. 838, 2404
March 21 to May 18, 1917; March 21 to May 18, 1917		The U.S dredge *Charleston* dredged shoals from Ship Island Pass and outer bar channel to maintain authorized dimensions. On June 30, 1917, the controlling depth was 24.7 feet.		208,115	ARCE, 1917; p. 857, 2495

Navigation Channel History for Ship Island Pass: 1841 to 2009					
Date	Authority	Description	New Work (cy)	Maintenance (cy)	Source
July 1-6, 1917; March 2 to April 1, 1918		The U.S dredge *Charleston* dredged shoals from Ship Island Pass and outer bar channel to maintain authorized dimensions. On June 30, 1918, the controlling depth was 24.4 feet.		55,500	ARCE, 1918; p. 892, 2545
Fiscal Year 1919		No dredging was completed during the fiscal year. On June 30, 1919, the controlling depth was 24.4 feet.			ARCE, 1919; p. 939, 2631
Fiscal Year 1920		No dredging was completed during the fiscal year. On June 14, 1920, the controlling depth was 21.5 feet.			ARCE, 1920; p. 912, 2366
Fiscal Year 1921		No dredging was completed during the fiscal year. On May 23, 1921, the controlling depth was 21 feet.			ARCE, 1921; p. 911
Fiscal Year 1922		Maintenance dredging was conducted in Ship Island Pass Channel, securing a depth of 22 feet over the project width of 300 feet.		101,457	ARCE, 1922; p. 936-937
Fiscal Year 1923		No dredging was completed during the fiscal year. On June 5, 1923, the controlling depth was 22.5 feet.			ARCE, 1923; p. 813-814
Fiscal Year 1924		Maintenance dredging was conducted in Ship Island Pass Channel to an average depth of 23.5 feet over the project width of 300 feet.		303,010	ARCE, 1924; p. 808
Fiscal Year 1925		No dredging was completed during the fiscal year. In June 1925, the controlling depth was 24 feet.			ARCE, 1925; p. 791
September 10-23, 1925		The U.S. dredge *Benyaurd* was operated in the Ship Island Bar Channel to restore the project depth (26 feet) over the project width (300 feet) for the length of the channel.		194,271	ARCE, 1926; p. 798
Fiscal Year 1927		No dredging was completed during the fiscal year. In June 1927, the controlling depth was 25 feet.			ARCE, 1927; p. 824
January 21, 1927	River and Harbor Act	Authorized the Chief of Engineers to relocate the channel across Ship Island Bar "at such point as may be deemed most desirable in the interest of economy and navigation."			ARCE, 1927; p. 822

Navigation Channel History for Ship Island Pass: 1841 to 2009					
Date	Authority	Description	New Work (cy)	Maintenance (cy)	Source
January 31, 1927	Chief of Engineers	Preliminary report and survey of Gulfport Harbor was authorized by the River and Harbor Act approved March 3, 1925. Recommended modification of existing project to provide for a channel 27 feet deep and 300 feet wide across Ship Island Pass outer bar. Also under examination was the proposed relocated channel 5,000 feet west of the existing channel. The relocated channel would be shorter, straighter, and the tidal currents would flow more nearly parallel to the direction of the channel.			H. Doc. 692, 69th Cong., 2nd Sess.; ARCE, 1927; p. 823
Fiscal Year 1928		No dredging was completed during the fiscal year. In June 1928, the controlling depth was 25 feet.			ARCE, 1928; p. 858
Fiscal Year 1929		No dredging was completed during the fiscal year. In June 1929, the controlling depth was 24 feet.			ARCE, 1929; p. 859-860
July 3, 1930	River and Harbor Act	Authorized a channel 27 feet deep and 300 feet wide across Ship Island Pass Bar.			ARCE, 1930; p. 929
Fiscal Year 1930		No dredging was completed during the fiscal year. In June 1930, the controlling depth was 24 feet.			ARCE, 1930; p. 930
Fiscal Year 1931		The U.S. hopper dredge *Benyaurd* was operated in the Ship Island Pass Bar Channel to establish a project depth of 27 feet throughout the length of the 300-ft wide relocated channel (approx. 4,000 ft.). Existing channel was 26 feet deep and 300 feet wide, implying that approx. 44,000 cy of new work was required to attain a channel depth of 27 feet.	44,000	299,280	ARCE, 1931; p. 928
Fiscal Year 1932		No dredging was completed during the fiscal year. In June 1932, the controlling depth was 27 feet.			ARCE, 1932; p. 828
Fiscal Year 1933		No dredging was completed during the fiscal year. In June 1933, the controlling depth was 27 feet.			ARCE, 1933; p. 498

Navigation Channel History for Ship Island Pass: 1841 to 2009					
Date	Authority	Description	New Work (cy)	Maintenance (cy)	Source
Fiscal Year 1934		No dredging was completed during the fiscal year. In June 1934, the controlling depth was 27 feet.			ARCE, 1934; p. 583
Fiscal Year 1935		No dredging was completed during the fiscal year. In June 1935, the controlling depth was 27 feet.			ARCE, 1935; p. 676
Fiscal Year 1936		No dredging was completed during the fiscal year. In June 1936, the controlling depth was 27 feet.			ARCE, 1936; p. 666-667
Fiscal Year 1937		No dredging was completed during the fiscal year. In June 1937, the controlling depth was 27 feet.			ARCE, 1937; p. 706-707
Fiscal Year 1938		No dredging was completed during the fiscal year. In June 1938, the controlling depth was 27 feet.			ARCE, 1938; p. 747
Fiscal Year 1939		No dredging was completed during the fiscal year. In June 1939, the controlling depth was 27 feet.			ARCE, 1939; p. 823
Fiscal Year 1940		No dredging was completed during the fiscal year. At the end of the FY, the controlling depth was 27 feet.			ARCE, 1940; p. 818
Fiscal Year 1941		No dredging was completed during the fiscal year. At the end of the FY, the controlling depth was 27 feet.			ARCE, 1941; p. 781
Fiscal Year 1942		No dredging was completed during the fiscal year. At the end of the FY, the controlling depth was 27 feet.			ARCE, 1942; p. 691-692
Fiscal Year 1943		No dredging was completed during the fiscal year. At the end of the FY, the controlling depth was 27 feet.			ARCE, 1943; p. 626
Fiscal Year 1944		No dredging was completed during the fiscal year. At the end of the FY, the controlling depth was 27 feet.			ARCE, 1944; p. 611

Navigation Channel History for Ship Island Pass: 1841 to 2009					
Date	Authority	Description	New Work (cy)	Maintenance (cy)	Source
Fiscal Year 1945		No dredging was completed during the fiscal year. At the end of the FY, the controlling depth was 27 feet.			ARCE, 1945; p. 850-851
Fiscal Year 1946		No dredging was completed during the fiscal year.			ARCE, 1946; p. 917-918
September 15-28, 1946		The U.S. hopper dredge *San Pablo* dredged material from the Ship Island Pass Bar Channel to maintain authorized dimensions.		77,395	ARCE, 1947; p. 899
February 24 to March 13, 1948		The U.S. hopper dredge *Lyman* dredged material from the Ship Island Pass Bar Channel to maintain authorized dimensions. In April 1948, the controlling depth was 27 feet.		202,320	ARCE, 1948; p. 994-995
November 23, 1899 to March 13, 1948	Existing River and Harbor Acts	Total dredging completed prior to authorizing a 32-ft deep by 300-ft wide channel at the Pass.	207,401	2,071,584	
April 20, 1948		Report submitted on a review of the reports of Gulfport Harbor with a view to determining if it was advisable to modify the existing project in any way. The Board recommended a channel 32 feet deep and 300 feet wide across Ship Island Bar to deep water in the Gulf of Mexico. The estimated amount to be removed, including 2 feet overdepth, was 1,300,000 cy of material. Yearly maintenance was estimated to be 250,000 cy.			H. Doc. 112, 81st Cong., 1st Sess.
June 30, 1948	River and Harbor Act	Provides for a channel 32 feet deep, 300 feet wide, and about 8 miles long across Ship Island Pass Bar.			ARCE, 1948; p. 994
Fiscal Year 1949		No dredging was completed during the fiscal year. In May 1949, the controlling depth was 27 feet.			ARCE, 1949; p. 897
November 10 to December 31, 1949 and January 1-5, 1950		The U.S. hopper dredge *Gerig* removed 3,434,276 cubic yards of material from the Ship Island Pass Bar Channel at a cost of $154,603.	3,434,276		ARCE, 1950; p. 906

Navigation Channel History for Ship Island Pass: 1841 to 2009					
Date	Authority	Description	New Work (cy)	Maintenance (cy)	Source
April 2-29, 1950		The U.S. hopper dredge *Hyde* removed 244,768 cubic yards of material from the Ship Island Pass Bar Channel at a cost of $56,645. The project authorized in 1948 was completed to a depth of 32 feet.	244,768		ARCE, 1950; p. 906
Fiscal Year 1951		No dredging was completed during the fiscal year. In May 1951, the controlling depth was 32 feet.			ARCE, 1951; p. 737
April 30 to May 15, 1952		The U.S. hopper dredge *Gerig* removed material from the Ship Island Pass Bar Channel to maintain authorized project dimensions.		669,411	ARCE, 1952; p. 693
Fiscal Year 1953		No dredging was completed during the fiscal year.			ARCE, 1953; p. 648
August 4-26, 1953		The U.S. hopper dredge *Langfitt* removed material from the Ship Island Pass Bar Channel to maintain authorized project dimensions.		748,962	ARCE, 1954; p. 445
Fiscal Year 1955		No dredging was completed during the fiscal year.			ARCE, 1955; p. 439-440
Fiscal Year 1956		No dredging was completed during the fiscal year. In July 1955, the controlling depth was 31 feet.			ARCE, 1956; p. 565-566
Fiscal Year 1957		No dredging was completed during the fiscal year. In June 1957, the controlling depth was 31 feet.			ARCE, 1957; p. 562
Fiscal Year 1958		No dredging was completed during the fiscal year. In Jan. 1958, the controlling depth was 31 feet.			ARCE, 1958; p. 513-514
Fiscal Year 1959		No dredging was completed during the fiscal year.			ARCE, 1959; p. 535
Fiscal Year 1960		No dredging was completed during the fiscal year. In May 1958, the controlling depth was 26 feet.			ARCE, 1960; p. 522-523

Navigation Channel History for Ship Island Pass: 1841 to 2009					
Date	Authority	Description	New Work (cy)	Maintenance (cy)	Source
Fiscal Year 1961		No dredging was completed during the fiscal year. In Feb. 1961, the controlling depth was 26.5 feet.			ARCE, 1961; p. 575-576
August 20-26, 1961		The U.S. hopper dredge *Langfitt* agitated 1,046,246 cubic yards of material in the Ship Island Pass Bar Channel. In April 1962, the controlling depth was 28 feet.			ARCE, 1962; p. 586-587
Fiscal Year 1964		No dredging was completed during the fiscal year. In March 1964, the controlling depth was 31.5 feet.			ARCE, 1964; p. 466
Fiscal Year 1965		No dredging was completed during the fiscal year. In June 1965, the controlling depth was 29 feet.			ARCE, 1965; p. 458
December 12-30, 1965		The U.S. hopper dredge *Langfitt* removed material from the Ship Island Pass Bar Channel to maintain authorized project dimensions. In Jan. 1966, the controlling depth was 32 feet.		734,955	ARCE, 1966; p. 495-496
October 20-31, 1966		Contractor's pipeline dredge *Orleans* removed sediment from the Ship Island Pass Bar Channel to maintain project dimensions (32 feet deep by 300 feet wide). In April 1967, the controlling depth was 29.5 feet.		519,905	ARCE, 1967; p. 486; Mobile District O&M
February 1-11, 1968		Contractor's pipeline dredge *Orleans* removed sediment from the Ship Island Pass Bar Channel to maintain project dimensions.		482,604	Mobile District O&M and ARCE, 1968; p. 372
December 8-18, 1968		The U.S. hopper dredge *Langfitt* removed sediment from the Ship Island Pass Bar Channel to maintain authorized project dimensions.		430,835	ARCE, 1969; p. 355
July 9-28, 1970		Contractor's pipeline dredge *Port Arthur* removed sediment from Ship Island Point to maintain project dimensions (32 feet deep by 300 feet wide). Dredged material was placed in open water disposal area.		521,009	ARCE, 1971; p. 10-10; Mobile District O&M

Navigation Channel History for Ship Island Pass: 1841 to 2009

Date	Authority	Description	New Work (cy)	Maintenance (cy)	Source
December 22, 1970 to January 15, 1971		The U.S. hopper dredge *Gerig* removed sediment from the Ship Island Pass Bar Channel to maintain authorized project dimensions.		370,089	ARCE, 1971; p. 10-10
June 2-14, 1972		The U.S. hopper dredge *McFarland* removed sediment from the Ship Island Pass Bar Channel to maintain authorized project dimensions.		232,503	ARCE, 1972; p. 10-10
Fiscal Year 1973		No dredging was completed during the fiscal year.			ARCE, 1973; p. 10-10
March 1-22, 1974		Contractor's pipeline dredge *Orleans* removed sand and silt from the Ship Island Pass Bar Channel (Ship Island Point) to maintain project dimensions. Dredged material was placed at Fort Massachusetts as beach nourishment.		546,210	ARCE, 1974; p. 10-9 and Mobile District O&M
February 16 to March 15, 1975		The U.S. hopper dredge *Davison* removed sediment from the Ship Island Pass Bar Channel to maintain authorized project dimensions. Dredged material was placed in open water disposal area.		164,960	ARCE, 1975; p. 10-9; Mobile District O&M
July 1-31, 1975		The U.S. hopper dredge *Hyde* removed sediment from the Ship Island Pass Bar Channel to maintain authorized project dimensions. Dredged material was placed in open water disposal area.		251,321	ARCE, 1976; p. 10-9; Mobile District O&M
August 18 to September 28, 1977		The U.S. hopper dredge *Langfitt* removed sediment (2,892,761 cy gross) from the Ship Island Pass bar channel (32+00S to 452+50S; 38,800 feet). Approximately 35% (32+00S to 176+50S; 13,550 feet) was removed from the littoral zone infilling area. All dredged material was placed in EPA East and West D/As.		1,012,466	Mobile District O&M
Fiscal Year 1978		Annual report makes reference to hopper dredging at a cost of $32,814, but no dredged quantity is provided.			ARCE, 1978; p. 10-11

Navigation Channel History for Ship Island Pass: 1841 to 2009					
Date	Authority	Description	New Work (cy)	Maintenance (cy)	Source
September 15 to October 5, 1979		The U.S. hopper dredge *Langfitt* removed sediment from the Ship Island Pass Bar Channel to maintain authorized project dimensions. Dredged material was placed in open water disposal area.		540,996	ARCE, 1979; p. 10-11; Mobile District O&M
January 16 to April 12, 1980		Contractor's pipeline dredge Deisel removed 67,386 cy of sand from Ship Island Pass - Ship Island Point and 87,212 cy from the sand borrow area. Sand was placed at Fort Massachusetts as beach nourishment.		154,598	ARCE, 1980; p. 10-10; Mobile District O&M
August 16 to October 17, 1982		Contractor's pipeline dredge *Louisiana* removed sediment from Ship Island Pass Bar Channel (stations 77+80 to 96+80; 137+90 to 152+90) to attain project dimensions. Dredged material was placed in open water disposal area.		361,809	Mobile District O&M
October 17 to December 14, 1983		Contractor's pipeline dredge *Fritz Jahncke* removed sediment from Ship Island Point (80+80 to 793+80) and placed at Fort Massachusetts as beach nourishment.		211,683	Mobile District O&M
September 22 to October 15, 1985		Contractor's hopper dredge *Manhattan Island* removed sediment from Ship Island Pass Bar Channel (79+00 to 167+50) to attain project dimensions. Dredged material was placed in open water disposal area.		885,539	Mobile District O&M
August 15, 1985	Supplemental Appropriations Act	Modify the existing Ship Channel to 36 x 300 feet in Mississippi Sound and 38 x 400 feet across the outer bar, with changes in the channel alignment and the entrance to the anchorage basin for safe and unrestricted navigation; in accordance with the 1976 Draft Environmental Impact Statement.			ARCE, 1985; Table 10-B; FEIS, 1989
September 26 to December 15, 1986		Contractor's pipeline dredge *Louisiana* removed sediment from Ship Island Pass Bar Channel (5+00N to 100+00S) to attain project dimensions. Dredged material was placed in open water disposal area.		423,467	Mobile District O&M
April 23 to May 18, 1987		Contractor's hopper dredge *Manhattan Island* removed sediment from Ship Island Pass Bar Channel (0+00 to 150+00) to attain project dimensions. Dredged material was placed in open water disposal area.		728,483	Mobile District O&M

Navigation Channel History for Ship Island Pass: 1841 to 2009

Date	Authority	Description	New Work (cy)	Maintenance (cy)	Source
July 4 to September 23, 1988		Contractor's pipeline dredge *Louisiana* removed sediment from Ship Island Pass Bar Channel (0+00 to 88+085) to attain project dimensions. Dredged material was placed in open water disposal area.		492,709	Mobile District O&M
June 1989		Final Environmental Impact Statement on Gulfport Harbor. The final recommended plan for the improvement of the Gulfport Harbor navigation channel included deepening the Ship Island Pass Bar Channel and the Gulf Channel to 38 feet at the existing width of 300 feet and realignment of the Ship Island Pass Bar Channel approximately 1900 feet to the west along alignment "A".			FEIS, 1989
October 25 to November 22, 1989		Contractor's hopper dredge *Manhattan Island* removed sediment from Ship Island Pass Bar Channel (93+08 to 178+00) to attain project dimensions. Dredged material was placed in open water disposal area.		167,584	Mobile District O&M
September 17-19, 1991		Contractor's pipeline dredge *Tom James* removed sediment from the Ship Island Impoundment Area (76+08 to 88+08). Dredged material was used for beach nourishment at Fort Massachusetts.		58,472	Mobile District O&M
November 23, 1899 to September 19, 1991	Existing River and Harbor Acts	Total dredging completed prior to authorizing a 38-ft deep by 400-ft wide channel at the Pass.	3,886,445	12,782,154	
May 10 to September 10, 1992		Contractor's pipeline dredge *Tom James* removed sediment from the Ship Island Pass channel (stations 415+00 - 700+00) as part of the Gulfport Harbor deepening project . Sand was placed in the littoral zone.	4,619,205		Mobile District O&M
October 1 to November 29, 1993		Contractor's pipeline dredge *Tom James* removed sediment from the Ship Island Pass channel (stations 520+00 - 652+90) as part of the Gulfport Harbor deepening project. Total new work for FY93 was 1,688,040 cy; however, total project new work paid for FY92 and FY93 was 5,943,023 cy. As such, 364,222 cy of work completed in FY93 was maintenance. Sand was placed in the littoral zone.	1,323,818	364,222	Mobile District O&M

Navigation Channel History for Ship Island Pass: 1841 to 2009					
Date	Authority	Description	New Work (cy)	Maintenance (cy)	Source
May 1-5, 1996		Contractor's pipeline dredge *Meridian* removed sediment from the Ship Island Impoundment Area (80+00 to 83+00). Sand was placed at Fort Massachusetts as beach nourishment.		56,453	Mobile District O&M
August 9-27, 1996		Contractor's hopper dredge *Padre Island* removed 623,254 cy of sediment from the Ship Island Pass Bar Channel and the Gulf Channel (580+00 to 935+00) to maintain funded project dimensions (38 feet deep by 300 feet wide). Approximately 1/3 of the sediment was removed from the area of littoral infilling. Dredged material was placed in EPA West D/A.		208,000	Mobile District O&M
October 2-18, 1997		Contractor's hopper dredge *Eagle 1* removed sediment from Ship Island Pass Bar Channel (615+00 to 645+00) to maintain funded project dimensions (38 feet deep by 300 feet wide). Dredged material was placed in the EPA West D/A.		107,860	Mobile District O&M
June 19 to July 15, 1998		Contractor's hopper dredge *Atchafalaya* removed sediment from Ship Island Pass Bar Channel (575+00 to 700+00) for emergency dredging purposes. Sand was placed in the littoral zone.		307,860	Mobile District O&M
April 28 to May 7, 2002		Contractor's pipeline dredge *George Williams II* removed sediment from the Ship Island Pass borrow area (0+08 to 1+45) for beach nourishment at Fort Massachusetts.		111,357	Mobile District O&M
December 1, 2002 to January 5, 2003		Contractor's hopper dredge *Manhattan Island* removed 1,074,290 cy of sediment from Ship Island Pass Bar Channel and the Gulf Channel for emergency maintenance dredging. Approximately 20% was removed from the area of littoral infilling (595+00 to 675+00). Dredged material was placed in EPA West D/A.		214,860	Mobile District O&M
November 25 to December 19, 2004		Contractor's hopper dredge *Bayport* removed 1,391,032 cy of sediment as part of emergency dredging from the Gulfport Bar Channel (595+00 to 965+00), including a portion of the Ship Island Pass bar channel . Approximately 28% was removed from the area of littoral zone infilling (595+00 to 697+00). Dredged material was placed in the EPA West disposal area.		389,489	Mobile District O&M
November 4 to December 13, 2005		The U.S. hopper dredge *McFarland* removed 390,000 cy of sediment from Ship Island Pass Bar Channel and the Gulf Channel. Approximately 65% was removed from the area of littoral zone infilling (610+00 to 697+00).		253,500	Mobile District O&M

Navigation Channel History for Ship Island Pass: 1841 to 2009					
Date	Authority	Description	New Work (cy)	Maintenance (cy)	Source
June 1 to 8, 2007		Contractor's hopper dredge *Newport* removed sediment from Ship Island Pass Bar Channel (612+36 to 670+00). Dredged material was placed in the Littoral Zone.		200,828	Mobile District O&M
May 31 to June 16, 2009		Contractor's pipeline dredge *G.D. Morgan* removed sediment from Ship Island Pass Bar Channel (633+65 to 685+35). Dredged material was placed in the Littoral Zone.		494,537	Mobile District O&M
1900 to 2009		Total dredging in the Ship Island Pass Bar Channel	9,829,468	15,491,120	
1900 to 2009		Average Channel Infilling Rate (cy/yr)		141,800	

Appendix C: Incremental and Cumulative Shoreline Change for the Mississippi Sound Barrier Islands

Dauphin Island, Alabama: 1847 to 2010

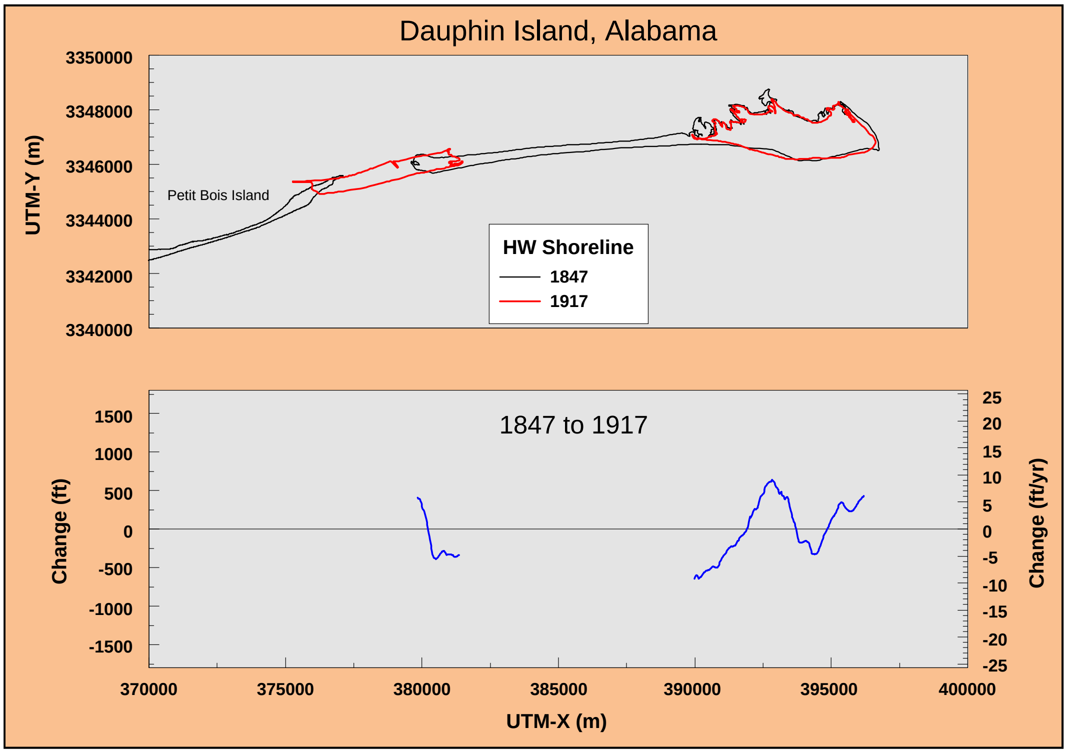


Figure C1. Change in historical shoreline position, Dauphin Island, AL, 1847 to 1917.

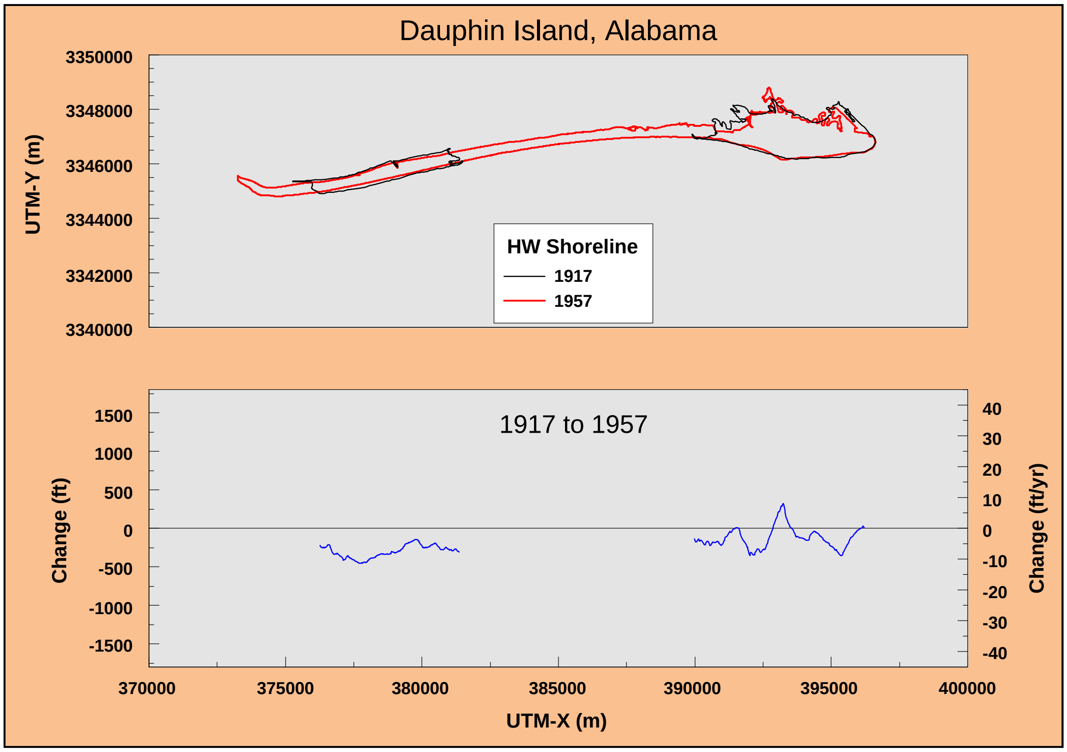


Figure C2. Change in historical shoreline position, Dauphin Island, AL, 1917 to 1957.

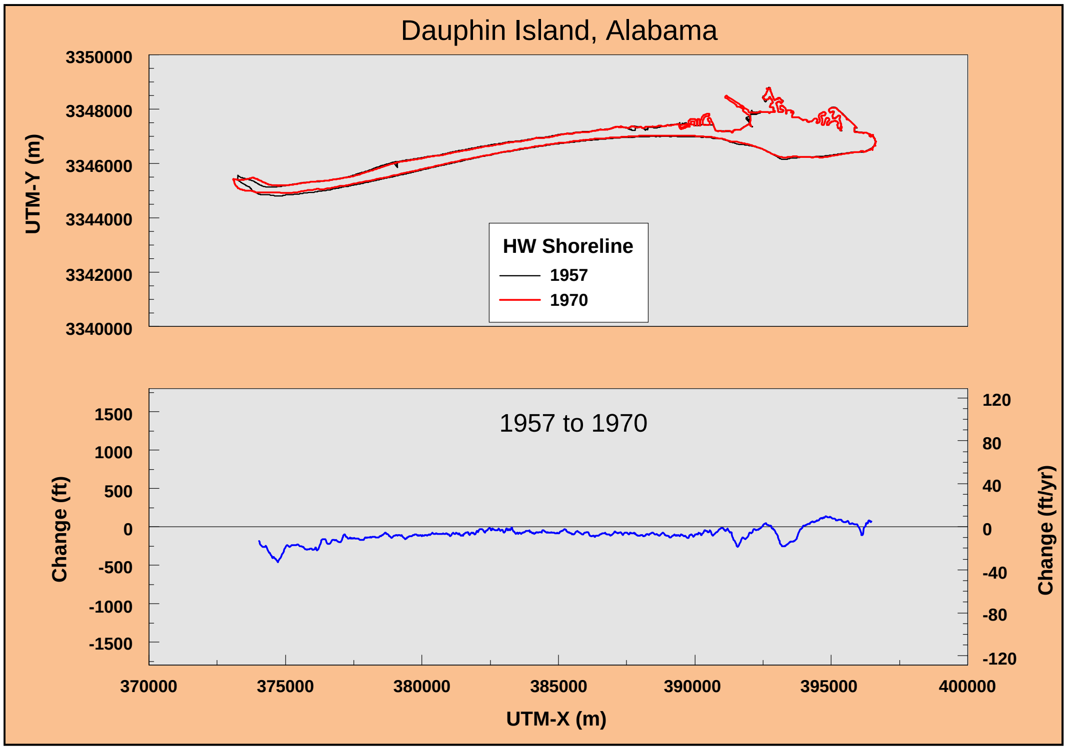


Figure C3. Change in historical shoreline position, Dauphin Island, AL, 1957 to 1970.

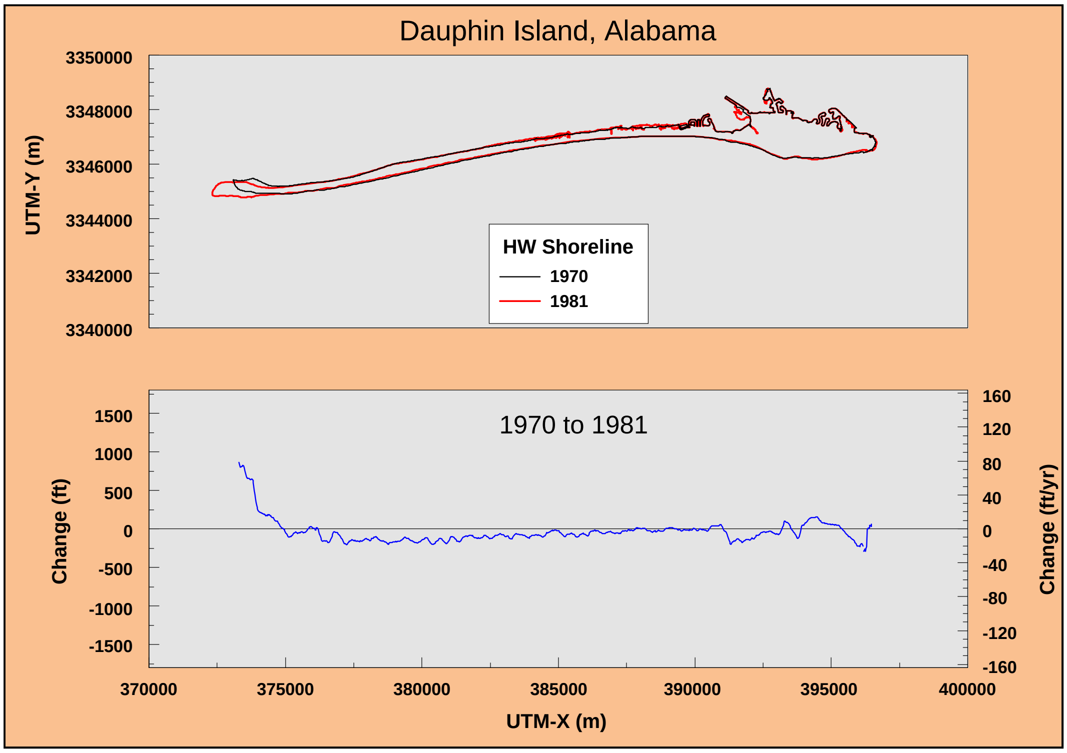


Figure C4. Change in historical shoreline position, Dauphin Island, AL, 1970 to 1981.

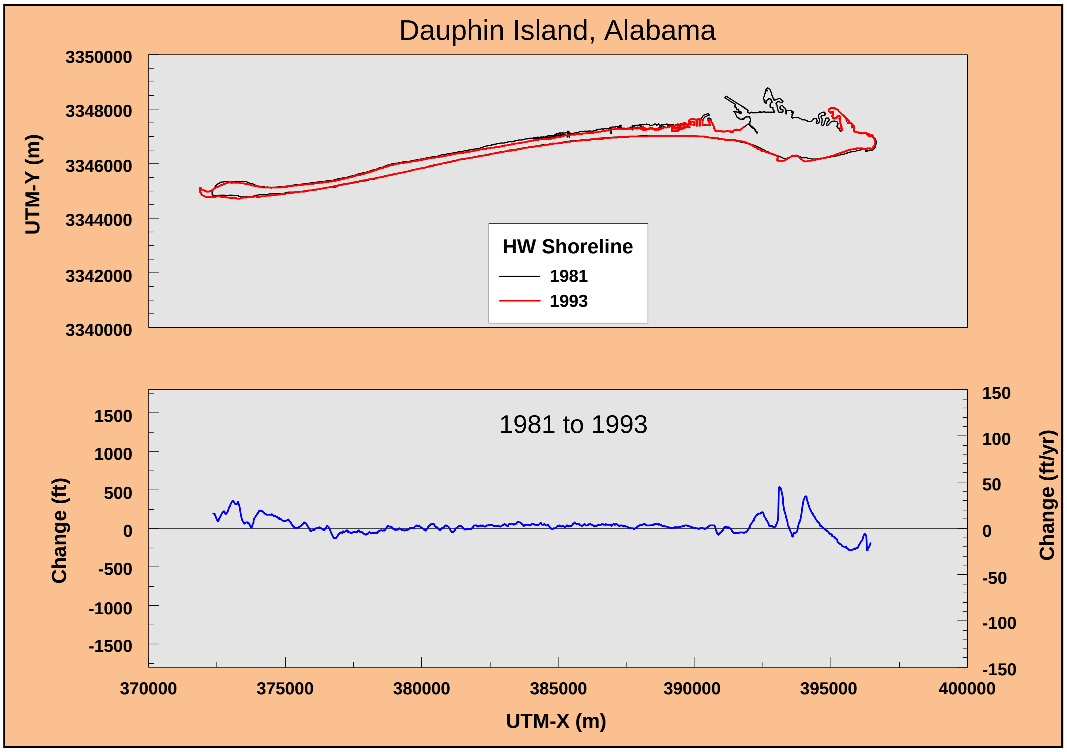


Figure C5. Change in historical shoreline position, Dauphin Island, AL, 1981 to 1993.

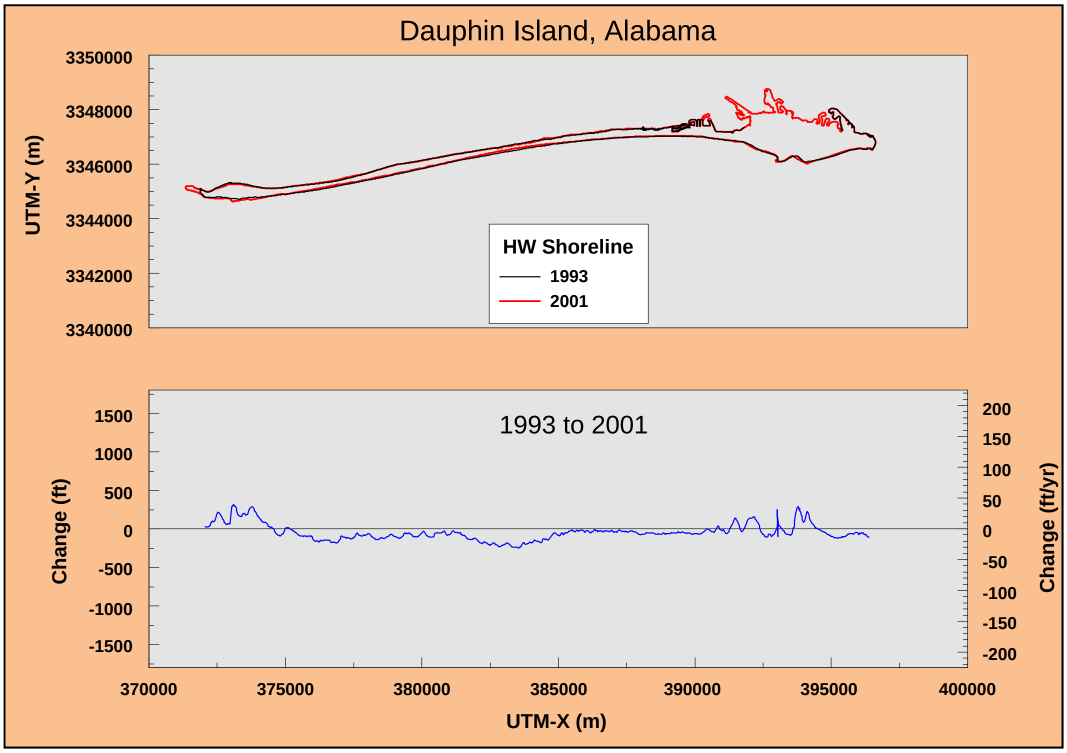


Figure C6. Change in historical shoreline position, Dauphin Island, AL, 1993 to 2001.

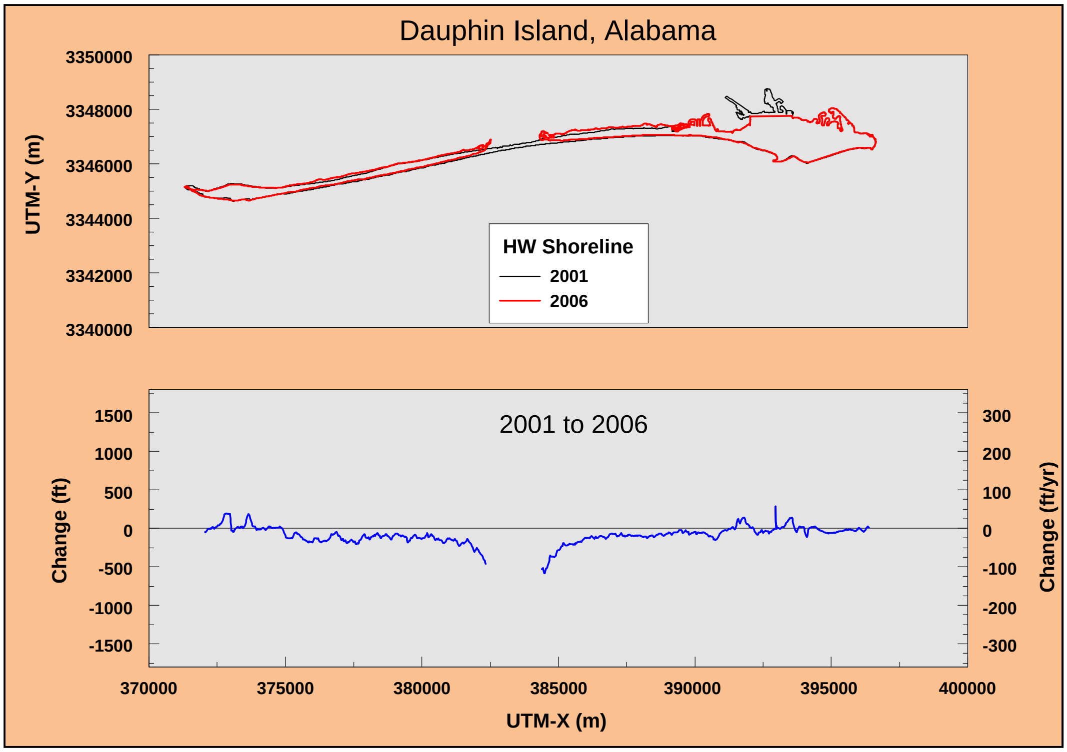


Figure C7. Change in historical shoreline position, Dauphin Island, AL, 2001 to 2006.

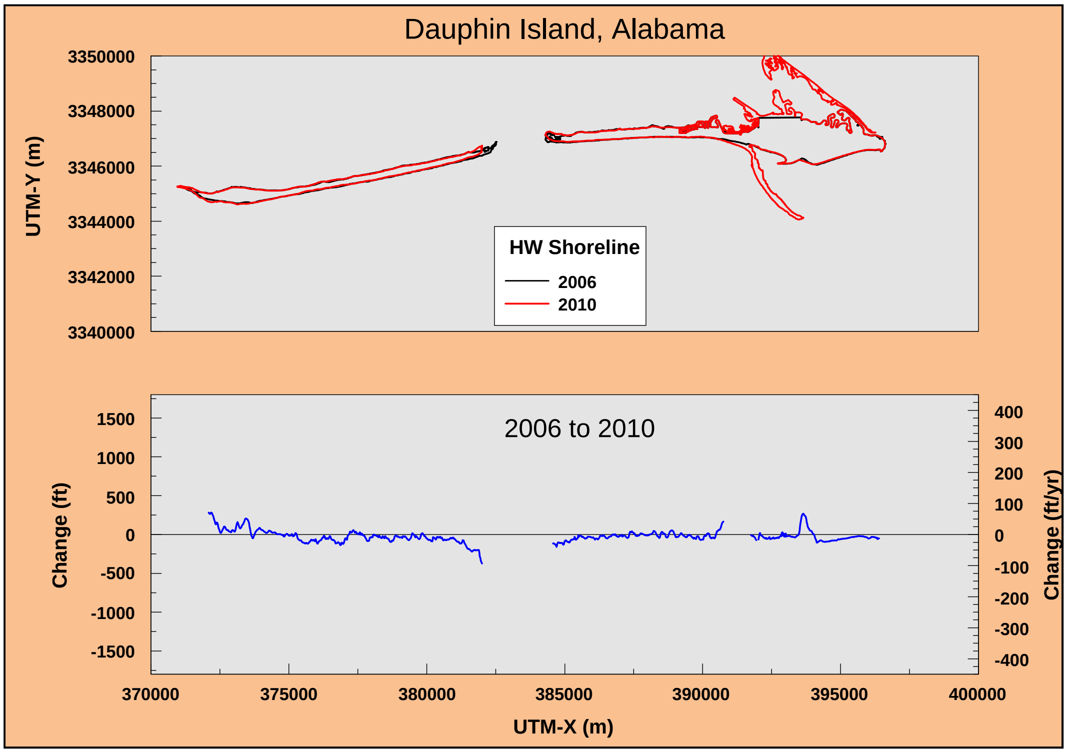


Figure C8. Change in historical shoreline position, Dauphin Island, AL, 2006 to 2010.

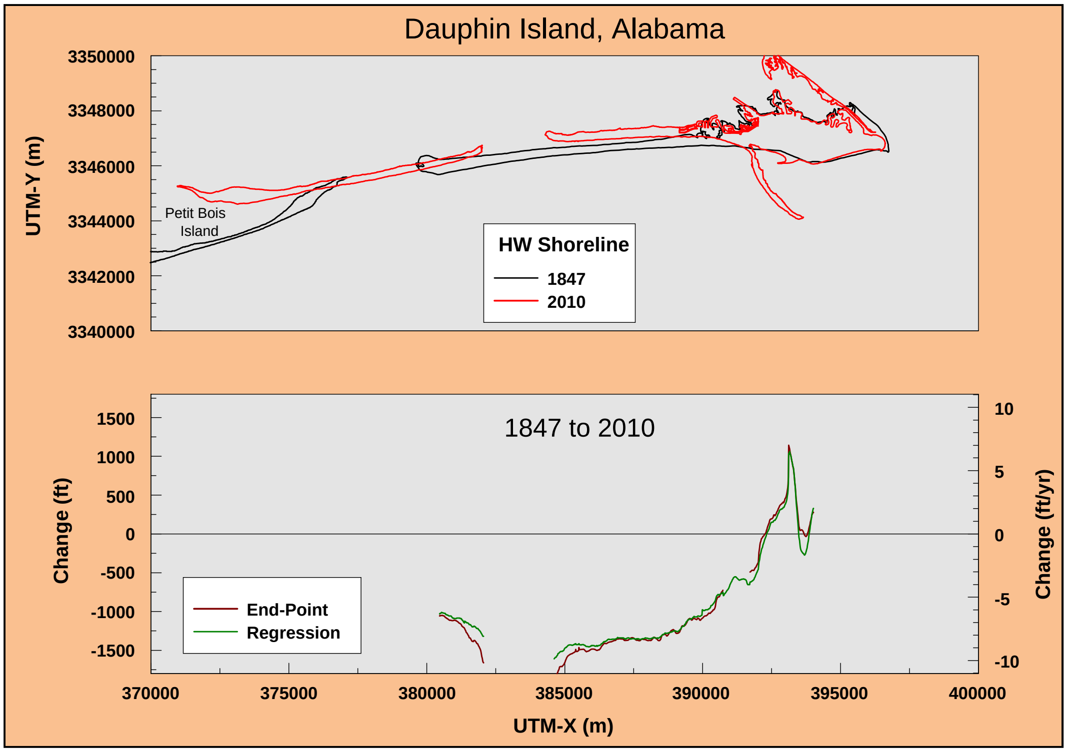


Figure C9. Change in historical shoreline position, Dauphin Island, AL, 1847 to 2010.

Petit Bois Island, Mississippi: 1848 to 2010

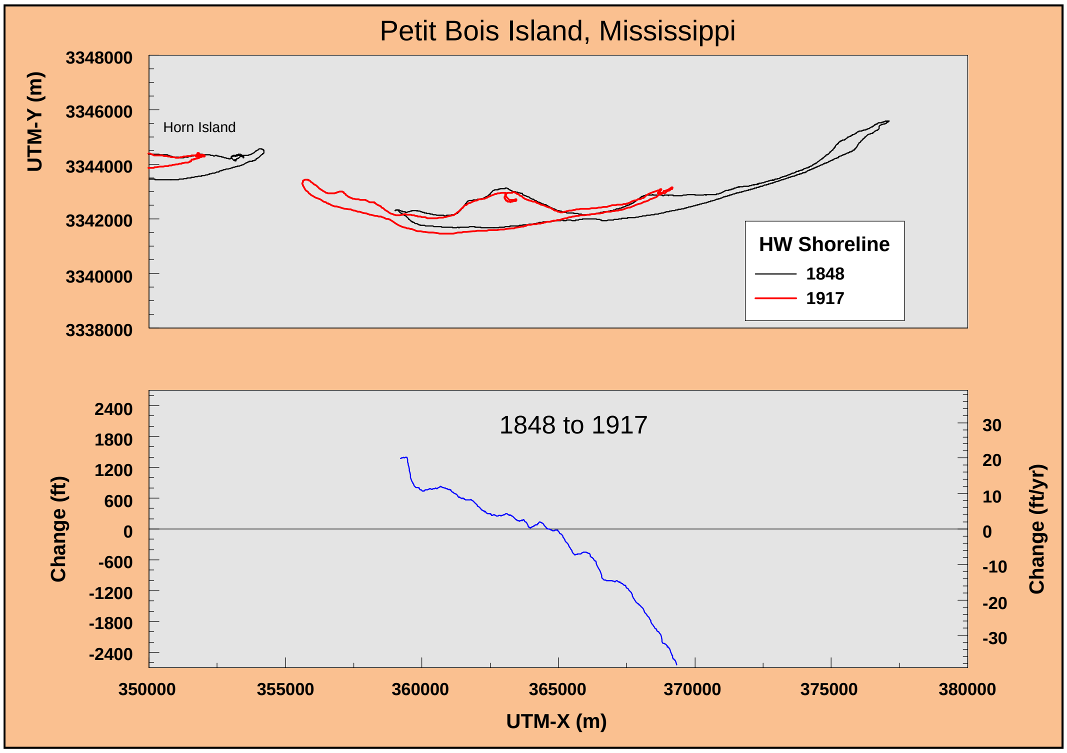


Figure C10. Change in historical shoreline position, Petit Bois Island, MS, 1848 to 1917.

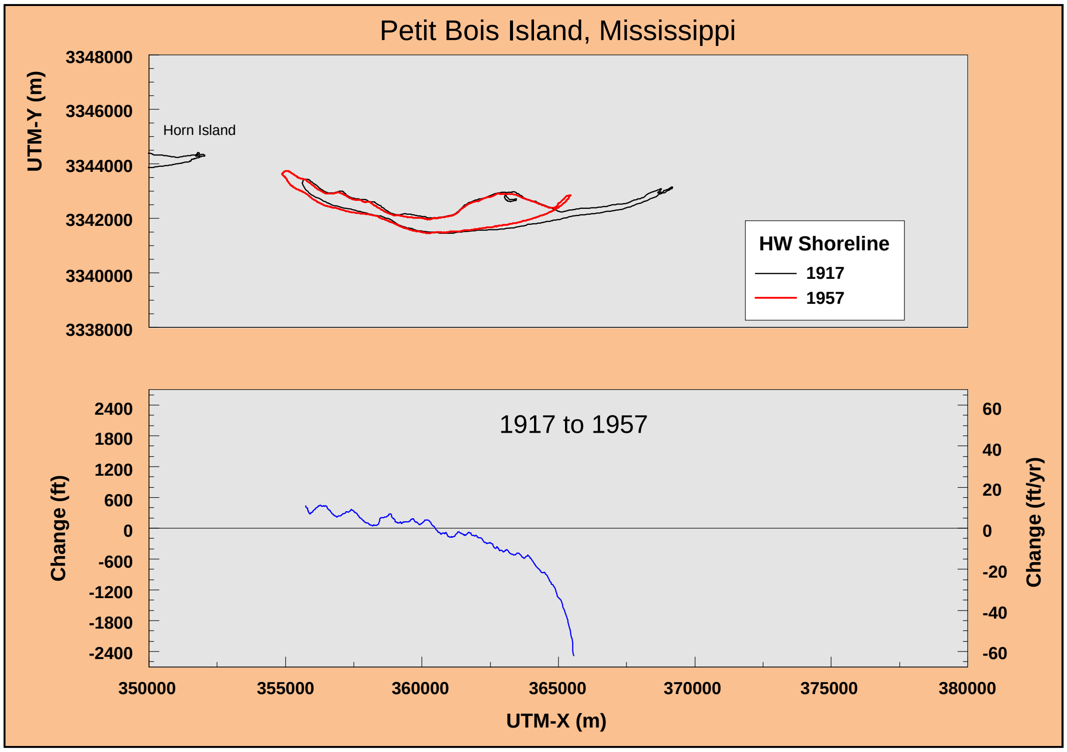


Figure C11. Change in historical shoreline position, Petit Bois Island, MS, 1917 to 1957.

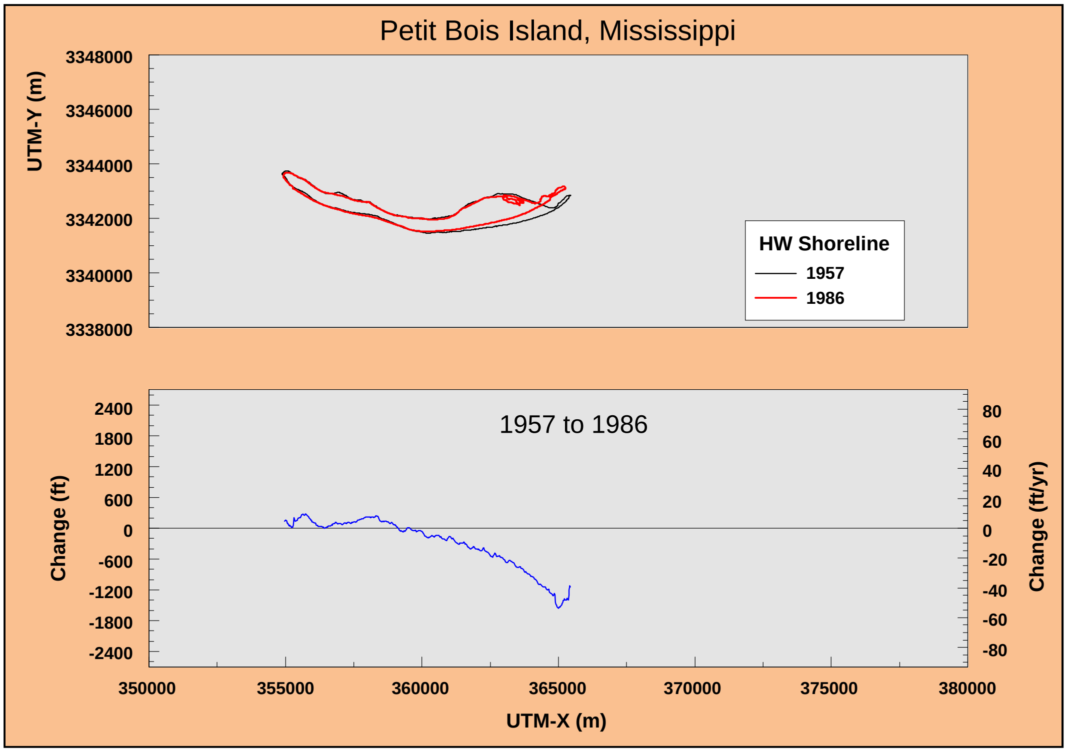


Figure C12. Change in historical shoreline position, Petit Bois Island, MS, 1957 to 1986.

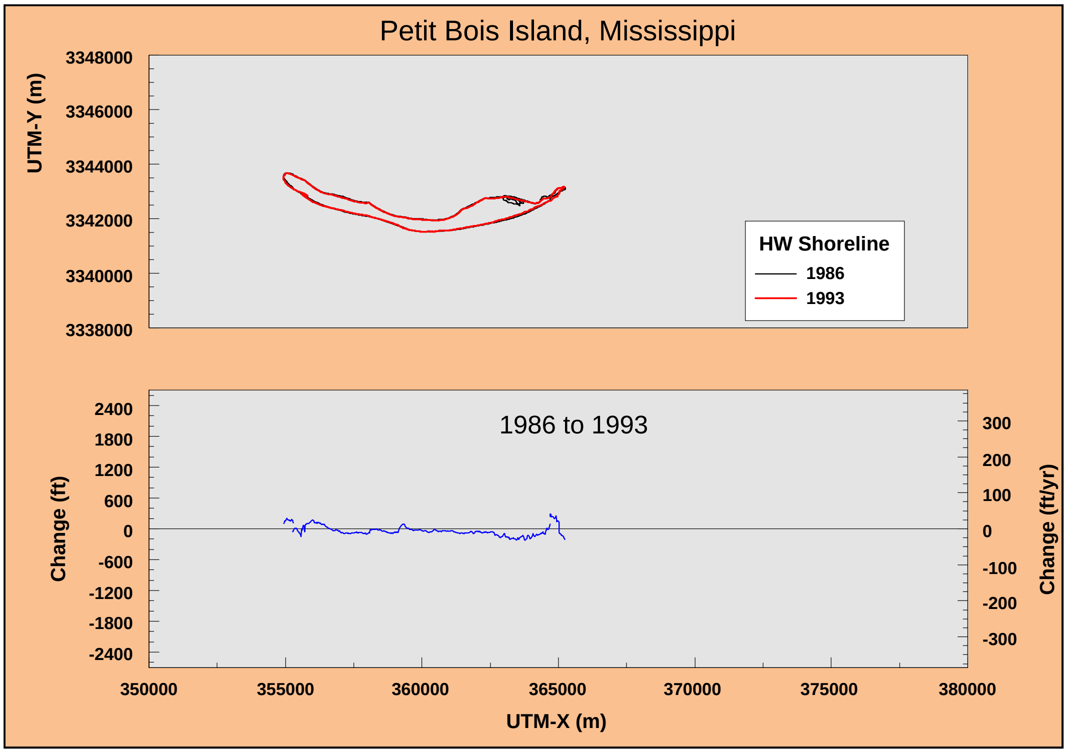


Figure C13. Change in historical shoreline position, Petit Bois Island, MS, 1986 to 1993.

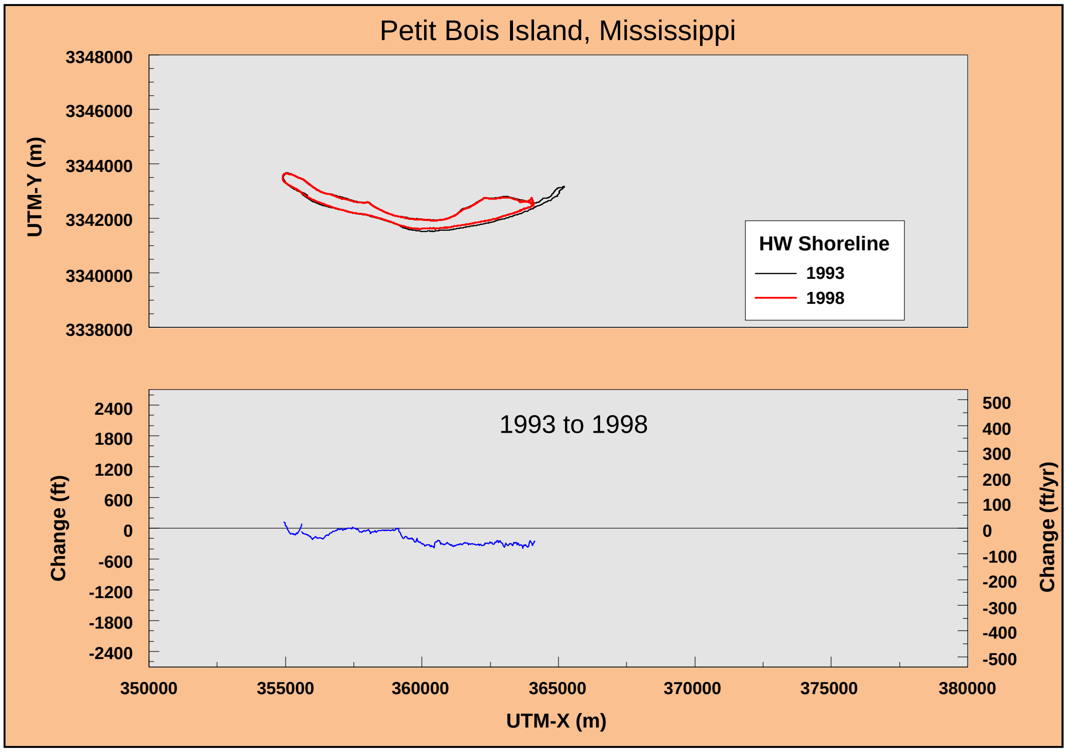


Figure C14. Change in historical shoreline position, Petit Bois Island, MS, 1993 to 1998.

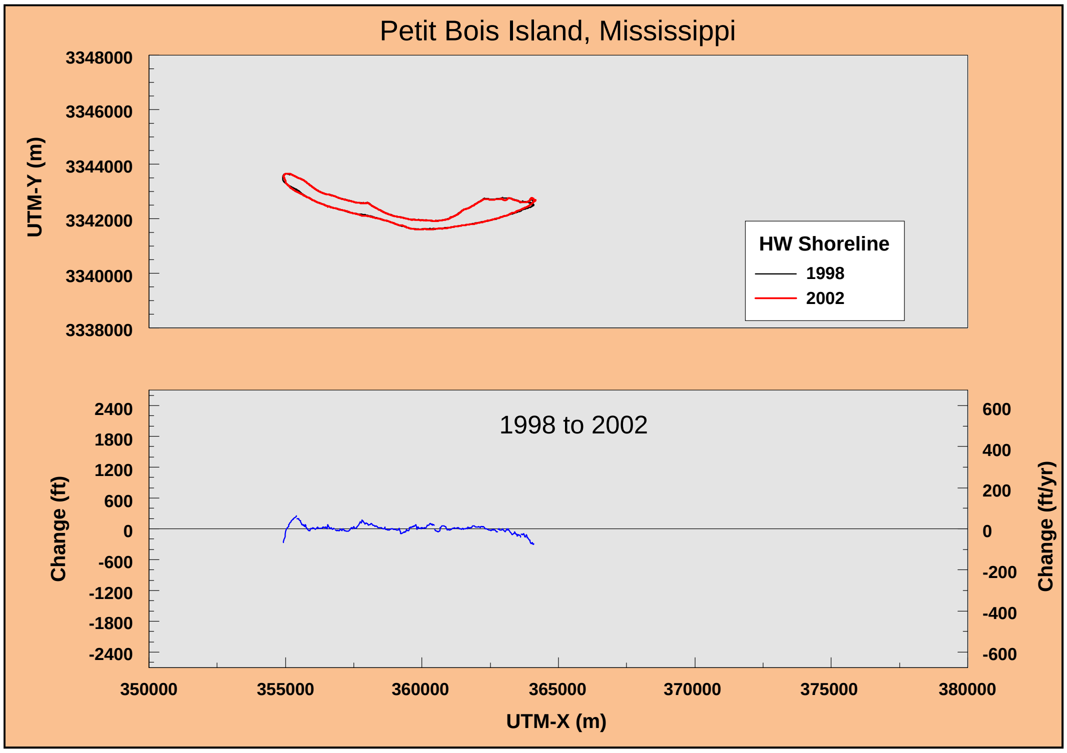


Figure C15. Change in historical shoreline position, Petit Bois Island, MS, 1998 to 2002.

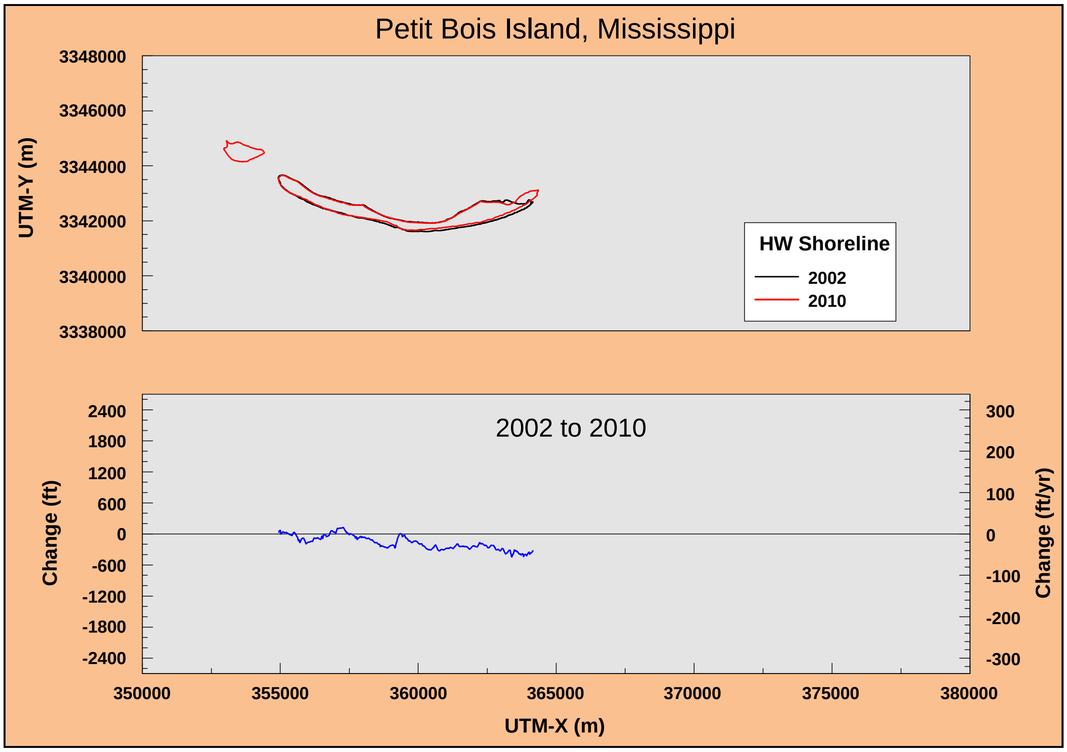


Figure C16. Change in historical shoreline position, Petit Bois Island, MS, 2002 to 2010.

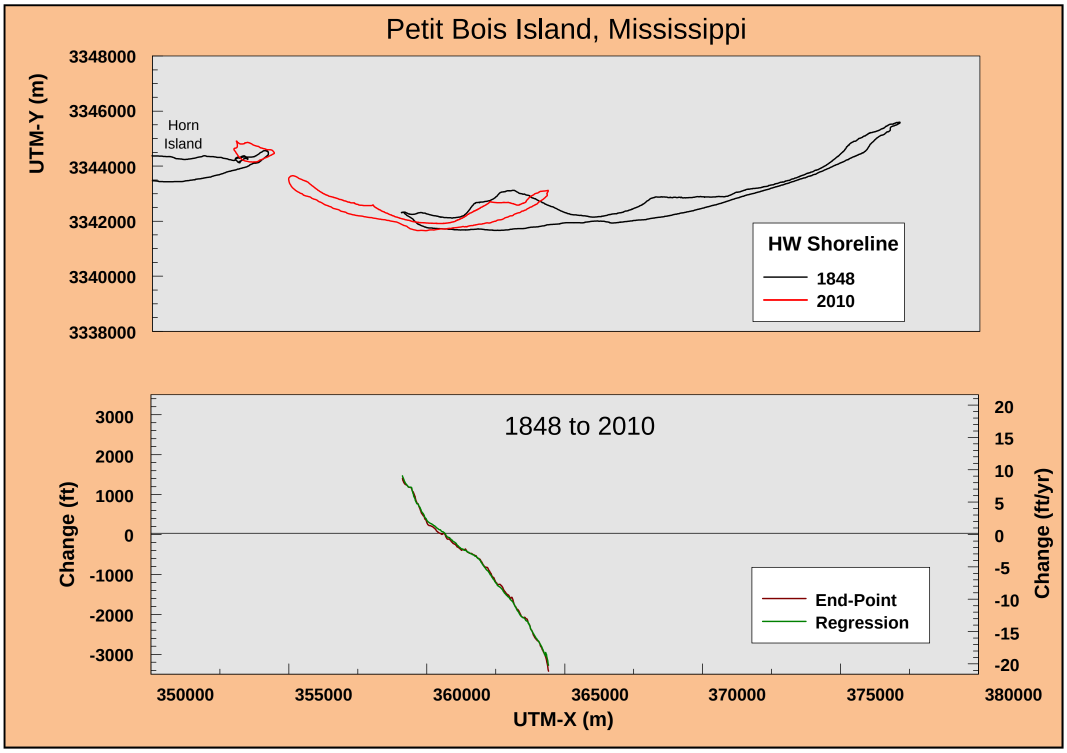


Figure C17. Change in historical shoreline position, Petit Bois Island, MS, 1848 to 2010.

Horn Island, Mississippi: 1849 to 2010

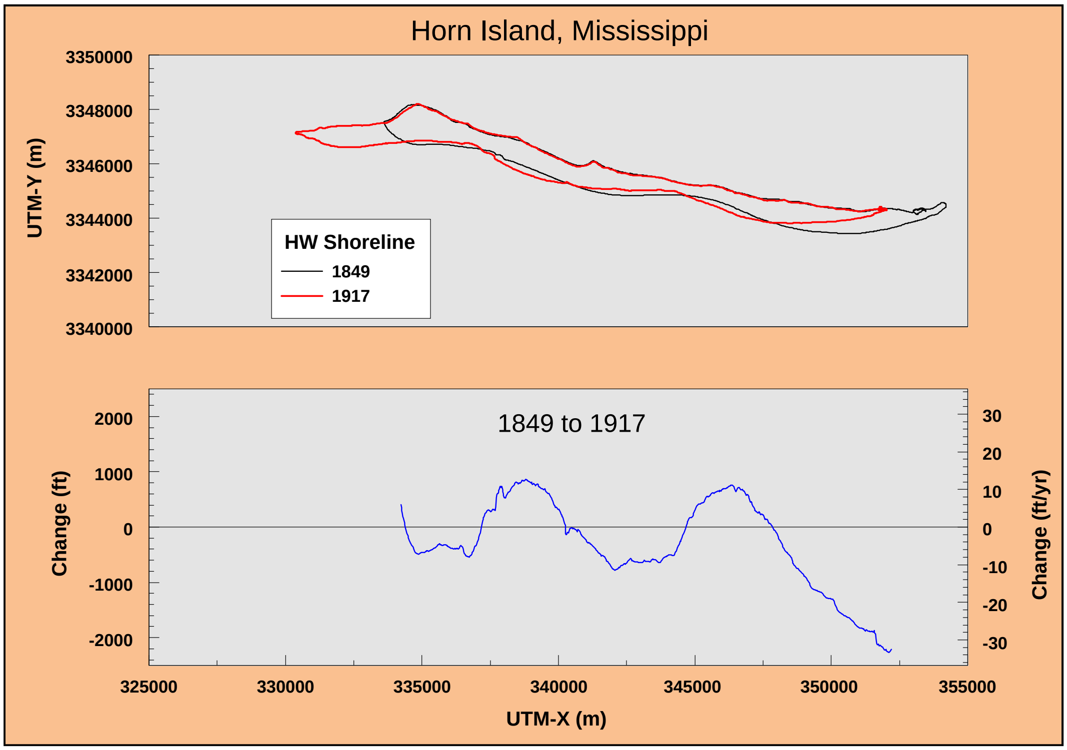


Figure C18. Change in historical shoreline position, Horn Island, MS, 1849 to 1917.

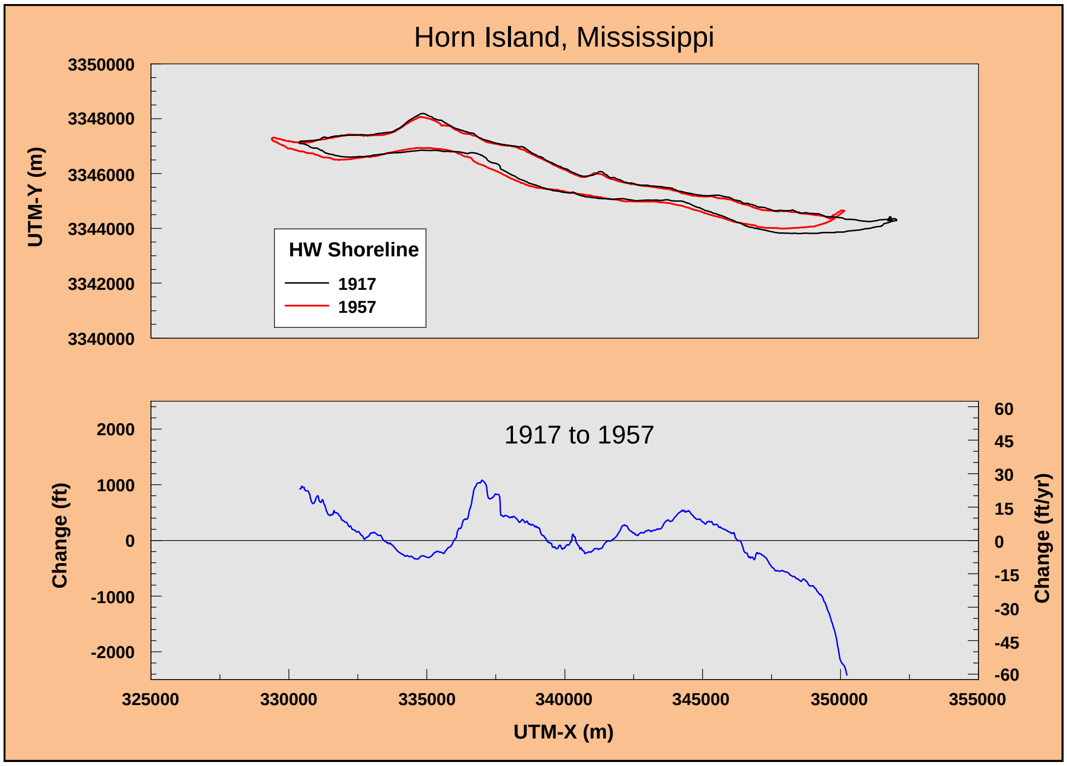


Figure C19. Change in historical shoreline position, Horn Island, MS, 1917 to 1957.

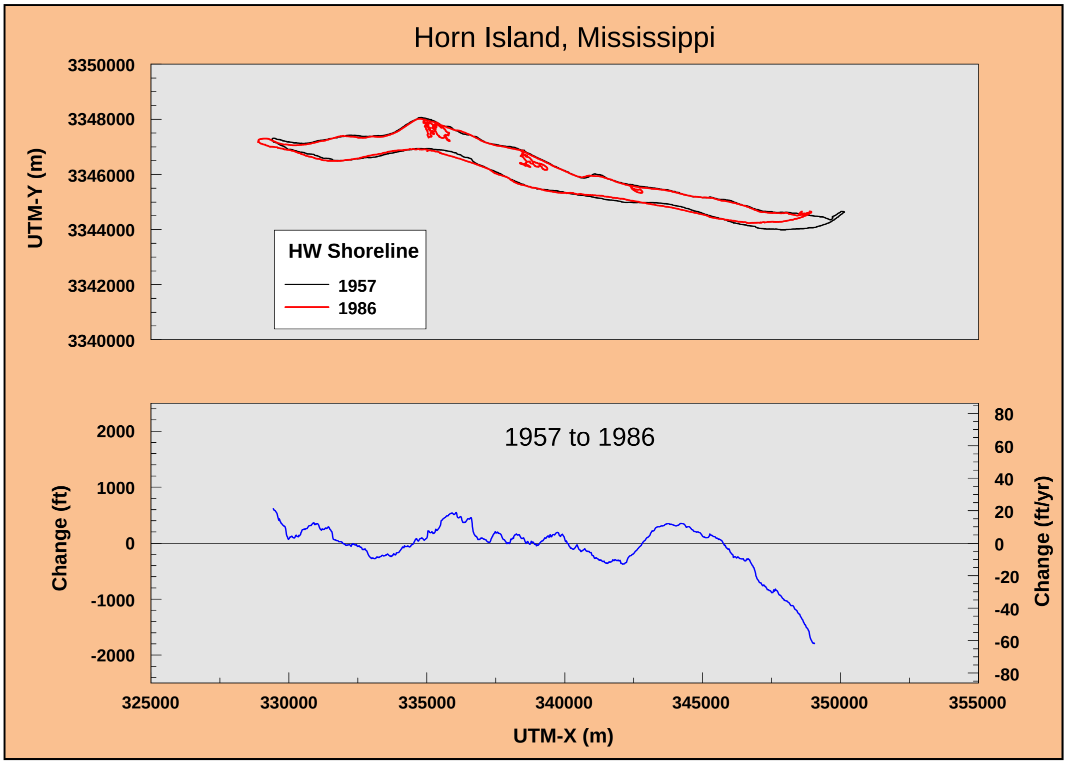


Figure C20. Change in historical shoreline position, Horn Island, MS, 1957 to 1986.

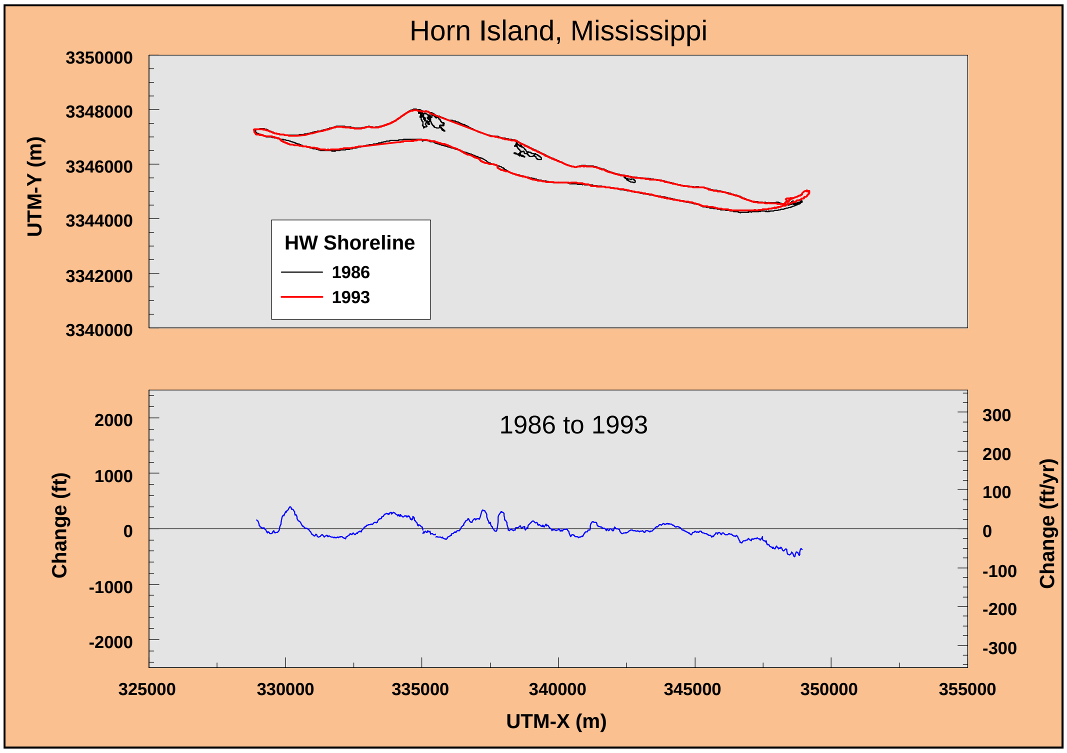


Figure C21. Change in historical shoreline position, Horn Island, MS, 1986 to 1993.

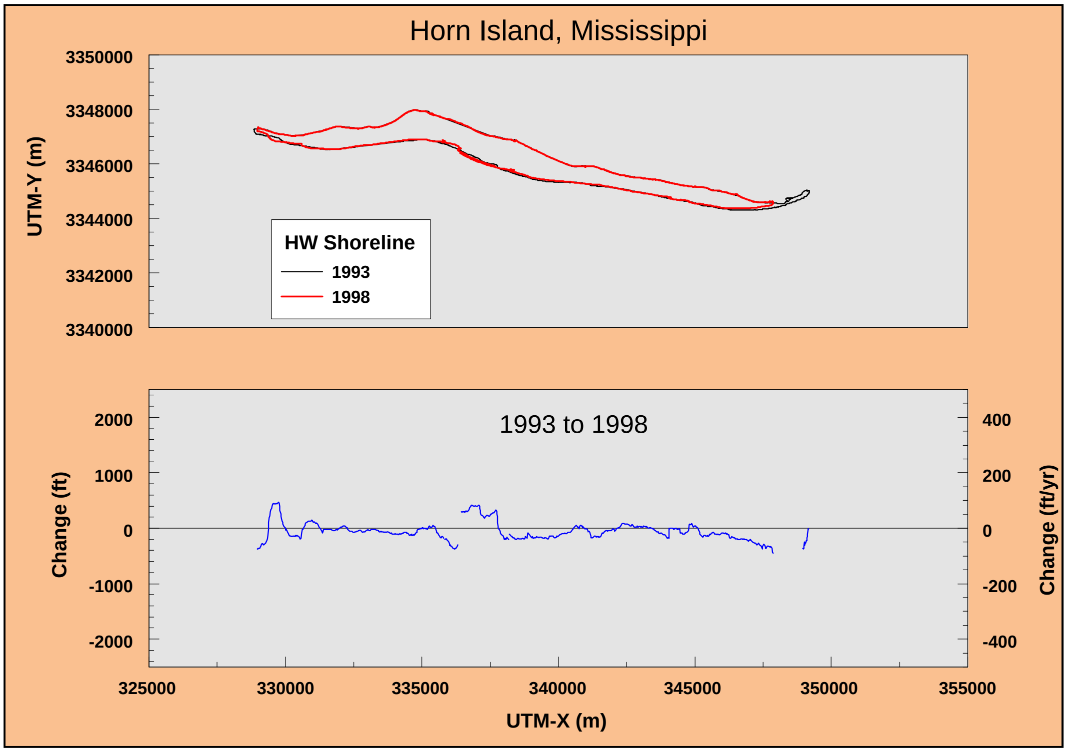


Figure C22. Change in historical shoreline position, Horn Island, MS, 1993 to 1998.

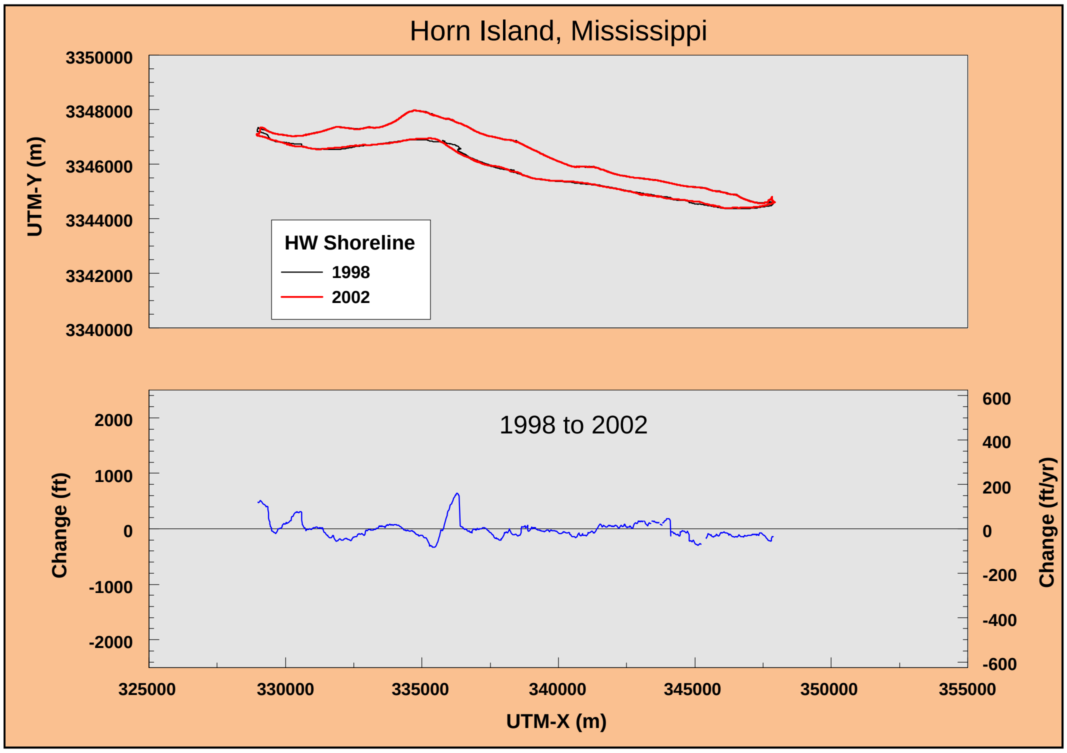


Figure C23. Change in historical shoreline position, Horn Island, MS, 1998 to 2002.

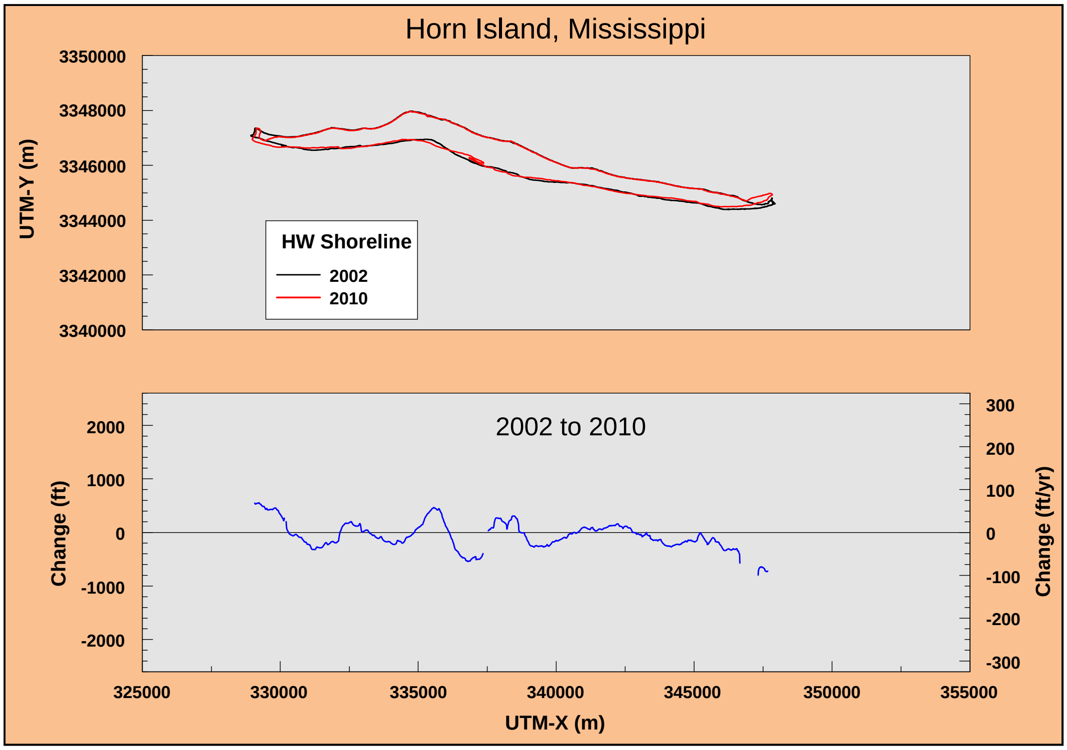


Figure C24. Change in historical shoreline position, Horn Island, MS, 2002 to 2010.

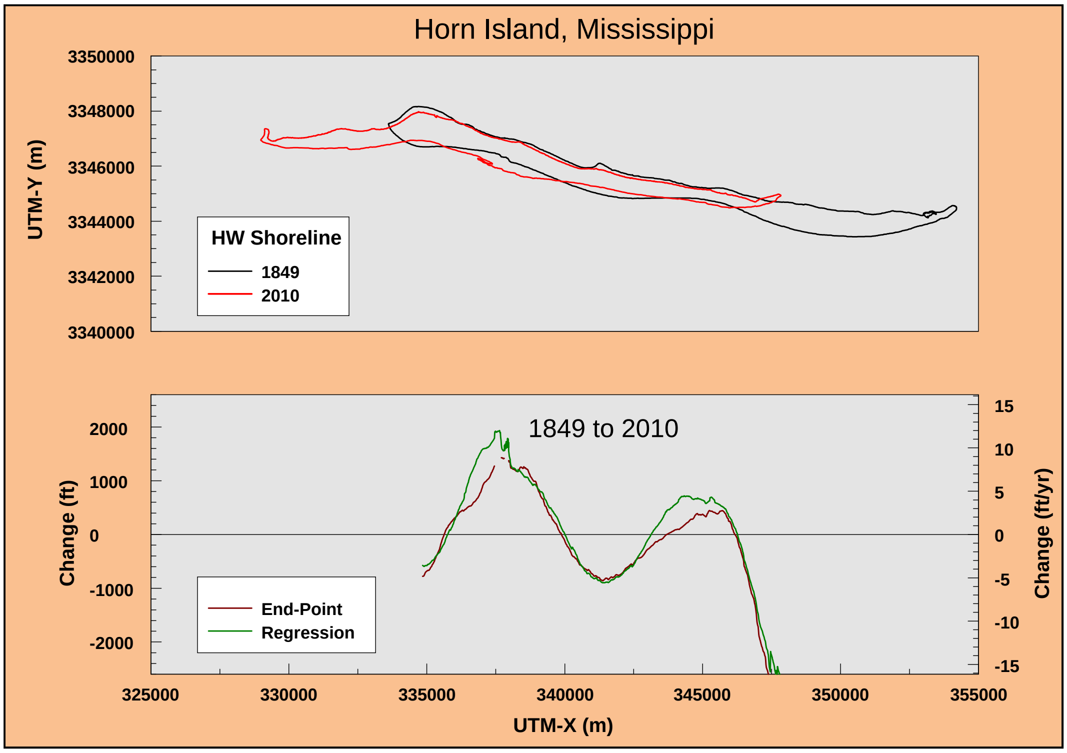


Figure C25. Change in historical shoreline position, Horn Island, MS, 1849 to 2010.

Ship Island, Mississippi: 1848 to 2010

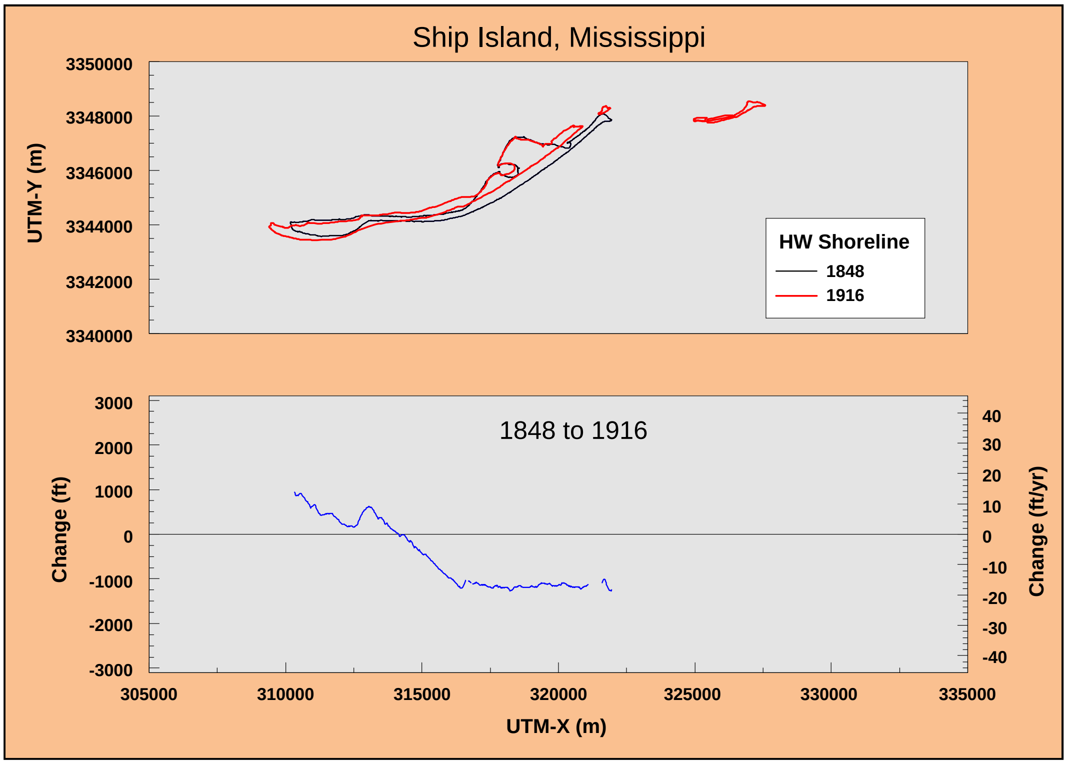


Figure C26. Change in historical shoreline position, Ship Island, MS, 1848 to 1916.

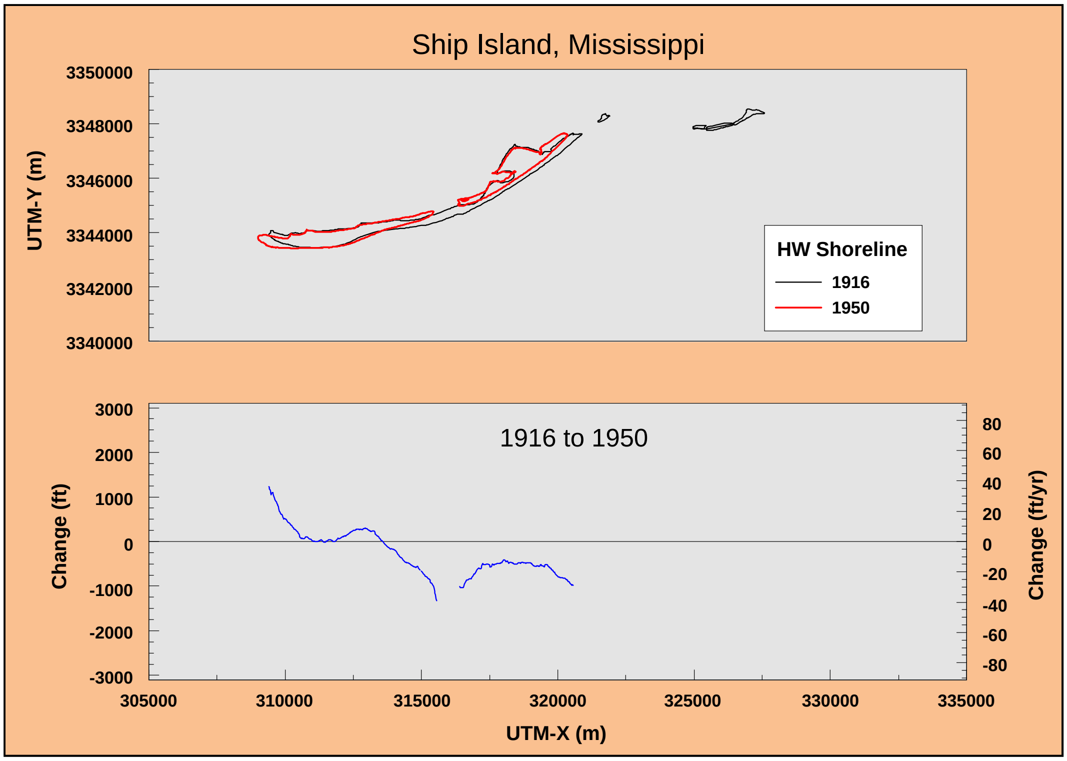


Figure C27. Change in historical shoreline position, Ship Island, MS, 1916 to 1950.

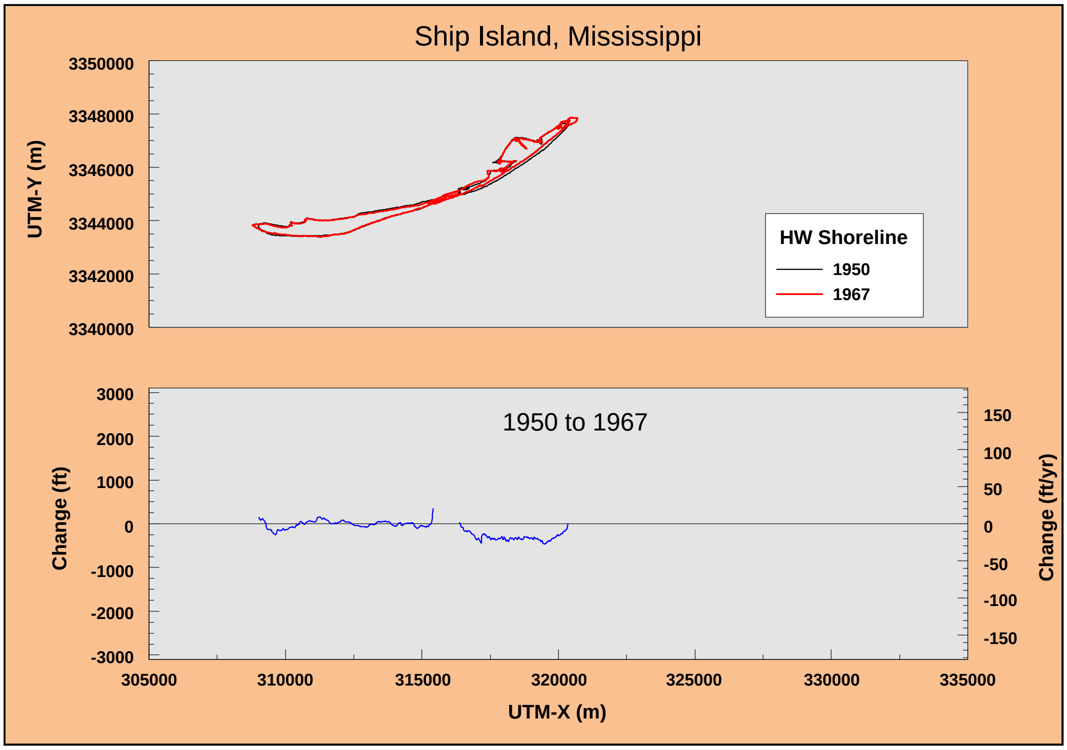


Figure C28. Change in historical shoreline position, Ship Island, MS, 1950 to 1967.

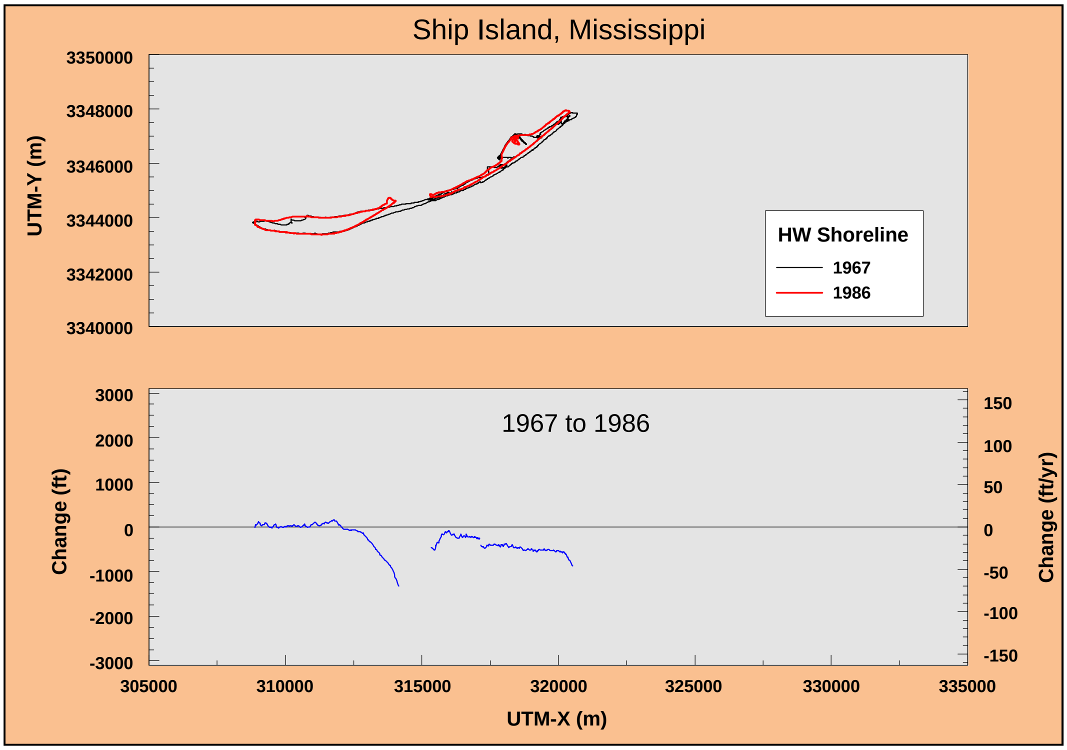


Figure C29. Change in historical shoreline position, Ship Island, MS, 1967 to 1986.

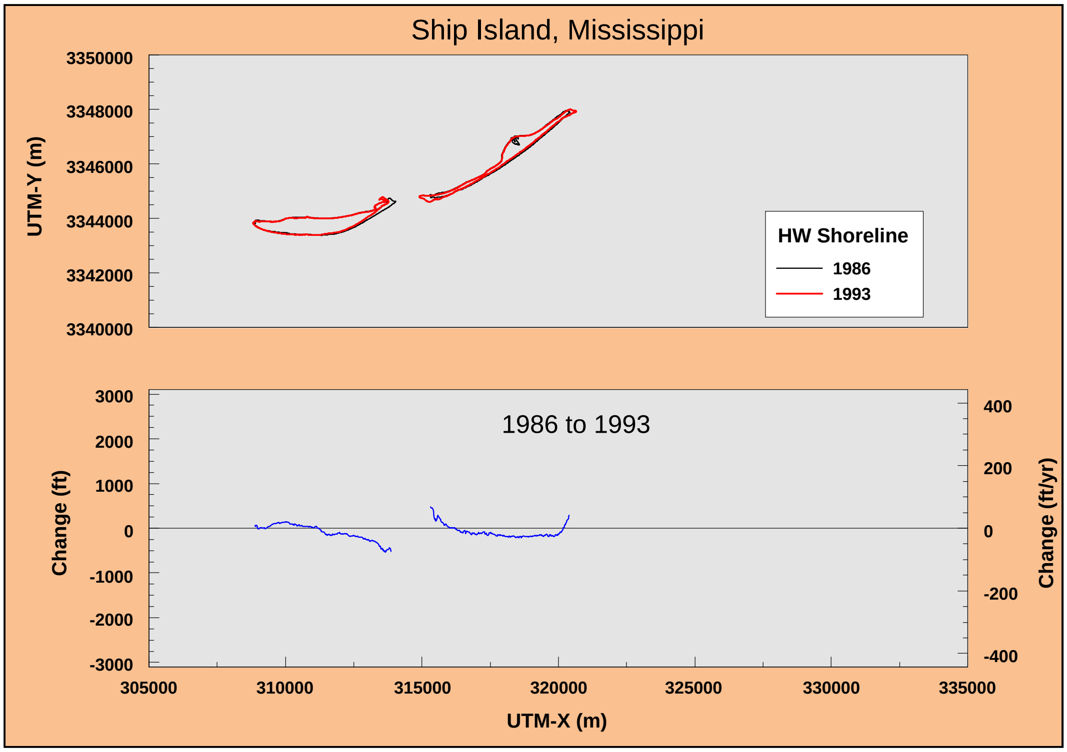


Figure C30. Change in historical shoreline position, Ship Island, MS, 1986 to 1993.

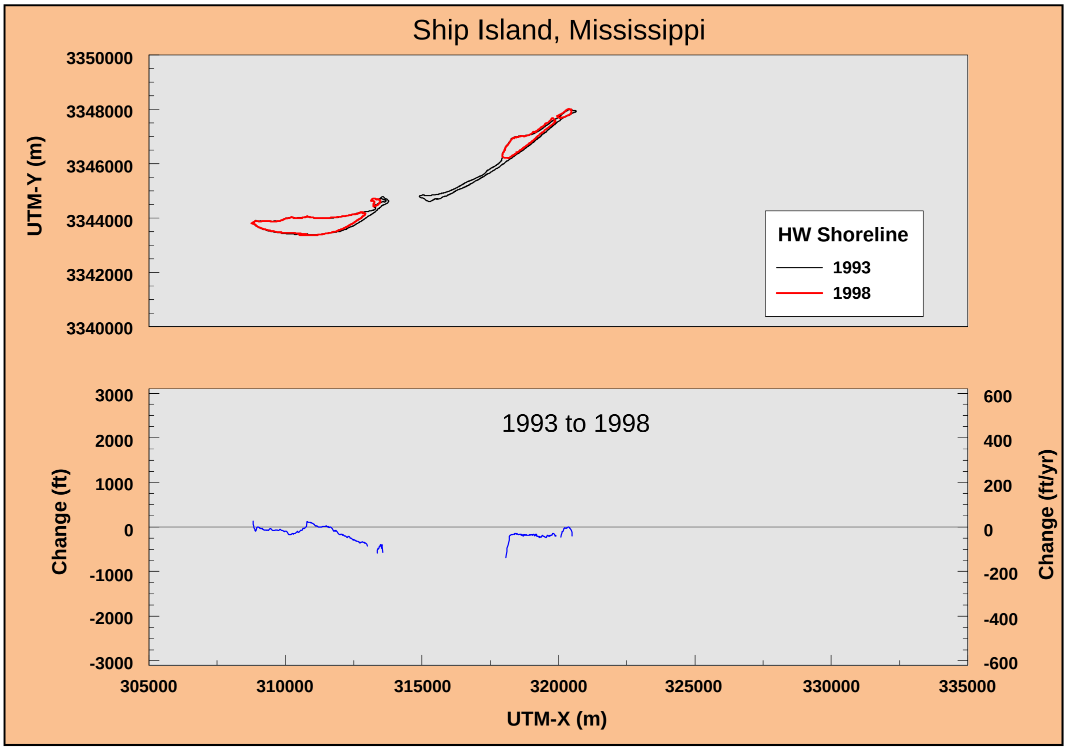


Figure C31. Change in historical shoreline position, Ship Island, MS, 1993 to 1998.

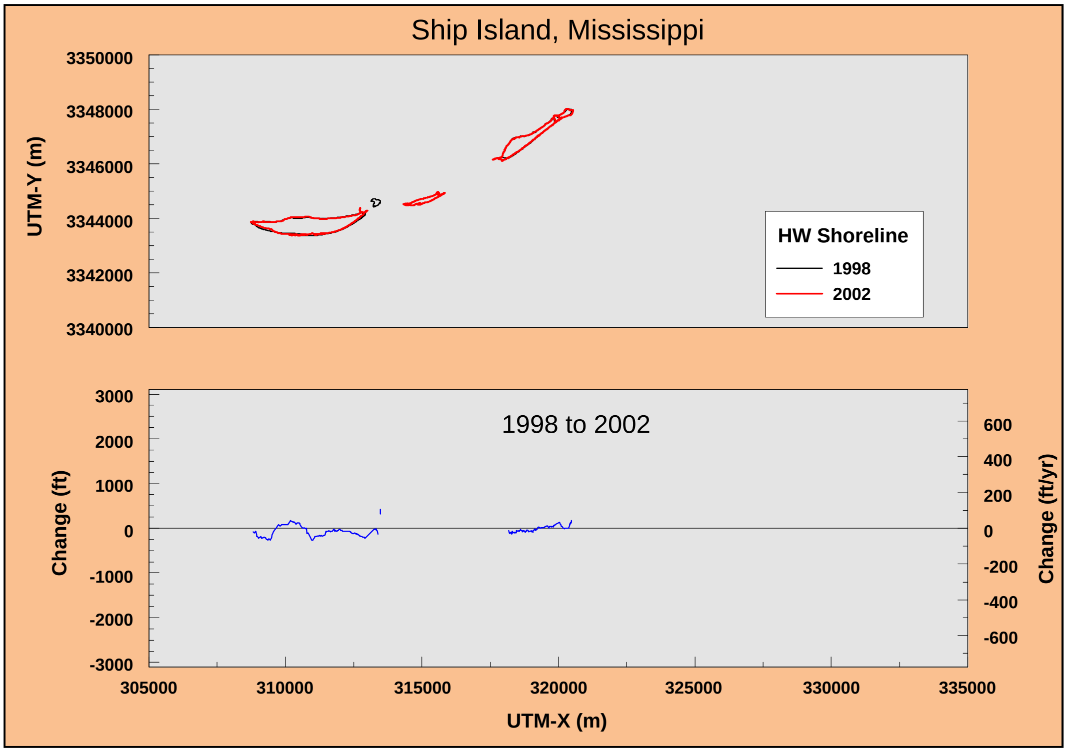


Figure C32. Change in historical shoreline position, Ship Island, MS, 1998 to 2002.

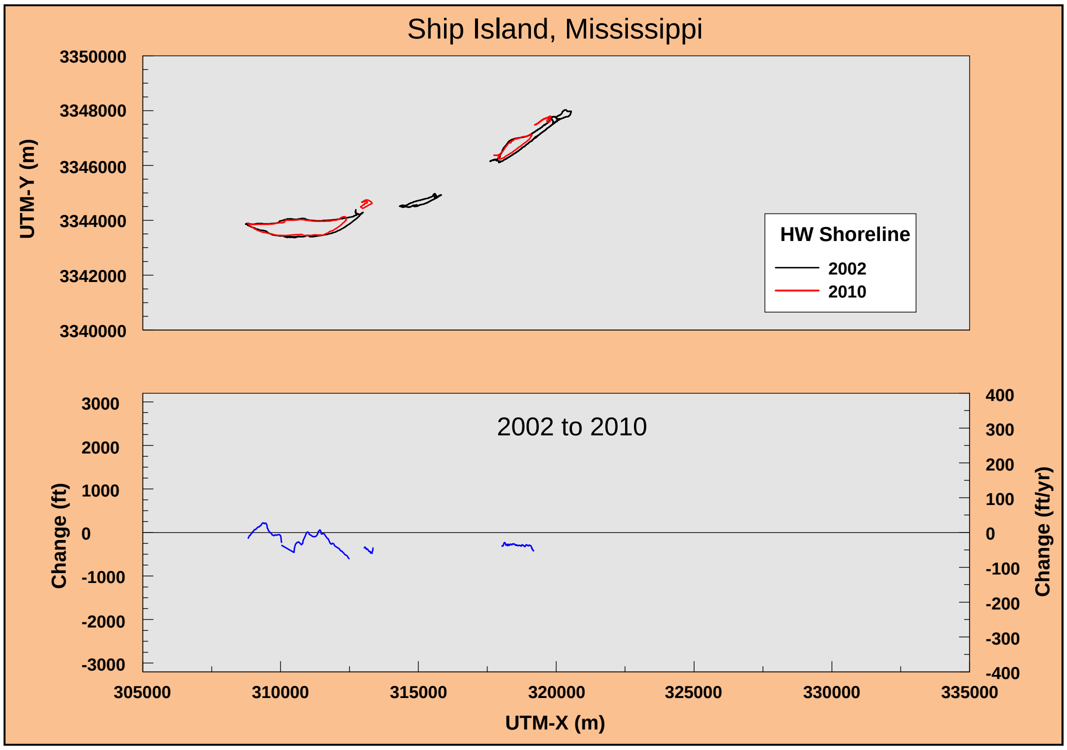


Figure C33. Change in historical shoreline position, Ship Island, MS, 2002 to 2010.

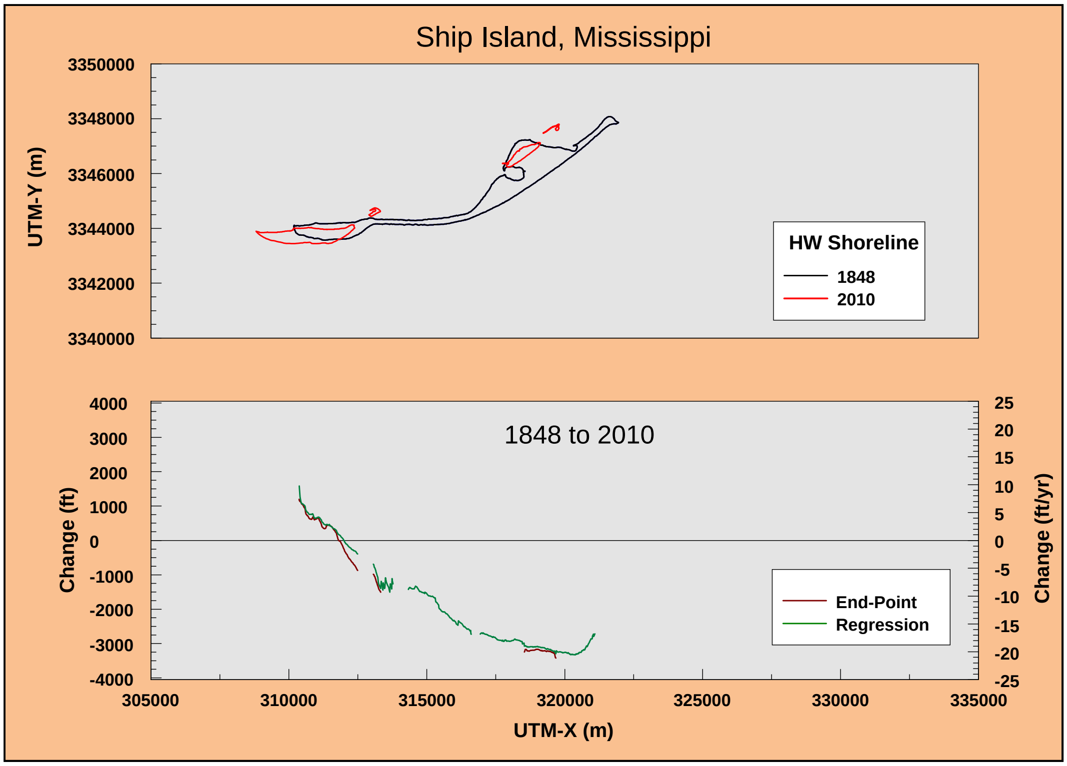


Figure C34. Change in historical shoreline position, Ship Island, MS, 1848 to 2010.

Cat Island, Mississippi: 1848 to 2010

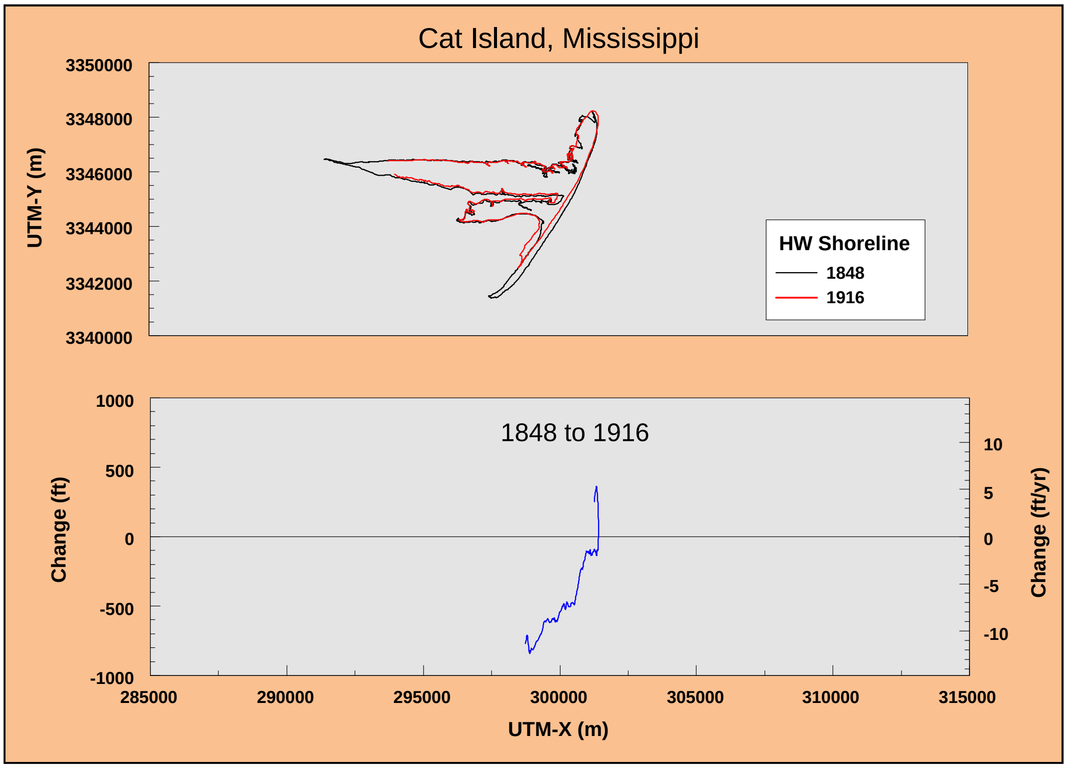


Figure C35. Change in historical shoreline position, Cat Island, MS, 1848 to 1916.

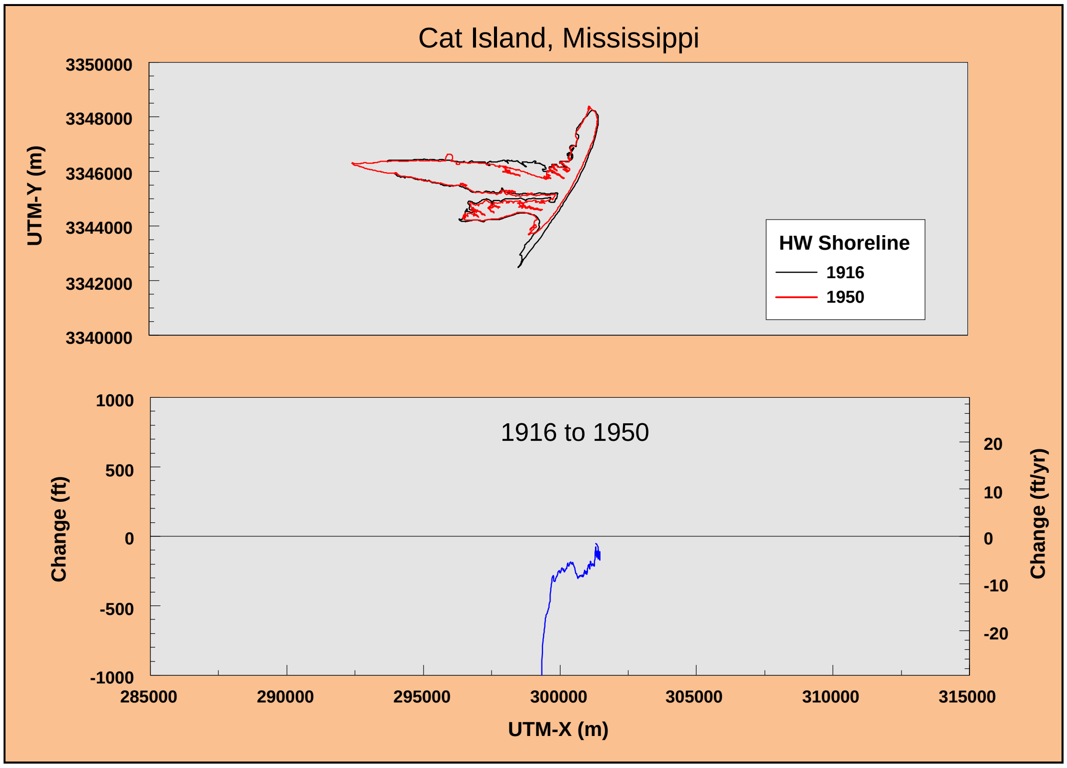


Figure C36. Change in historical shoreline position, Cat Island, MS, 1916 to 1950.

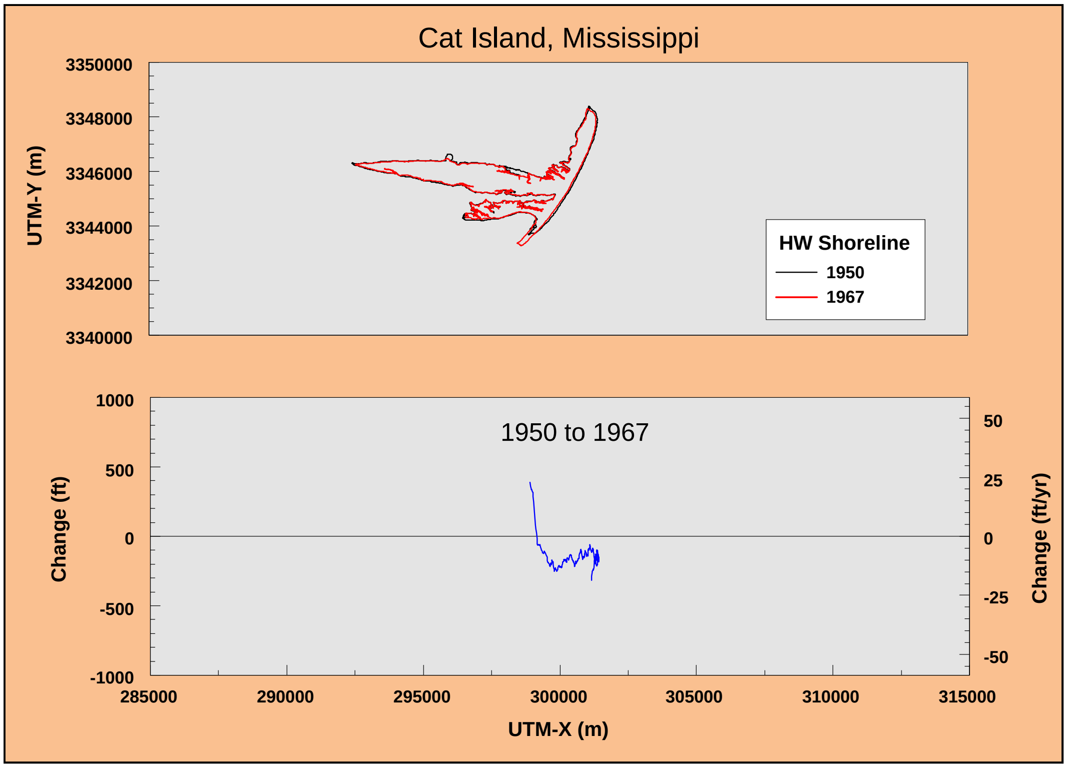


Figure C37. Change in historical shoreline position, Cat Island, MS, 1950 to 1967.

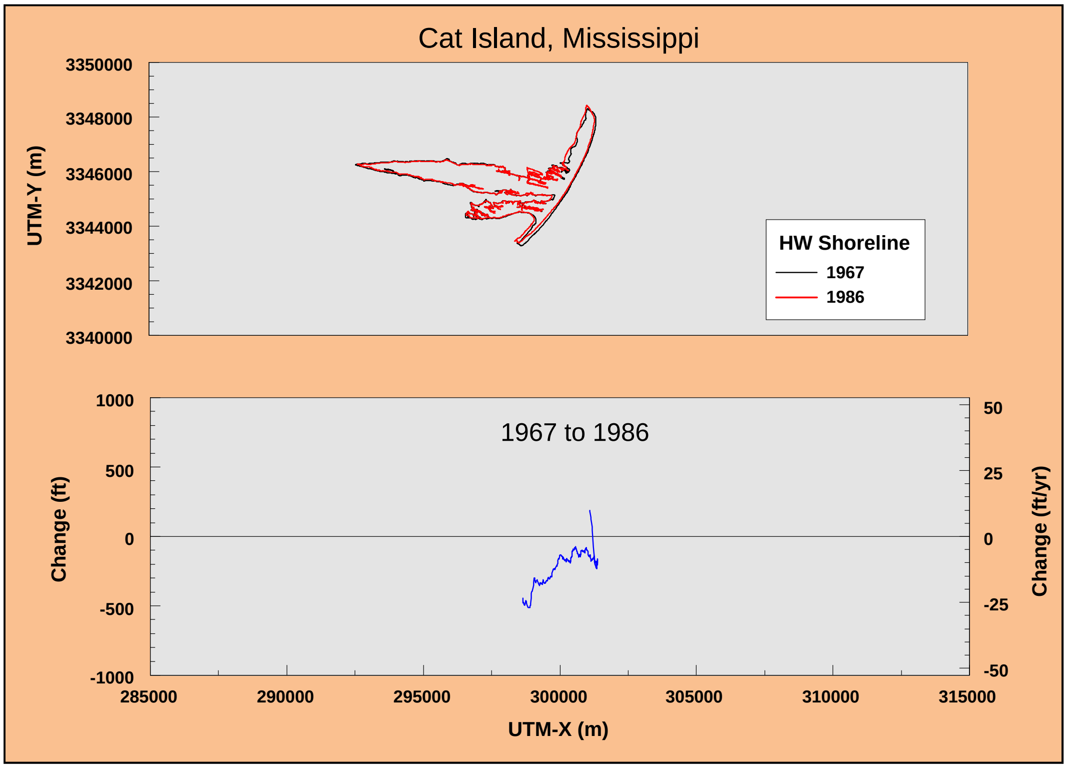


Figure C38. Change in historical shoreline position, Cat Island, MS, 1967 to 1986.

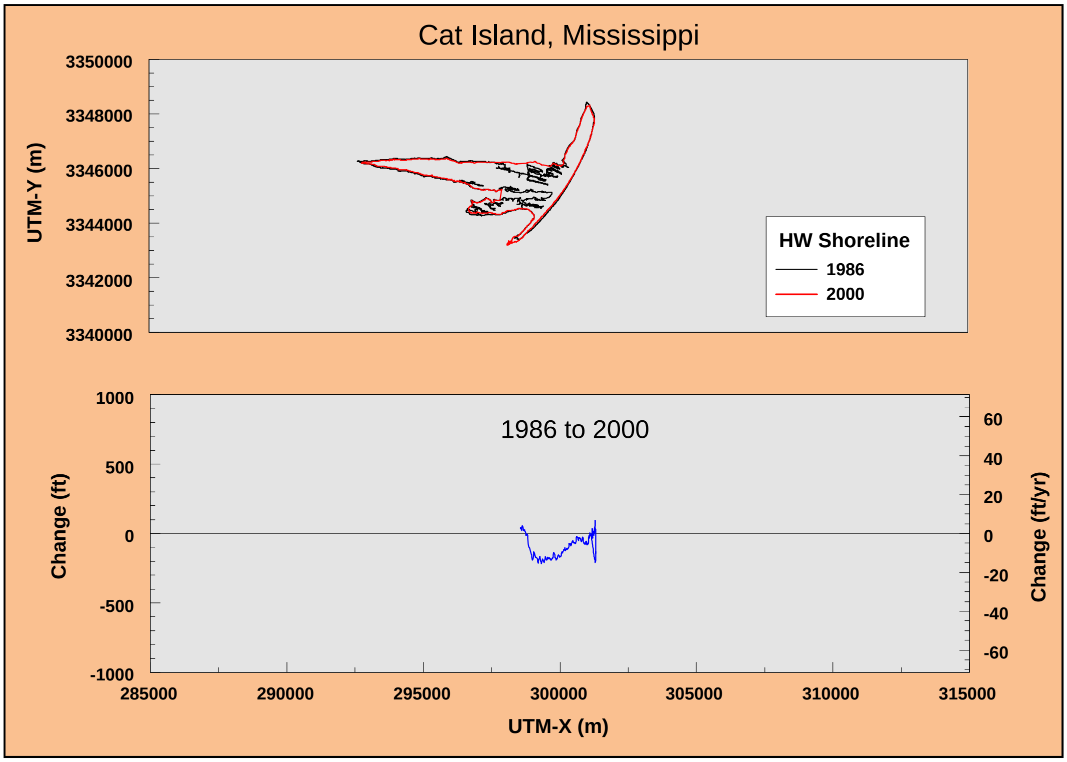


Figure C39. Change in historical shoreline position, Cat Island, MS, 1986 to 2000.

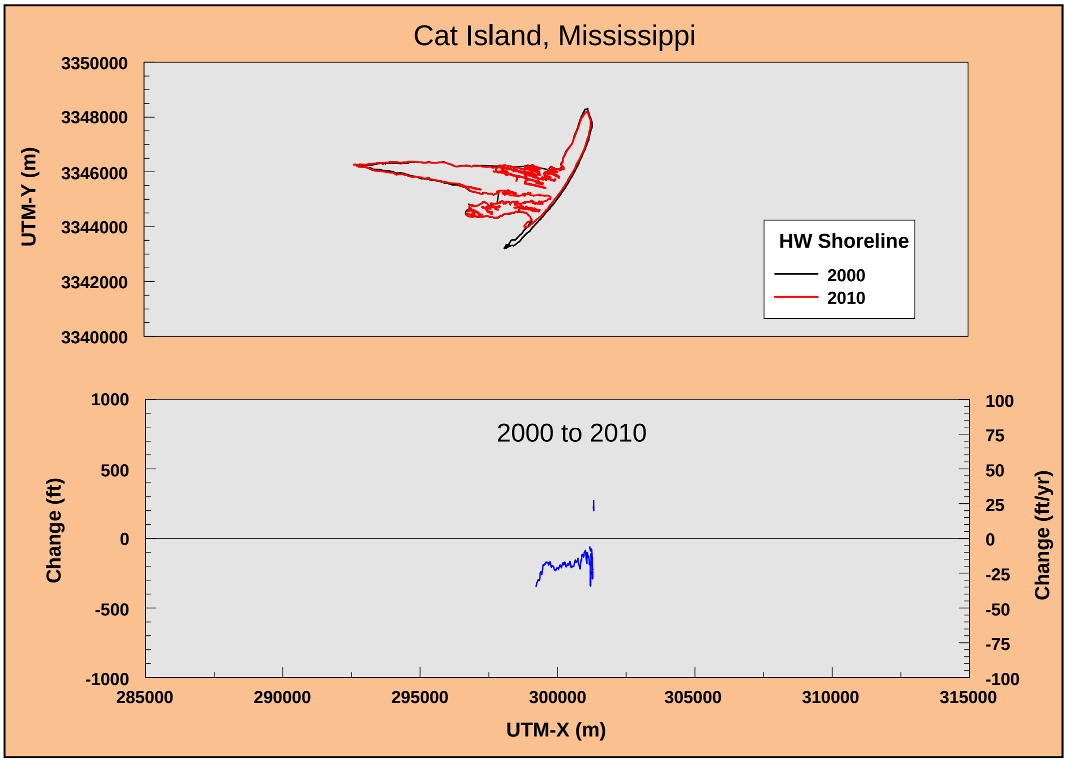


Figure C40. Change in historical shoreline position, Cat Island, MS, 2000 to 2010.

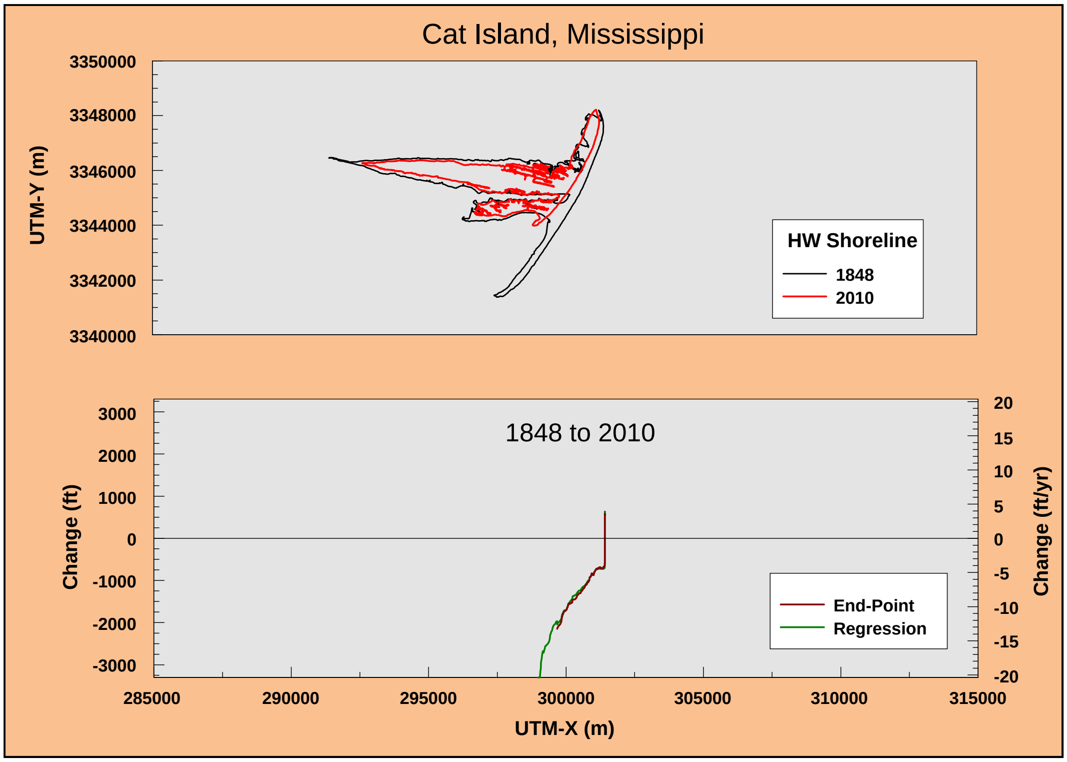
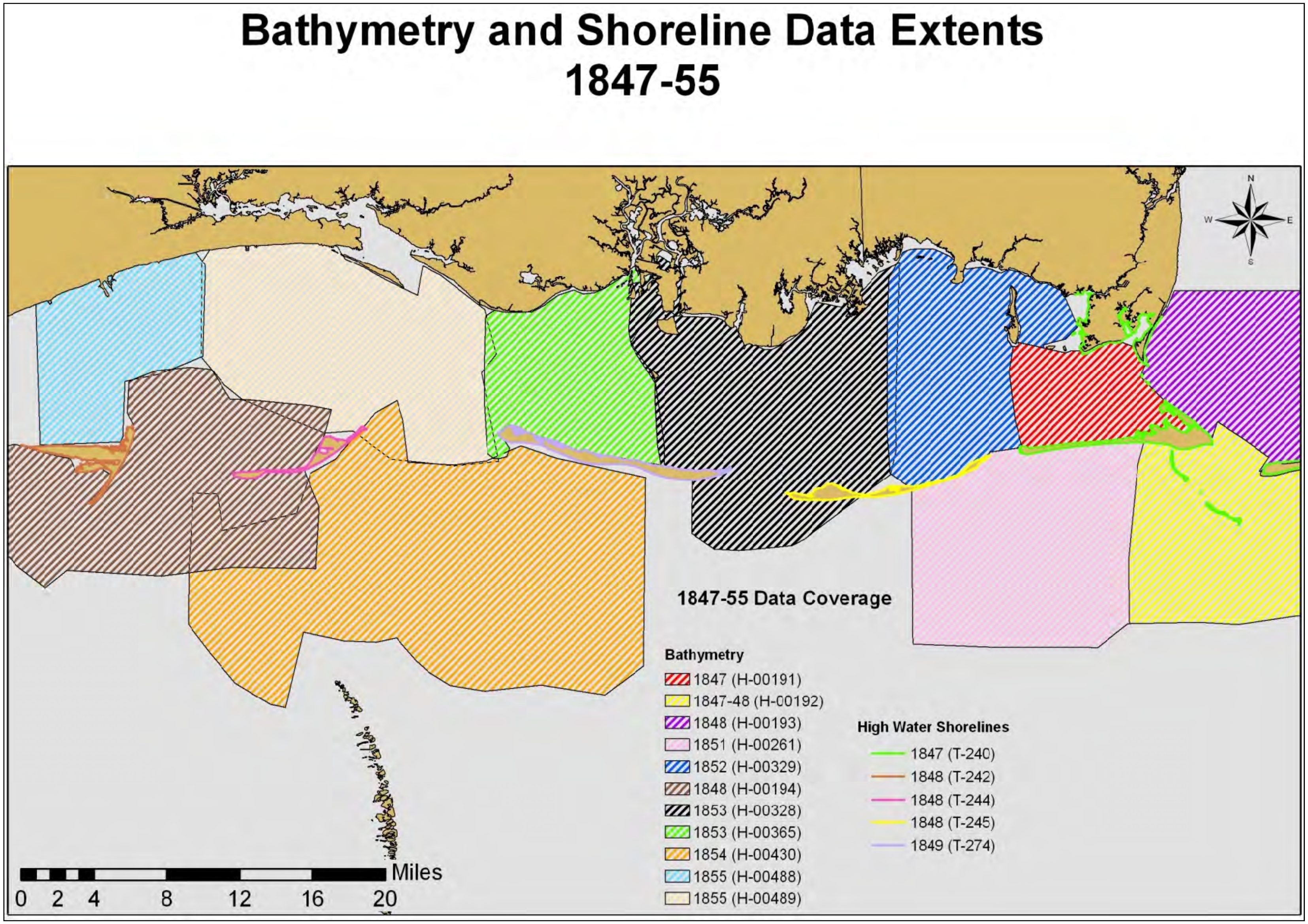
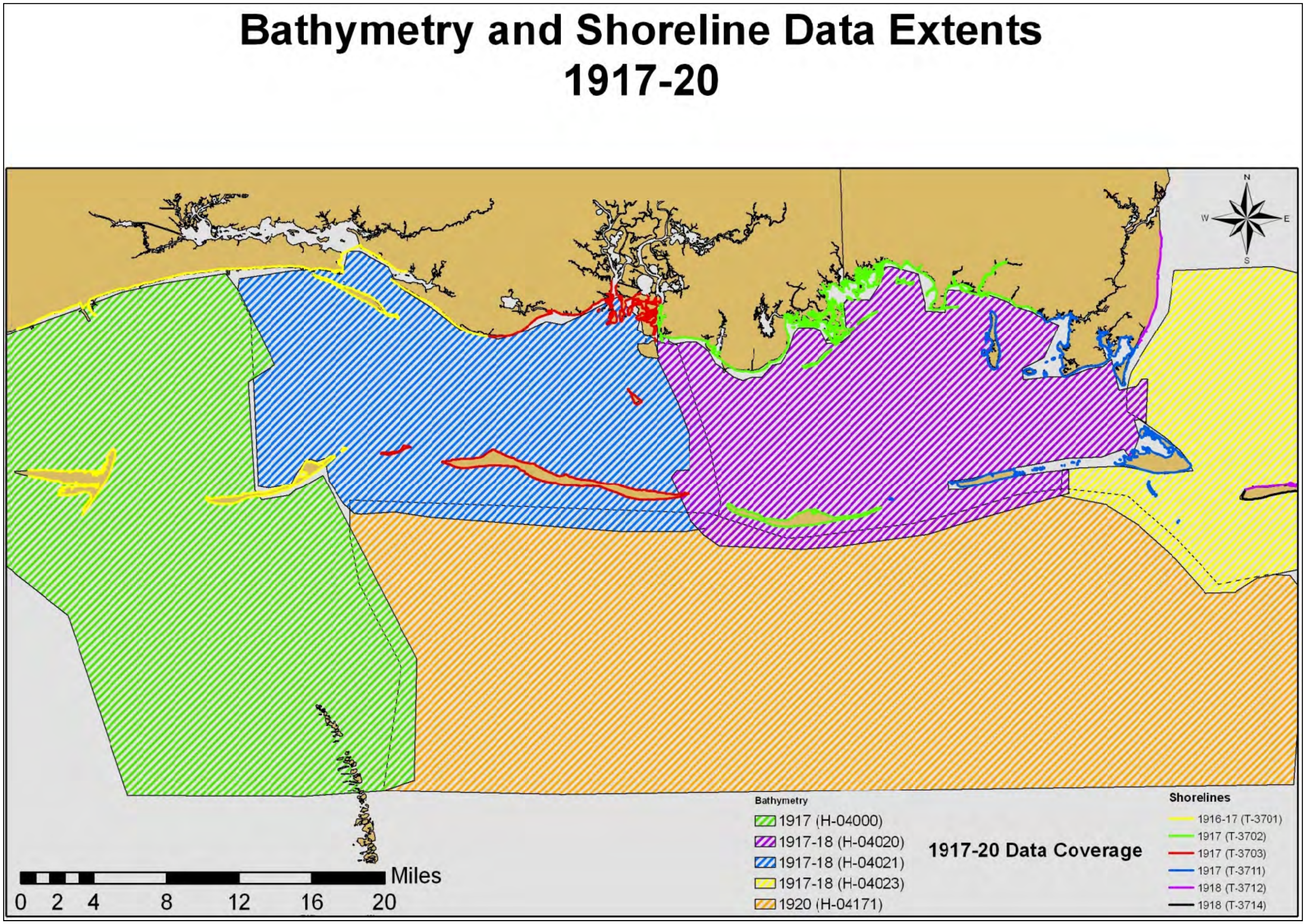


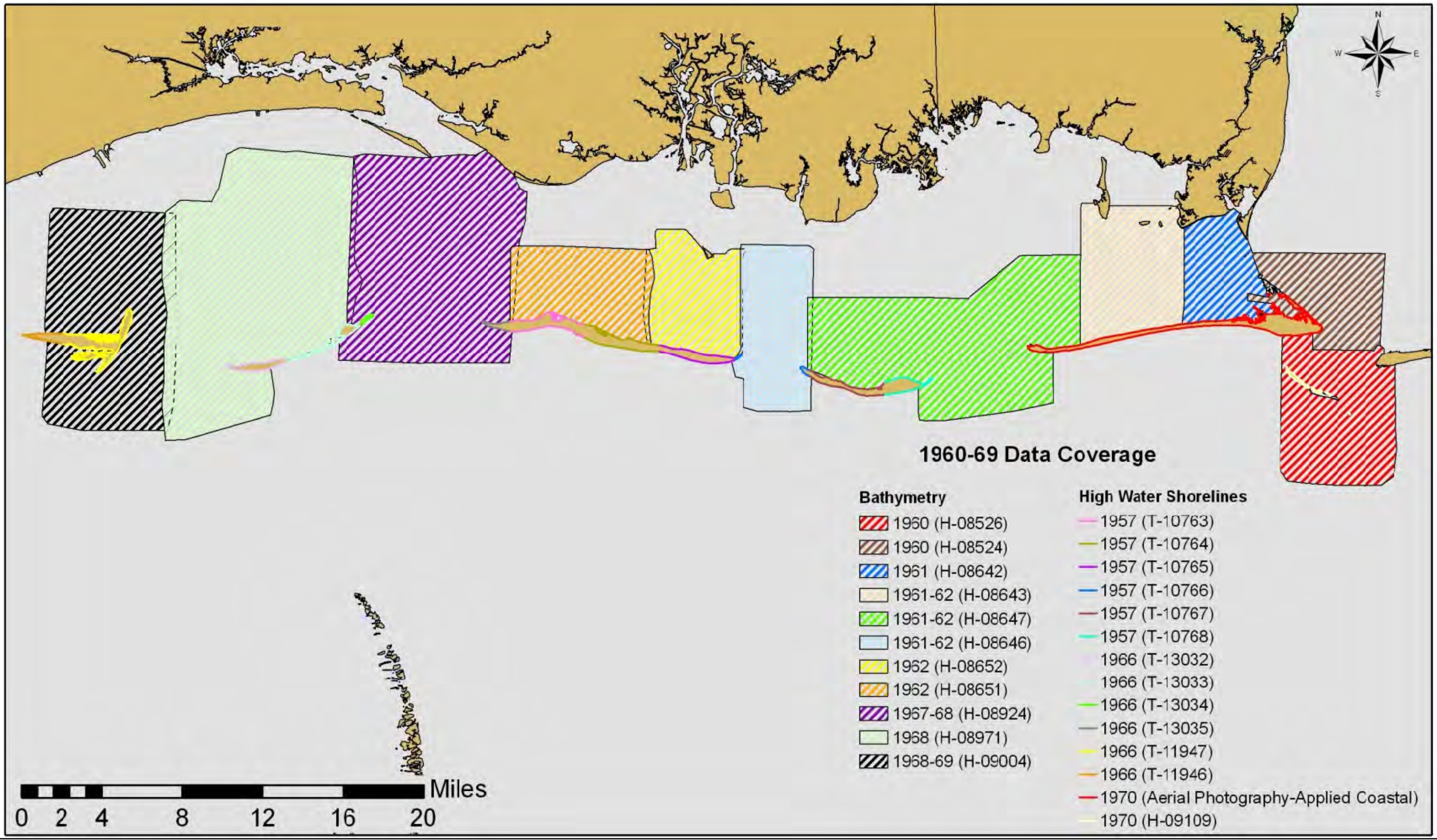
Figure C41. Change in historical shoreline position, Cat Island, MS, 1848 to 2010.

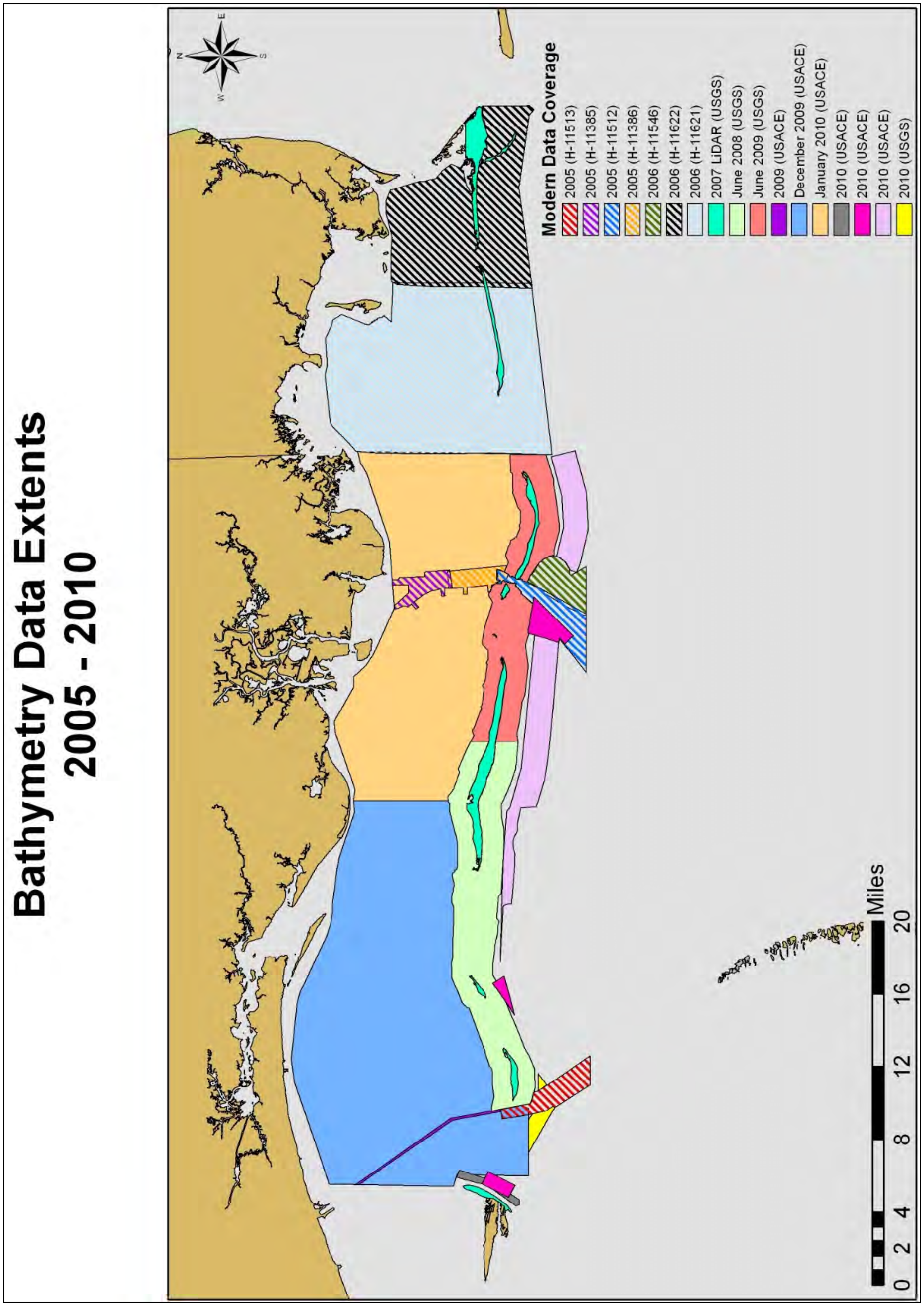
Appendix D: Bathymetry and Shoreline Data Extents


Bathymetry and Shoreline Data Extents
1847-55
N
W
E
S
1847-55 Data Coverage
Bathymetry
▨ 1847 (H-00191)
▨ 1847-48 (H-00192)
▨ 1848 (H-00193)
▨ 1851 (H-00261)
▨ 1852 (H-00329)
▨ 1848 (H-00194)
▨ 1853 (H-00328)
▨ 1853 (H-00365)
▨ 1854 (H-00430)
▨ 1855 (H-00488)
▨ 1855 (H-00489)
High Water Shorelines
— 1847 (T-240)
— 1848 (T-242)
— 1848 (T-244)
— 1848 (T-245)
— 1849 (T-274)
Miles
0
2
4
8
12
16
20


Bathymetry and Shoreline Data Extents
1917-20
N
W
E
S
Bathymetry
1917 (H-04000)
1917-18 (H-04020)
1917-18 (H-04021)
1917-18 (H-04023)
1920 (H-04171)
1917-20 Data Coverage
Shorelines
1916-17 (T-3701)
1917 (T-3702)
1917 (T-3703)
1917 (T-3711)
1918 (T-3712)
1918 (T-3714)
0 2 4 8 12 16 20
Miles

Bathymetry and Shoreline Data Extents 1960-69




Bathymetry Data Extents
2005 - 2010
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S
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Modern Data Coverage
2005 (H-11513)
2005 (H-11385)
2005 (H-11512)
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2006 (H-11546)
2006 (H-11622)
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2007 LiDAR (USGS)
June 2008 (USGS)
June 2009 (USGS)
2009 (USACE)
December 2009 (USACE)
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14. ABSTRACT

Shoreline and beach evolution for the barrier islands fronting Mississippi Sound are driven by longshore transport processes associated with storm and normal wave and current conditions. Although beach erosion and washover deposition are processes that have influenced island changes, the dominant mechanism by which sand is redistributed along the barrier islands and in the passes is by longshore currents generated by wave approach from the southeast.

Historical shoreline and bathymetric survey data were compiled for the barrier islands and passes fronting Mississippi Sound to identify net littoral sediment transport pathways, quantify the magnitude of net sand transport, and develop an operational sediment budget spanning a 90-year period. Net littoral sand transport along the islands and passes is primarily unidirectional (east-to-west). Beach erosion along the east side of each island and sand spit deposition to the west result in an average sand flux of about 300,000 to 400,000 cy/yr throughout the barrier island system. Dog Keys Pass, located updrift of East Ship Island, is the only inlet acting as a net sediment sink and is the widest pass in the system (about 6 miles). As such, a deficit of sand exists along East Ship Island. Littoral sand transport decreases rapidly along West Ship Island, where exchange of sand between islands terminates because of wave sheltering from shoals and islands of the old St. Bernard delta complex, Louisiana. These data are being used to assist with design of a large island restoration project along Ship Island, Mississippi.

15. SUBJECT TERMS		
	Island restoration	Ship Island
Bathymetric change	Navigation channel dredging	
Horn Island	Petit Bois Island	

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