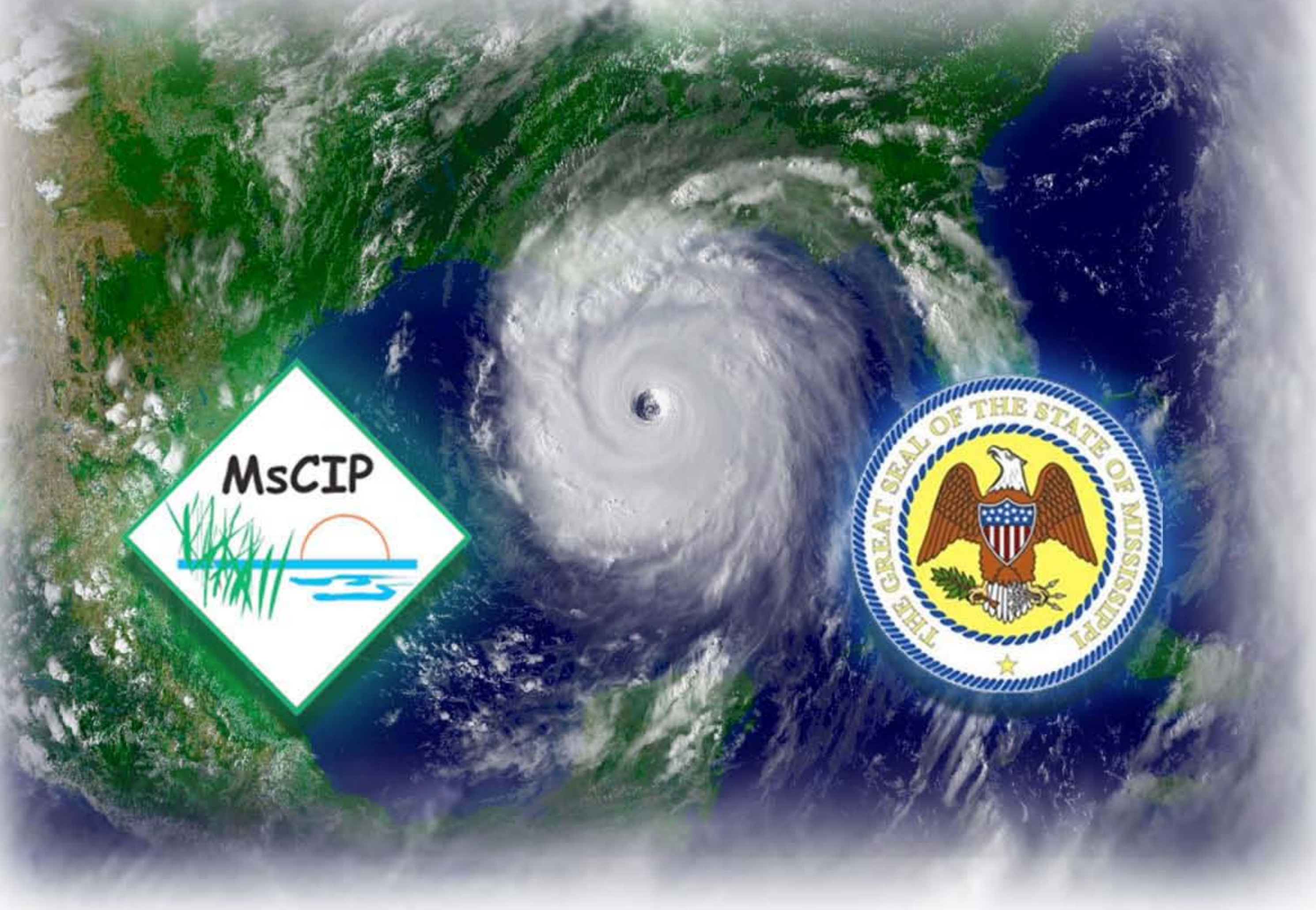
US Army Corps
of Engineers
Mobile District

June 2009

Mississippi Coastal Improvements Program (MsCIP)
Hancock, Harrison, and Jackson Counties, Mississippi

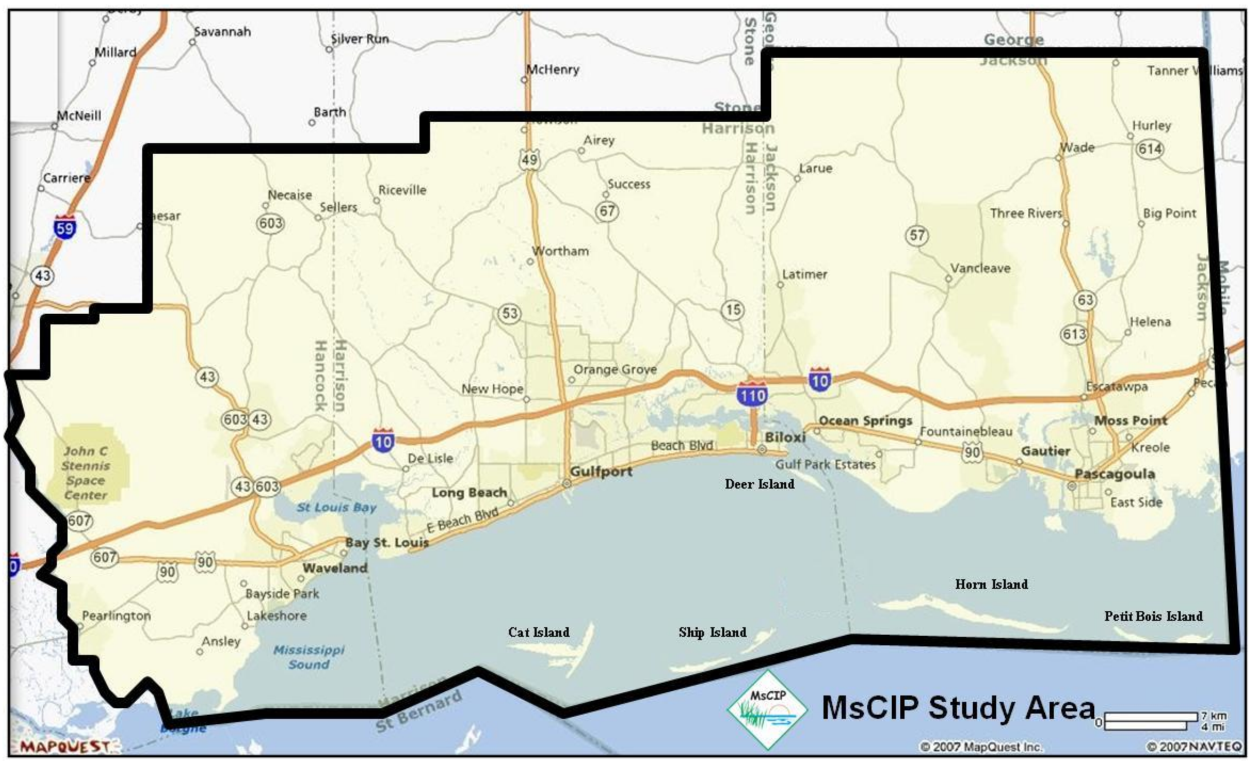
APPENDIX H BARRIER ISLANDS



FOREWORD

This document is one of a number of technical appendices to the Mississippi Coastal Improvements Program (MsCIP) Comprehensive Plan and Integrated Feasibility Report and Environmental Impact Statement.

The Mississippi Coastal Improvements Program (MsCIP) Comprehensive Plan Integrated Feasibility Report and Environmental Impact Statement provides systems-based solutions and recommendations that address: hurricane and storm damage reduction, ecosystem restoration and fish and wildlife preservation, reduction of damaging saltwater intrusion, and reduction of coastal erosion. The recommendations contained in the Main Report/EIS also provide measures that aid in: greater coastal environmental and societal resiliency, regional economic re-development, and measures to reduce long-term risk to the public and property, as a consequence of hurricanes and coastal storms. The recommendations cover a comprehensive package of projects and activities, that treat the environment, wildlife, and people, as an integrated system that requires a multi-tiered and phased approach to recovery and risk reduction, irrespective of implementation authority or agency.



The MsCIP Study Area

The purpose of the Comprehensive Plan Report is to present, to the Congress of the United States, the second of two packages of recommendations (i.e., the first being the "interim" recommendations funded in May 2007, and this "final" response, as directed by the Congress), directed at recovery of vital water and related land resources damaged by the hurricanes of 2005, and development of recommendations for long-term risk reduction and community and environmental resiliency, within the three-county, approximately 70 mile-long coastal zone, including Mississippi Sound and its barrier islands, of the State of Mississippi.

This appendix, the Main Report/EIS, and all other appendices and supporting documentation, were subject to Independent Technical Review (ITR) and an External Peer Review (EPR). Both review processes will have been conducted in accordance with the Corps "Peer Review of Decision Documents" process, has been reviewed by Corps staff outside the originating office, conducted by a Regional and national team of experts in the field, and coordinated by the National Center of Expertise in Hurricane and Storm Damage Protection, North Atlantic Division, U.S. Army Corps of Engineers.

The report presents background on the counties that comprise the Mississippi coastline most severely impacted by the Hurricanes of 2005, their pre-hurricane conditions, a summary of the effects of the 2005 hurricane season, problem areas identified by stakeholders and residents of the study area, a summary of the approach used in analyzing problems and developing recommendations directed at assisting the people of the State of Mississippi in recovery, recommended actions and projects that would assist in the recovery of the physical and human environments, and identification of further studies and immediate actions most needed in a comprehensive plan of improvements for developing a truly resilient future for coastal Mississippi.

This appendix contains detailed technical information used in the analysis of existing and future without-project conditions, in the development of problem-solving measures, and in the analysis, evaluation, comparison, screening, and selection of alternative plans, currently presented as tentatively-selected recommendations contained in the Main Report/EIS.

Each appendix functions as a complete technical document, but is meant to support one particular aspect of the feasibility study process. However, because of the complexity of the plan formulation process used in this planning study, the information contained herein should not be used without parallel consideration and integration of all other appendices, and the Main Report/EIS that summarizes all findings and recommendations.

This appendix, The Comprehensive Barrier Island Restoration Plan Appendix, contains detailed supporting data and technical information on the engineering and environmental options that were configured to meet the goals of the Comprehensive Plan. The goal of this plan will be to help restore the sediment transport and budget system for the Mississippi barrier islands. The Comprehensive Barrier Island Restoration Plan was developed through a joint effort of many Federal agencies including the National park Service who has jurisdiction over most of Mississippi's barrier islands as part of the Gulf Islands National Seashore.

EXECUTIVE SUMMARY

Soon after Hurricane Katrina, the notion became widely accepted by the public that if the Mississippi barrier islands had been in a “pre-Hurricane Camille” condition, there would have been much less storm damage during Katrina. During Hurricane Camille, there was extensive land loss on the islands and little natural recovery had occurred since then. Also during Camille, Ship Island was breached and this breach has remained open and is now known as Camille Cut. This massive restoration of the barrier islands was included in the State’s Hurricane Recovery Program which was published soon after Katrina. During completion of the Mississippi Coastal Improvements Program Report, the Mississippi Barrier Islands were subject to several different design concepts for storm damage reduction including total restoration to the pre-Camille condition. These plans are fully described in the Engineering Appendix. Subsequent computer modeling of storm damage reduction benefits from any engineered changes reveal that storm surge reduction was not large, but other benefits would be obtained from simply maintaining the existence of the islands. These benefits include reduction of wave damage to the mainland coast and many important environmental benefits associated with maintaining Mississippi Sound as an estuary formed by the islands. Coordination with the National Park Service (NPS) who has ownership of most of the islands and other agencies has resulted in a plan that will provide continuing existence for the islands that have been badly eroded by storms. Ship Island received sufficient storm damage to endanger its survival in the future. This plan, the Comprehensive Barrier Island Restoration Plan, was coordinated with the NPS and includes direct sand placement in the breach of Ship Island with plantings of dune grasses, additional sand placed into the local littoral zone, changes in the Regional Sediment Management Practice, and additional studies of Cat Island where little data is available. The program also has the potential to make beneficial use of dredged material that has been deposited in both inland and offshore areas if quality objectives are clearly demonstrated. After implementation, a long term monitoring program will be established to monitor the project. This data will be extremely valuable in future programs such as this and can provide the NPS with information that they can use to better manage their coastal resources.

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CHAPTER 1 BACKGROUND AND GENERAL INFORMATION

The Barrier Island Restoration Plan consists of a comprehensive, all-inclusive plan to construct the best combination of the various options that have been developed for the Mississippi Barrier Islands. The State Plan to “restore the barrier islands to a pre-Camille footprint” offered many different ideas to accomplish this goal. An important factor that was not forgotten during this study was that the Mississippi Barrier Islands are owned within the National Park Service as the “Gulf Islands National Seashore”. Coordination with many agencies has resulted in a plan that will provide many benefits including economic, environmental and storm damage reduction. The loss of land mass on the barrier islands has been documented and the continued loss will result in a change in the ecology of the Mississippi Sound that is formed by the island chain. The best method to accomplish any restoration requires that the different options be integrated to maximize benefits and prevent any adverse environmental impacts, modeled to predict the best benefits from any sand placement, and to bring consensus to the many agencies that would be involved in this type of plan. The options discussed in the Engineering Appendix have been based on three basic concepts for island restoration and identified to include:

- Adding additional land mass to the existing islands by using sand dredged and transported from an off-shore location. The new land mass would be shaped into dunes and marshes and planted with native marsh, maritime forest and dune vegetation or simply planted with these types of vegetation and allowing the effects of nature to create the land forms. The anticipated source of the sand is the St. Bernard Shoals, but this needs further investigation to verify the quantity and quality of the sand.

- Adding sand into the littoral zone at specific locations between the islands based on additional sediment transport modeling. This would allow the littoral currents to move the sand onto the islands where the natural process of island building could take place. This would not directly affect the present-day islands and would help mitigate any effects of dredging the ship channels that pass through the chain of islands where sand may have been lost from the system. This option would obtain the sand from the beneficial use of dredged material from an inland river source or from offshore borrow areas.

- Planting native vegetation to help provide environmental restoration of the existing islands where the vegetation was destroyed by Katrina. These options may also consist of shaping existing sand into low dunes on the beaches or adding sand from an offshore source to create dunes several feet above the existing beach. These dunes would be planted with sea oats to help in the re-establishment of the dunes on the beaches. This would be along with planting of maritime forests in the inland’s interior where they were mostly destroyed by Hurricane Katrina. This plan was completed during the fall of 2007 and combined two of the engineering options described in the Engineering Appendix, incorporated some additional studies at Cat Island and recommended changes in the current practices under the Regional Sediment Management Plan. In compiling this plan, several documents were used. In the order included in this appendix is the “National Park Service Vision Statement for the Mississippi Barrier Islands”, results of the “Sediment Transport Modeling and Sediment Budget”, studies of “Inland River Sand Sources for Use at Barrier Islands”, an “Overview of All Barrier Island Options (Line of Defense-1) from Engineering Appendix”, and the “Multi-agency Mississippi Barrier Island Restoration Recommendation”. The resulting plan is included in Chapter 7 as “The Comprehensive Barrier Island Restoration Plan”. After completion of sand placement and planting vegetation, the project will be subject to an 11 year monitoring program described in Chapter 7.

CHAPTER 2 NATIONAL PARK SERVICE VISION STATEMENT

During the study phase for the Barrier Islands, the National Park Service (NPS) issued a Vision Statement for the Mississippi Barrier Islands. As a tool for the planners and engineers, this document set forth the details of any modifications that might be conceived for the barrier islands during this study that would carry the endorsement of the NPS. A copy of this document is included below.

United States Department of the Interior

NATIONAL PARK SERVICE
Southeast Regional Office
Atlanta Federal Center
1924 Building
100 Alabama St., SW.
Atlanta, Georgia 30303

IN REPLY REFER TO:
SER-SNRM

JUN 22 2007

Brigadier General Joseph Schrodel
Commander, South Atlantic Division
U. S. Army Corps of Engineers
60 Forsyth Street, Room 9M15
Atlanta, GA 30303-8801

Dear General Schroedel:

As requested by the Mississippi Coastal Improvements Program (MsCIP) Planning Team Program Manager, Dr. Susan Rees, in January 2007, the National Park Service has prepared and is enclosing its "Vision Statement for the Management of the Mississippi Barrier Islands, Gulf Islands National Seashore, National Park Service, June 22, 2007." This document is being copied to the MsCIP Project Delivery Team – Mobile, for incorporation into the draft Comprehensive Plan (MsCIP), which will be released in the fall of 2007 for agency and public reviews fall of 2007.

We appreciate the opportunity to participate in and provide feedback for this important planning process, and we look forward to a continued cooperative relationship with the U.S. Army Corps of Engineers Mississippi Coastal Improvements Program. Please let us know if we can provide additional information.

Sincerely,

Art Frederick

For Patricia A. Hooks
Regional Director
Southeast Region

Enclosure

cc: Colonel Peter F. Taylor, Jr., COE w/ enclosure
cc: Dr. Susan Rees, COE w/ enclosure

TAKE PRIDE® IN AMERICA

cc: Mississippi Coastal Improvements Program, COE w/ enclosure
cc: Jerry Eubanks, Superintendent, NPS – GUIS
cc: Sam D. Hamilton, Southeast Regional Director, USFWS
cc: Ray Aycock, USFWS - ES/MS
cc: Suzette Kimball, Eastern Regional Director, USGS
cc: Jack Kindinger, Deputy Director for Science / St. Petersburg, USGS
cc: S. Jeffress Williams, Coastal Marine Geologist / Woods Hole, USGS

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Vision Statement for the
Management of the Mississippi Barrier Islands
Gulf Islands National Seashore
National Park Service

June 2007

Executive Summary

The National Park Service (NPS) has a direct interest in the barrier island components of the Mississippi Coastal Improvements Program (MsCIP), since Horn, Petit Bois, East and West Ship Islands, and portions of Cat Island are within Gulf Islands National Seashore (Seashore). The Seashore's purpose is to preserve, protect, and interpret its Gulf Coast barrier island and bayou ecosystem and its system of coastal defense fortifications, while providing for public use and enjoyment. Undeveloped natural resource areas protected by the NPS provide habitat for several endangered species, stop-over habitat for migratory birds, and critical nursery habitat for marine flora and fauna, and serve as an enclave for complex terrestrial and aquatic plant and animal communities that characterize the northern Gulf Coast. The Seashore also contains one of the most complete collections of publicly accessible seacoast defense structures in the United States, from early French and Spanish exploration and colonization through World War II.

Barrier islands are dynamic coastal landforms that act as the interface between ocean and land, and bear the full impact of atmospheric and oceanic energy. Hurricanes, variations in sediment supply, and sea level rise anticipated from global warming will drive changes in island location and morphology. Effective barrier island management requires adaptation to their dynamics.

Based on federal statutes such as the National Park Service Organic Act and the park's enabling legislation, NPS Management Policies, and the Seashore's management plans, the NPS is mandated to preserve natural conditions and processes, and to preserve cultural resources. If peer-reviewed scientific studies indicate that human activities have altered or interfered with natural conditions or processes of the Mississippi barrier islands, such as the natural sediment supply and transport rate and direction, the NPS would consider actions that would attempt to restore those natural processes. Restoration of natural processes would help to re-establish a more natural biological and geological condition within park boundaries.

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Restoration actions that NPS may consider acceptable and consistent within its legal mandates and authorities are:

<u>Immediate measures (1 year or less)</u>

- Sediment dredged from Ship Island Pass channel should be placed on the beach along the north (sound) shoreline near Fort Massachusetts on West Ship Island. The fort is a listed classified structure on the National Register of Historic Places. Renourishment would better protect the structural integrity of the fort, which currently is threatened by shoreline erosion, migration, and encroachment. Beach renourishment near the documented French Warehouse archaeological site on East Ship Island should also be undertaken, as this site is also currently exposed and threatened by erosion.
- Placement of sand fencing on the upper beach areas of East and West Ship Islands would assist natural dune formation and enhance wildlife habitat. Similar actions would not be appropriate on Horn and Petit Bois Islands given their designation as wilderness areas.
- Planting of sea oats and other native beach grasses and vegetation on East and West Ship Islands would aid the process of natural dune formation.

<u>Long term measures</u>

- Sand dredged from adjacent navigational/shipping channels should be re-deposited within the littoral system of the barrier islands. The additional sand supply would assist the island's natural recovery from recent storm events, and partially offset prior disruption to sediment transport and deposition from past human intervention. The sand must be free from contaminants and compatible in grain size, composition, and color with the existing beach and nearshore sediments.
- A Quality Assurance/Quality Control plan should be developed that includes adaptive management steps to halt, modify or mitigate the effects of activities with negative or adverse impacts to natural or cultural resources.

In order to make informed management decisions, and before beginning long-term measures, the NPS recommends additional scientific study to ensure that actions are effectively targeted and will not harm park resources.

1. Measure bathymetry to 40-ft depth from Dauphin Island to Cat Island, to help develop an improved sediment budget from 1917/20 (the most recent data set with complete bathymetric coverage) to the present.
2. Develop models to predict future location and geometry of the barrier islands at specific time intervals, perhaps 25, 50 and 100 years or longer into the future. Models should include forecasts of sea-level rise linked to global climate change.
3. Assess the quantity of sediment that has entered the Mississippi barrier island system through time from Mobile Pass and the Mobile ebb tidal delta, the primary source of sediment to the barrier islands.
4. Examine barrier island morphologic changes since the 2005 hurricane season to determine the extent of post-storm recovery.

I. <u>Introduction</u>

The National Park Service (NPS) has a direct interest in the barrier island components of the Mississippi Coastal Improvements Program (MsCIP). These barrier islands -- Horn, Petit Bois, East and West Ship Islands, and portions of Cat Island -- are all situated within Gulf Islands National Seashore, a unit of the National Park System. NPS also administers the 401-acre Davis Bayou area on the mainland near Ocean Springs, MS.

Gulf Islands National Seashore includes outstanding natural, cultural, and recreational resources along the Northern Gulf of Florida and Mississippi. These include several coastal defense forts spanning more than two centuries of military activity, archeological values, pristine examples of intact Mississippi coastal barrier islands, salt marshes, bayous and submerged seagrass beds, complex terrestrial communities, emerald green water, and white sand beaches.

The barrier islands within the Seashore are nationally significant for several reasons. Specifically, these islands:

1. Contain one of the most complete collections of publicly accessible seacoast defense structures in the United States, representing a continuum of development from early French and Spanish exploration and colonization through World War II.
2. Provide the public with recreational opportunities on natural and scenic island, beach, dune and water areas which possess the rare combination of remaining undeveloped and in a wilderness state, yet are located in close proximity to major population centers.
3. Provide habitat for several endangered species in diverse ecosystems, stop-over habitat for migratory birds, and critical nursery habitat for marine flora and fauna, and serve as an enclave for complex terrestrial and aquatic plant and animal communities that characterize the northern Gulf Coast and fully illustrate the natural processes which shape these unique areas.
4. Contain land and marine archeological resources which represent a continuum of human occupation in a coastal environment and are important in enhancing the knowledge of the past including interactions between the earliest settlers and original inhabitants of this area of the Gulf Coast.
5. Provide a benchmark to compare conditions in developed areas of the Gulf Coast to natural areas within the park.

The NPS manages the Gulf Coast barrier island system in accordance with the various federal laws which govern the National Park System and Gulf Islands National Seashore, NPS national management policies, and park-specific planning and management documents. The NPS management vision for the barrier islands, and several restoration actions potentially consistent with that vision, are explained in Section II. The legal, policy, and administrative authorities which form the foundation of the NPS's vision are explained in Section III. NPS management questions involving further scientific studies are presented in Section IV. The geomorphic origin and history of the island chain are explained in Appendix A.

II. NPS's Vision for the Mississippi Barrier Islands

The NPS's vision for management of the Mississippi barrier islands includes the preservation of natural biological and geological marine and terrestrial conditions and processes, and the preservation of cultural resources, consistent with peer-reviewed and documented scientific study.

Horn and Petit Bois Islands, which are designated wilderness areas, receive an even higher level of protection. In these areas, the NPS vision and management focuses on providing park visitors with an undisturbed environment, a pristine and unencumbered viewshed, an atmosphere of solitude, an opportunity for primitive, unconfined recreation, and negligible evidence of resource impairment. The NPS implements this vision by controlling nonconforming uses, preventing unnecessary or undue reduction of wilderness values, and applying the "minimum requirement" concept of the 1964 Wilderness Act to all proposed projects involving these islands.

The NPS's vision for the Mississippi barrier islands reflects an appreciation for the islands' geomorphic origin and history (see Appendix A). Studies indicate that hurricanes have historically segmented these barriers. A hurricane in 1740 split Isle Dauphin into Petit Bois and Dauphin Islands, while the July 1916 storm cut the Isle of Caprice in two. Furthermore, in 1969, Hurricane Camille split Ship Island into West Ship and East Ship Islands. Hurricanes, variations in sediment supply, and sea level rise anticipated from global warming will drive changes in island location and morphology. Effective barrier island management requires adaptation to their dynamics.

Nonetheless, if peer-reviewed studies provide evidence that human activities have altered or interfered with the natural condition or processes of the Mississippi barrier islands, such as the natural sediment supply and transport rate and direction, the NPS would consider actions that would attempt to restore these natural processes. Restoration of natural processes would, in turn, help to reestablish a more natural biological and geological marine and terrestrial condition within park boundaries, which NPS is charged to promote. Adaptive management principles would govern restoration actions, facilitated by continuing analysis of monitoring data to assess project effectiveness.

The following are restoration actions and associated specifications that NPS may consider acceptable and consistent with the legal mandates and other authorities listed above. NPS restoration actions identified below are contingent upon dedicated funding support for materials and staffing being provided as a component or line item cost incorporated into the MsCIP, as current NPS base funding is insufficient to cover these expenditures.

Immediate measures (1 year or less)

- Sediment dredged from Ship Island Pass channel should be placed on the beach along the north (sound) shoreline near Fort Massachusetts on West Ship Island. The fort is a listed classified structure on the National Register of Historic Places. Renourishment would better protect the structural integrity of the fort, which currently is threatened by active shoreline processes, including erosion, migration, and encroachment. Similarly, beach renourishment near the documented French Warehouse archeological site (GUIS-98, 22Hr-638) on East Ship Island would also be undertaken, as this site is also currently exposed and threatened by erosion due to active shoreline processes.

- Placement of sand fencing behind the upper beach area on both East Ship and West Ship Islands to assist in the process of natural dune formation and enhance wildlife habitat. Specific length and placement design of fencing will be determined in cooperation with park staff. Similar actions on Horn and Petit Bois islands are not feasible considering their designation as wilderness areas, and the coinciding higher conservation standards, and non-manipulative management objectives applying to these areas, as stipulated in Section III, C of this document.

- Planting of sea oats and other native beach grasses and vegetation on East and West Ship Islands as deemed appropriate by park science and natural resources management staff. The native vegetation could also aid in the process of natural dune formation.

Long term measures

- Sediment (sand) dredged from any of the adjacent navigational/shipping channels should be re-deposited within the littoral system of the barrier islands. Sand would be placed to mimic to the greatest extent possible natural sediment depositional processes, including within the surf zones, or as otherwise prescribed based on analysis of the longshore transport system. Sand placement would supplement the supply to the island where it has been significantly diminished or eliminated by dredging of shipping channels, with an estimated withdrawal of ~72 mcy of sand from the system over the last 100+ years. The additional sand supply would assist the island's natural recovery from recent storm events, and partially offset prior disruption to sediment transport and deposition from human-caused intervention.

- Any placement of dredged sediment within the park boundaries, whether on a barrier island beach or within the littoral system, would be contingent upon tests that show that the sediments are free from contaminants and are compatible in grain size, composition, and color with the existing beach and nearshore sediments. Dredging and sediment disposal, which have a significant potential to impact many of the animal communities on and around the islands, should be timed to avoid periods of high or seasonal animal activity. Limiting sediment dredging and disposal actions to certain months would reduce or minimize impacts to several threatened and endangered species that spend at least a portion of the year within the barrier island area, as well as non-listed species such as migratory shorebirds which may be particularly sensitive to on-island and nearshore disturbances.

- A Quality Assurance/Quality Control (QA/QC) plan should be developed, possibly as part of the NEPA or environmental compliance process, to monitor both adverse and beneficial impacts of any activities undertaken within the boundaries of GUIS as part of the MSCIP. The QA/QC plan should include monitoring during construction activities to measure immediate or short-term impacts, as well as for a specified time period after construction activities are completed to measure long-term or cumulative impacts. The plan should also include adaptive management steps to halt or modify activities, or to mitigate the effects of activities, should negative or adverse impacts to natural or cultural resources be noted during monitoring. The QA/QC plan would be developed through coordination between the US Army Corps of Engineers, National Park Service, the US Fish and Wildlife Service and the National Marine Fisheries Service.

III. Statutory, Policy, and Administrative Foundation of the NPS Vision for the Mississippi Barrier Islands

The NPS vision for managing the Mississippi barrier islands is derived directly from the federal laws which govern the National Park System and Gulf Islands National Seashore. Because Horn and Petit Bois Islands are also designated wilderness areas, the NPS's vision for these islands is additionally derived from the law which established the National Wilderness Preservation System.

A. Statutory Basis for NPS Management of the Mississippi Barrier Islands

In the **National Park Service Organic Act of 1916** (16 U.S.C. § 1), Congress stated that "There is hereby created in the Department of the Interior a service to be called the National Park Service, which shall be under the charge of a director....The service thus established shall promote and regulate the use of the Federal areas known as national parks, monuments, and reservations hereinafter specified, except such as are under the jurisdiction of the Secretary of the Army, as provided by law, by such means and measures as conform to the fundamental purpose of the said parks, monuments, and reservations, which purpose is to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations."

Subsequently, in the **National Park System General Authorities Act of 1970**, Congress clarified that national park areas are to be "preserved and managed for the benefit and inspiration of all of the people of the United States, in light of the high public value and integrity of the National Park System" (16 U.S.C. § 1a-1). In the **National Parks Omnibus Management Act of 1998,** Congress instructed the NPS to integrate the results of scientific research into its management decisions (16 U.S.C. § 5936).

In the **enabling legislation which established Gulf Islands National Seashore**, Congress instructed the NPS to preserve for public use and enjoyment the outstanding natural, historic, and recreational values of the area, including wildlife natural resources and the military forts within the park (16 U.S.C.§ 459h). Congress further stipulated that "[t]he Secretary of the Interior and the Secretary of the Army may cooperate in the study and formulation of plans for beach erosion control and hurricane protection of the Seashore. Any such protective works or spoil deposit activities undertaken by the Chief of Engineers, Department of the Army, shall be carried out within the seashore in accordance with a plan that is acceptable to the Secretary of the Interior and that is consistent with the purposes of sections 459h to 459 h-10 of this title."

As required by the **Endangered Species Act of 1973** (16 U.S.C. § 1531 et seq.), the NPS also strives to conserve threatened and endangered species at Gulf Islands National Seashore, ensuring that its authorization, funding, or implementation of activities will not jeopardize the existence of any endangered or threatened species of plant or animal (including fish) or result in the destruction or deterioration of critical habitat of such species.

The Mississippi barrier islands also contain a number of sites of historic/archaeological value, including Fort Massachusetts on West Ship Island, which is a listed classified structure on the National Register of Historic Places. The NPS preserves these cultural resources and landscapes as required by the **National Historic Preservation Act** (16 U.S.C. § 470 et seq.).

Additionally, Horn and Petit Bois islands are designated wilderness areas and are therefore subject to the provisions of the **Wilderness Act of 1964** (16 U.S.C. §§ 1131, 1133), which directs federal land management agencies to preserve the wilderness character of the areas, including the preservation of natural conditions with the imprint of man's work substantially unnoticeable.

B. Policy Basis for NPS Management of the Mississippi Barrier Islands

The NPS's management vision for the Mississippi barrier islands is additionally derived from the Service-wide NPS Management Policies. Updated in 2006 after extensive review and comment from the general public, the scientific community, and agency employees, the NPS Management Policies are mandatory for all NPS employees unless specifically waived or modified in writing by the Secretary of the Interior, the Assistant Secretary of the Interior, or the Director of the National Park Service.

The sections of the NPS Management Policies most relevant to NPS management of the Mississippi barrier islands are quoted here. The policies are available in their entirety at www.nps.gov/policy/mp/policies.html or www.nps.gov/policy/MP2006.pdf.

(1) Section 4.4.2.4: Management of Natural Landscapes

"Natural landscapes disturbed by natural phenomena, such as landslides, earthquakes, floods, hurricanes, tornadoes, and fires, will be allowed to recover naturally unless manipulation is necessary to (1) mitigate for excessive disturbance caused by past human effects, (2) reserve cultural and historic resources as appropriate based on park planning documents, or (3) protect park developments or the safety of people. Landscape and vegetation conditions altered by human activity may be manipulated where the park management plan provides for restoring the lands to a natural condition."

(2) Section 4.8.1.1: Shorelines and Barrier Islands

"Natural shoreline processes (such as erosion, deposition, dune formation, overwash, inlet formation, and shoreline migration) will be allowed to continue without interference. Where human activities or structures have altered the nature or rate of natural shoreline processes, the Service will, in consultation with appropriate state and federal agencies, investigate alternatives for mitigating the effects of such activities or structures and for restoring natural conditions…Any shoreline manipulation measures proposed to protect cultural resources may be approved only after an analysis of the degree to which such measures would impact natural resources and processes, so that an informed decision can be made through an assessment of alternatives. Where erosion control is required by law, or where present developments must be protected in the short run to achieve park management objectives, including high-density visitor use, the Service will use the most effective method feasible to achieve the natural resource management objectives while minimizing impacts outside the target area."

(3) Section 4.1.5: Restoration of Natural Systems

"The Service will reestablish natural functions and processes in parks unless otherwise directed by Congress. Landscapes disturbed by natural phenomena, such as landslides, earthquakes, floods, hurricanes, tornadoes, and fires, will be allowed to recover naturally unless manipulation is necessary to protect other park resources, developments, or employee and public safety. Impacts on natural systems resulting from human disturbances include the introduction of exotic species; the contamination of air, water, and soil; changes to hydrologic patterns and sediment transport; the acceleration of erosion and sedimentation; and the disruption of natural processes. The Service will seek to return such disturbed areas to the natural conditions and processes characteristic of the ecological zone in which the damaged resources are situated. The Service will use the best available technology, within available resources, to restore the biological and physical components of these systems, accelerating both their recovery and the recovery of landscape and biological community structure and function."

(4) Section 4.4.1: General Principles for Managing Biological Resources

"The National Park Service will maintain as parts of the natural ecosystems of parks all plants and animals native to park ecosystems….by

- preserving and restoring the natural abundances, diversities, dynamics, distributions, habitats, and behaviors of native plant and animal populations and the communities and ecosystems in which they occur; …. and
- minimizing human impacts on native plants, animals, populations, communities, and ecosystems, and the processes that sustain them."

(5) Section 4.4.2.3: Management of Threatened or Endangered Plants & Animals

"The Service will survey for, protect, and strive to recover all species native to national park system units that are listed under the Endangered Species Act. The Service will fully meet its obligations under the NPS Organic Act and the Endangered Species Act to both proactively conserve listed species and prevent detrimental effects on these species."

(6) Section 4.6.4: Floodplains

"In managing floodplains on park lands, the National Park Service will (1) manage for the preservation of floodplain values; (2) minimize potentially hazardous conditions associated with flooding; and (3) comply with the NPS Organic Act and all other federal laws and executive orders related to the management of activities in flood-prone areas, including Executive Order 11988 (Floodplain Management), the National Environmental Policy Act, applicable provisions of the Clean Water Act, and the Rivers and Harbors Appropriation Act of 1899."

(7) Section 4.6.5: Wetlands

"The Service will manage wetlands in compliance with NPS mandates and the requirements of Executive Order 11990 (Protection of Wetlands), the Clean Water Act, the Rivers and Harbors Appropriation Act of 1899, and the procedures described in Director's Order 77-1 (Wetland Protection). The Service will (1) provide leadership and take action to prevent the destruction, loss, or degradation of wetlands; (2) preserve and enhance the natural and beneficial values of wetlands; and (3) avoid direct and indirect support of new construction in wetlands unless there are no practicable alternatives and the proposed action includes all practicable measures to minimize harm to wetlands."

(8) Sections 6.1, 6.3.3, 6.3.5, & 6.3.7: Wilderness Management

These sections direct the National Park Service to manage wilderness areas for the use and enjoyment of the American people in such a manner as will leave them unimpaired for future use and enjoyment as wilderness. They further charge the NPS to (1) administer designated wilderness lands consistently among agencies but in no way diminish any established NPS wilderness standards and values.; (2) keep human-caused intrusions within wilderness to an absolute minimum; (3) ensure proposed actions are narrow in scope and the least required to effectively preserve wilderness character; and (4) apply science-based decision making in all NPS wilderness areas.

(9) Sections 5.3.5, 5.3.5.1, 5.3.5.1.1-4: Cultural Resources

Recognizing that the NPS is the steward of many of America's most important cultural resources, including archeological sites, as well as historic and prehistoric structures, the NPS Management Policies specify that park cultural resource management involves: (1)

research to identify, evaluate, document, register, and establish basic information about cultural resources and traditionally associated peoples; (2) planning to ensure that management processes for making decisions and setting priorities integrate information about cultural resources and provide for consultation and collaboration with outside entities; and, (3) stewardship to ensure that cultural resources are preserved and protected, receive appropriate treatments to achieve desired conditions, and are made available for public understanding and enjoyment.

C. Administrative Planning Basis for NPS Management of the Mississippi Barrier Islands

In 1978, Gulf Islands National Seashore produced a General Management Plan (GMP) which provides long-term direction for administering the Seashore. Congress requires each park unit to have a GMP to guide park decisions about resource preservation, visitor use, and park management. GMPs are developed and adopted with much public review and input. Gulf Islands National Seashore is developing a new General Management Plan, which is anticipated to be completed in 2009-2010. Until then, the existing 1978 GMP, its 1983 amendment, and a 1995 updated Statement for Management will remain in effect.

As directed by the 1978 GMP, the NPS must manage the Mississippi barrier islands in the following ways:

- Keep development to a minimum, and manage Petit Bois and Horn Islands as wilderness areas emphasizing their primitive character and limited development.
- Promote diverse marine biota in Mississippi Sound, and the surrounding Gulf of Mexico waters and diverse estuarine biota at Davis Bayou, and assure that activities within the Seashore have the least possible effect on the population of fish, shellfish, and other marine and estuarine organisms.
- Minimize disturbance of natural landforms, vegetation, and wildlife by human-caused activities and restoring ecological conditions on lands adversely affected by such uses and activities in the past.
- Protect and perpetuate the Seashore's natural resources and managing them in ways that enhance natural, ecological, and geological processes and mitigate the adverse effects of human activities.
- Perpetuate suitable habitat conditions to support the Seashore's rich flora and fauna, with particular emphasis on Federally or State endangered or threatened species or, other species of management concern.
- Allow for the natural processes of storms and hurricanes related to barrier island development, by minimizing construction and development of facilities in areas prone to natural channelization and overwash, or otherwise dynamically active.

NPS management of Horn and Petit Bois Islands is also based on the Congressionally-mandated Wilderness Management Plan, completed in 2004. In accordance with this plan, the NPS objectives for these island wilderness areas are to (1) provide for solitude and primitive, unconfined recreation; (2) preserve the character of the wilderness, including a pristine, unencumbered viewshed; and (3) control nonconforming use and prevent unnecessary or undue reduction of wilderness values. The plan further establishes that the NPS's desired future condition for Horn and Petit Bois Islands is a wilderness area unaffected by the works and acts of humankind, where minimum tools or techniques are used in the completion of any project.

IV. <u>Information Needs for NPS Management</u>

The questions listed below were developed by NPS to highlight perceived scientific data needs and research gaps with respect to geomorphology issues to be addressed for NPS to make informed management decisions as to potential restoration alternatives for the barrier islands as part of the MsCIP. The study needs following the questions identify studies and research likely to yield data that could be used to address NPS management needs framed in the questions. The study needs should be regarded as only an initial list, and NPS would welcome the opportunity to work with the Army Corps of Engineers and the U.S. Geological Survey, as well as other agencies, to further refine these study needs.

A. NPS Scientific Data/Research Questions

1. To what extent have human-caused actions, principally from dredging of shipping channels in proximity to the MS barrier islands, altered the sediment transport and depositional processes of the islands?
2. Taking a modeling approach, what would the configuration/make-up of the MS barrier islands be today had sediment transport processes not been disrupted through human intervention, including reoccurring dredging to maintain adjacent shipping channels?
3. Taking a modeling approach, what is the projected future (25, 50, & 100-year intervals) configuration/make-up of the barrier islands given existing conditions vs. what the islands may otherwise look like if natural processes, including hurricane effects, were the only contributing factor to island migration historically and over time?
4. Factoring in the unpredictability of climate change and sea level rise, as well as hurricane frequency, what is the projected future location and configuration of the barrier islands (25, 50, & 100-year intervals)? The modeling studies should use both the long-term relative sea-level rise for the area, as well as one or more increased rates of sea-level rise as predicted with global climate warming data.
5. Given the present sediment transportation and depositional processes, where might additional sand be introduced into the active coastal system to most effectively maintain the MS barrier islands?

B. Further Study Needs

1. Measurement of the present-day bathymetry to a 40-ft depth for the Mississippi barrier island area from Dauphin Island to Cat Island. The most recent bathymetric data from 1960/1971 included only limited

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coverage offshore of the barrier islands. More extensive coverage of the present-day bathymetry could be used to formulate an improved historical sediment budget from 1917/20 (the most recent data set with complete bathymetric coverage) to the present. Measurement of the present-day bathymetry would allow the ongoing dredging and placement activities around Ship Island Pass and Horn Island Pass to be incorporated into the sediment budget.

2. Modeling studies to predict future location and geometry of the barrier islands at various scenarios of sea level rise. Existing information on historical shoreline change, bathymetric change, and dredging records, as well as any additional present-day bathymetric data that could be collected, may also be utilized in the studies that would predict future change in the barrier islands at specific time intervals (perhaps 25, 50, 100 years or longer) in the future. The modeling studies should use both the long-term relative sea-level rise for the area, as well as one or more increased rates of sea-level rise as predicted with global climate warming data.
3. Better understanding of the quantity of sediment that has entered the Mississippi barrier island system from Mobile Pass and the Mobile ebb tidal delta, the origin of the sediment supply to the barrier islands. A sediment budget should be developed for the Dauphin Island area that would quantify sediment transport from Mobile Pass and the Mobile Pass ebb tidal delta to Dauphin Island, and from Dauphin Island westward towards Petit Bois Island. A historical sediment budget could be developed based on existing bathymetric change, shoreline position change and dredging records. A hypothetical present-day sediment budget could also be developed based upon present-day bathymetric data and shoreline positions, incorporating dredging activities in and around Mobile Pass.
4. Studies to examine barrier island morphologic changes since the 2005 hurricane season to help determine the extent of storm recovery. Studies may use a combination of data sets, and include for example, the present-day bathymetry and hypothetical sediment budget. Full LiDAR (scanning airborne laser altimetry) and aerial video and photography coverage of the islands could be collected and compared with post-Katrina data collected in 2005 to quantify changes in elevation and shoreline position. Precise shoreline position and elevation data may also be collected in the field using high resolution GPS ground surveys to verify the laser altimetry data. These data sets may help identify the most effective locations and quantities of additional sediment to be introduced into the barrier island littoral system.

Appendix A
Geomorphology of the Mississippi Barrier Islands

Barrier islands are extremely dynamic coastal landforms. They act as the interface between ocean and land, and bear the full impact of atmospheric and oceanographic energy. Composed primarily of sand and water, the features and habitats of the islands are constantly changing and evolving through time. The following excerpt from the Geologic Resource Evaluation Scoping Summary for Gulf Islands National Seashore (KellerLynn, 2007) briefly describes the origin and history of the Mississippi barrier islands located within the seashore.

The six barrier islands along the Mississippi Sound are parallel to the Pleistocene mainland coast (fig. 1). Dauphin Island, the only island not part of the national seashore, is at the mouth of Mobile Bay; westward are Petit Bois, Horn, East Ship, West Ship, and Cat islands. The sound behind the islands is very wide, more than 7 miles (11 km) on average, and deepens gradually from the mainland shore to the islands, with depths exceeding 20 feet (6.1 m) locally (Kwon, 1969).

As in Florida, the barrier islands in Mississippi formed from shoals (Otvos, 1979). Natural interactions between relative sea level, sediment supply, and meteorological-oceanographic conditions, and human-induced changes from dredging, sediment diversion, and habitat modifications resulted in the present configuration (Schmid, 2003). According to Otvos and Giardino (2004), the earliest barrier islands emerged between 5,700 and 5,000 years ago, when sea level was lower than present by 3.2 to 4.9 feet (1.0–1.5 m).

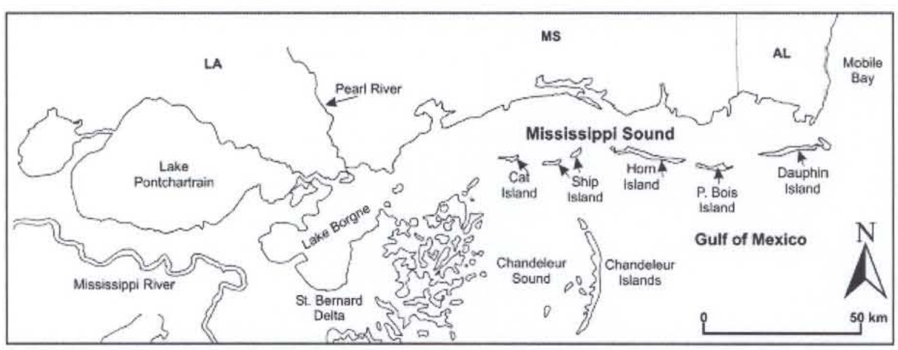

Figure 1. Index map of major landforms in the Mississippi Sound barrier island chain. *Source*: Otvos and Giardino (2004).

The islands formed against a background of decelerating late Holocene sea-level rise. At this time, eastern Dauphin Island represented a higher Pleistocene ground that was veneered by Holocene beach and dune deposits. Dauphin Island became the transmission site for large volumes of littoral sand. From this small island, the rest of Dauphin Island aggraded and extended westward as a narrow, shore-parallel sandy shoal platform (Otvos and Giardino, 2004). By "capturing" the sand that arrived from the Alabama mainland shore through current and drift processes via the Mobile Bay ebb-tidal delta and steering it westward along its south shore, eastern Dauphin Island probably played an important role in originally determining the general offshore position of the whole barrier island chain, which extended well into southeastern Louisiana (Otvos and Giardino, 2004). Many new barrier sectors formed downdrift by gradual extension over adjacent shoal platform areas.

Historic trends indicate that island reduction by storm and fair-weather erosion to subtidal levels alternated with periods of platform aggradation above low-tide level. For instance, the earliest islands and beach ridges of still existing islands east of Cat Island were replaced by shoal areas or more recent islands (Otvos, 1981). Square Handkerchief Shoal west of and aligned with Cat Island probably represents the platform of an extinct barrier (Otvos and Giardino, 2004). Between 3,500 and 4,000 years ago, the St. Bernard delta of the Mississippi River (see fig. 1) prograded into the area west of the Mississippi barrier islands. Mainland extension and marsh development as a result of this progradation stranded the barrier islands and halted their westward migration. Sediments from the delta created shoals in present-day Mississippi Sound, which interrupted westward-directed littoral drift, diminished the impact of the Gulf wave regime, and deactivated Cat Island and the Square Handkerchief Shoal by approximately 2,400 years ago. Cat Island, its sand supply from the other islands cut off by surrounding shoal waters, kept eroding on its eastern end. Shore erosion, combined with subsidence, eliminated the oldest ridge sets off northern Cat Island long ago (Otovs, 1979). Another example of periodic erosion and aggradation is "Isle of Caprice," which existed between Horn and "Ship" islands between the early 1900s and 1940. This island and its neighboring group of islands ("Dog Keys") had a history of emergence, punctuated by episodes of these islets becoming shoals (Otvos, 1979; 1981).

The erosive history of the island chain suggests a relatively short life expectancy (Otvos and Giardino, 2004). French and British charts from the 18th century indicate that Dauphin and Petit Bois islands once formed a single entity ("Isle Dauphin") (Otvos, 1979). The oldest (eastern) part of Petit Bois Island formed the western sector of this ancient island that also incorporated present-day Dauphin Island. After Petit Bois and Dauphin were separated, Petit Bois gradually lost its narrow eastern sector. Widening to a record 5.3 miles (8.5 km) by 1957, Petit Bois Pass now overlaps with the former island area. Since the 1850s, Petit Bois has prograded westward, in downdrift direction (Otvos, 1979). While Petit Bois advanced approximately 3.1 miles (5.0 km) westward between 1850 and 1974, its 9.6-mile- (15.5 km) long eastern sector reverted to a shoal platform. Chart and survey data document a 26% area reduction in Ship, Horn, and Petit Bois islands, declining from a combined surface area of 15.5 square miles (40.2 km^2) in 1850 to 11.5 square miles (29.7 km^2) in 2000 (Otvos and Giardino, 2004).

Although episodic, hurricane destruction and segmentation have played an essential role in the evolution of all the Mississippi Sound barriers (Otvos, 1979) (see "Hurricane-generated Features" section). For instance, during the 1740 hurricane, Isle Dauphin was separated into Petit Bois and Dauphin islands (Otvos, 1979); Isle of Caprice was cut in two by the July 1916 hurricane (Otvos, 1979); and Ship Island was split into West Ship and East Ship islands during Hurricane Camille in 1969 (Falls, 2001). In 2005, Hurricane Katrina completely submerged the entire barrier island chain, segmenting several of the islands and causing significant erosion.

Chapter 3 Sediment Transport Modeling and Sediment Budget

3.1 Introduction and Purpose

In order to conceive any realistic plan for island restoration, it is necessary to understand the physical processes that move sand along the littoral drift zone off the coast of Mississippi. This littoral zone influences the character of the Mississippi barrier islands as they exist in an ever-changing cycle. To help in this understanding, a sediment transport model was conducted to establish a sediment budget for the islands. This study evaluated the existing regional sediment transport magnitudes and directions for the Mississippi and Alabama barrier islands fronting Mississippi Sound and the mainland coast, including an analysis of historical long-term barrier island migration. Based on analysis of previous studies, historical bathymetric and shoreline change, and numerical modeling, a suite of sediment budgets was developed. First, a conceptual sediment budget was developed through a review of existing studies; this budget formed the framework for the historical and calculated sediment budgets. Next, a historical sediment budget was developed through analysis of bathymetric and shoreline position change through time. Engineering activities and significant storm events were also documented. A calculated sediment budget was developed based on numerical modeling of regional waves and sediment transport, for the Gulf and Bay shorelines of the barrier islands as well as the mainland coast. The final sediment budget was formulated from all these intermediate budgets, and is presented herein along with a summary of information pertinent to the final budget. Details about the conceptual, historical, and calculated sediment budgets and further discussion of the entire study can be found in the draft Regional Sediment Budget for Mississippi Mainland and Barrier Island Coasts, (Rosati et al. 2007). Volume change and sediment budget calculations in the 2007 draft MsCIP sediment budget report will be updated during the advanced engineering and design phase using the Jan 2008 upgrade to ESRI's ArcGIS. This recent software upgrade allows more accurate procedures for quantifying volumetric change than were applied when the report was originally written in the spring of 2007. These changes are not likely to impact overall trends in the regional sediment transport system, but may change the magnitude of volumetric differences.

3.2 Mississippi Coast Physical Setting and Processes

The barrier islands in the project area, Cat, West and East Ship, Horn, Petit Bois, and Dauphin Islands, provide the offshore boundary for Mississippi Sound (Figure 3.2-1). These islands are the first line of defense for the mainland as tropical storms, hurricanes, and cold fronts pass the region. Table 3.2-1 summarizes the tropical storm and hurricane history for locations in and around the study area from 1871 (or 1872) through 2006. Because data were not provided for a city in Hancock County, New Orleans, Louisiana is shown in Table 3.2-1 to provide a western boundary to the study area. Locations in Hancock County are assumed to have storm occurrences similar to those presented for New Orleans and Gulfport.

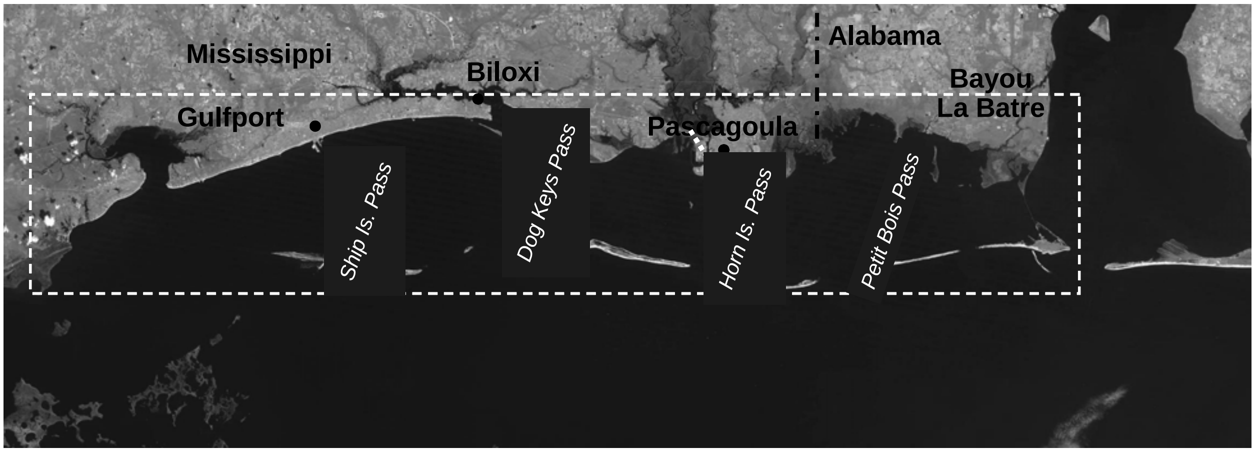

Figure 3.2-1. Mississippi Gulf Coast, showing barrier island system, navigation channels, and the area of study for the regional sediment budget (image courtesy NASA's Earth Observatory, dated 15 Sep 05)

Table 3.2-1.
Storms within 60 miles of selected Mississippi, Alabama, and Louisiana Cities west of Mobile Bay, 1871/2 through 2006[1]

Location (from west to east)	Year of Storm Occurrence t=tropical storm; b=brush; h=hurricane	Frequency of Occurrence (yr)	
		Brush or Hit	Direct Hit
New Orleans, LA	1879h, 1879t, 1887h, 1888b, 1897b, 1892t, 1893h, 1900tb, 1901h, 1905t, 1907t, 1909h, 1914t, 1915h, 1916b, 1932t, 1934tb, 1936t, 1944tb, 1947h, 1948h, 1949t, 1955t, 1964t, 1965h, 1969b, 1979h, 1985b, 1988t, 1992b, 1998t, 2002t(2), 2004tb, 2005t, 2005h	3.8	12.4
Gulfport, MS	1872t, 1879b, 1881b, 1885t, 1885tb, 1887t, 1892t, 1893h, 1895t, 1900t, 1901b, 1904tb, 1905tb, 1906h, 1907tb, 1912b, 1914tb, 1916h, 1923t, 1926t, 1932b, 1934tb, 1944t, 1947h, 1947t, 1955tb, 1960t, 1965b, 1969h, 1979b, 1985h, 1988b, 1998h, 2002tb, 2002t(2), 2004b, 2005t, 2005h	3.5	15.1
Biloxi, MS	1879b, 1880b, 1881t, 1885t, 1885tb, 1887t, 1892tb, 1893h, 1895h, 1900t, 1901h, 1906h, 1907tb, 1912h, 1916h, 1923t, 1926h, 1932h, 1934tb, 1947h, 1955tb, 1960t, 1969h, 1985h, 1997b, 1998h, 2002t, 2002tb, 2004b, 2005t, 2005h	4.4	11.3
Pascagoula, MS	1872b, 1881t, 1885t, 1885tb, 1887t, 1893h, 1893b, 1895t, 1900t, 1901h, 1902tb, 1904tb, 1906h, 1912h, 1914tb, 1916h, 1923tb, 1926h, 1932h, 1934tb, 1944tb, 1947b, 1950b, 1960b, 1969h, 1979h, 1985h, 1998h, 2002t, 2004h, 2005t, 2005h	3.8	9.7
Dauphin Island, AL	1880b, 1881t, 1882b, 1885, 1887t, 1893h, 1895tb, 1900t, 1901t, 1902t, 1904t, 1906h, 1910h, 1911b, 1912b, 1914tb, 1916b, 1919tb, 1922tb, 1923tb, 1926h, 1932h, 1934t, 1939t, 1944tb, 1947t, 1950h, 1956b, 1959t, 1960tb, 1979h, 1985h, 1985tb, 1995b, 1997h, 1998b, 2002t, 2004h, 2005(2)tb, 2005h	3.3	11.3

[1] http://www hurricanecity.com/. This database does not have any locations in Hancock County, Mississippi; thus, data for New Orleans, Louisiana are included to provide a western boundary for the study area. Locations in Hancock County are assumed to have storm occurrences similar to those provided for New Orleans and Gulfport.

The frequency of direct landfall is approximately equal for Biloxi, Pascagoula, and Dauphin Island, with a direct hit every 10-11 years. The likelihood for a direct hit decreases to approximately once every 15 and 12 years for Gulfport and New Orleans, respectively. However, all locations listed in Table 3.2-1 have historically been brushed or hit with a tropical storm or hurricane approximately once every 3-4 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. 1999).

The 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 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.

Tides in Mississippi Sound are diurnal, with a tidal range of 1.5 ft and 1.8 ft for the mean and spring tides at Biloxi, Mississippi[2], respectively. However, the relatively shallow and large area of the Sound create strong currents in the 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 the 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).

For the Gulf barrier island beaches, net longshore sediment transport is from east to west, although local reversals in the net transport occur adjacent to the tidal passes. The primary sources of sediment are longshore sediment transport from east to west, and, potentially, the offshore shelf (Otvos 1979, Cipriani and Stone 2001). Cipriani and Stone (2001) discussed that a well-defined cellular structure exists for each barrier island in which, over historic times, little sand transfer exists between islands. However, dredging records at Horn Island and Ship Island Passes (also called Pascagoula Bar Channel and Gulfport Bar Channel, respectively) suggest that infilling of sand from adjacent barrier islands occurs, indicating the potential for transport of sand between islands. Eastern Dauphin Island, with a Pleistocene core, is more stable than the other barriers although eastern Dauphin Island has been eroding in response to the dominant westerly-directed transport. Based on grain size analysis, Cipriani and Stone (2001) inferred that offshore sources may provide some sediment to central Petit Bois Island. The Mississippi Sound barrier islands range from very well vegetated, with maritime forests on east Dauphin Island, to low elevation barriers that are overwashed and breached during hurricanes. Long-term relative sea level rise for Dauphin Island, Alabama from 1966 to 1997 was 0.12 +/- 0.023 in/year[3].

On the mainland coast, beach change in Harrison County has been dominated by harbor construction, beach restoration and replenishment since 1951 (Byrnes et al. 1993a, 1993b). Cross-shore sediment transport processes dominate beach change, with wave-induced sediment transport processes of secondary importance, typically from east-to-west (Byrnes et al. 1993a, 1993b). Hancock County had beach nourishment in 1993-1994 between Waveland and Bay St Louis and again in 1996 for the Bay St Louis Downtown beach (Schmid 2002). Net longshore transport in Hancock County is generally from northeast to southwest. The bays, distributaries, and bayous of

[1] http://www.wavcis.lsu.edu/, dated 11 December 2006, accessed 11 December 2006.
[2] http://tidesandcurrents.noaa.gov/tides05/tab2ec4.html#107, dated 25 March 2005, accessed 11 December 2006.
[3] http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=8735180, dated 10 February 2006, accessed 29 July 2006.

the remaining coast are typically bordered with marsh populated by *Spartina-Juncus* succession (Christmas 1973).

3.3 Review of Existing Studies and Dredging Database

Existing studies were reviewed for the project area to provide information about sediment transport processes of the barrier island and mainland coast. This knowledge gained was incorporated into the sediment budget as appropriate. For a full summary of each study that was reviewed, please see Rosati et al. (2007).

Dredging rates for navigation channels within Mississippi Sound were also evaluated in the study. As was shown in Figure 3.2-1, the study area is traversed by many navigation channels: two "bar" channels that extend through Horn Island Pass (also called Pascagoula Bar Channel) and Ship Island Pass (also called Gulfport Bar Channel); the Gulf Intercoastal Waterway (GIWW) that runs east-west through Mississippi Sound; and five Sound navigation channels that extend from Gulfport, Biloxi, Pascagoula, Bayou Cassotte, and Bayou La Batre. The SAM dredges these channels on a regular basis. The U.S. Army Corps of Engineers' Navigation Data Center[4] (NDC) has documented all Corps contract and non-contract dredging for all Districts for Fiscal Year (FY) 1990 through 2005. NDC's database for SAM's entire District dredging program is provided in Rosati et al. (2007).

Byrnes and Griffee (2007) culled historical dredging and placement information from published Corps reports and databases to develop annual dredging and placement rates for each of the bar channels. Sediment dredged from the GIWW and other channels extending through Mississippi Sound was side-cast or placed in disposal areas to either side of the channels, and is assumed to shoal primarily from fine sediment that is mobilized in the bay. Thus, these dredging and placement activities in the Sound do not change the sediment budget for the mainland and barrier islands. However, dredging and placement adjacent to the barrier islands (Ship Island Pass/Gulfport Bar Channel and Horn Island Pass/Pascagoula Bar Channel) must be considered in the sediment budget.

Dredging data provided by Byrnes and Griffee (2007) have been analyzed to provide estimated maintenance shoaling rates for each of the Bar Channels as a function of channel depth, width, and length (Table 3.3-1). Of particular interest is the maintenance dredging rate as a function of channel depth, as shown in Figure 3.3-1.

Table 3.3-1.
Summary of Dredging Rates for Navigation Channels Adjacent to Barrier Islands (modified from Byrnes and Griffee 2007)

Date	Description	New Work (cy)	Maintenance (cy)
Ship Island Pass/Gulfport Bar Channel (Data from 1881-2003)			
Mar 1899–Mar 1948	26-ft deep, 300-ft width, 0.76-mile long channel (1.9-mile length dredged in 1922)	163,401	2,115,576 (43,175 cy/yr) (33,028 cu m/yr)
Mar 1948–Jul 1992	32-ft deep, 300-ft wide, 8 miles long	3,679,044	21,111,495 (476,200 cy/yr) (364,292 cu m/yr)
Nov 1993–Apr 2003	38-ft, 300-ft wide, 8 miles long	9,695,988	5,456,817 (579,485 cy/yr) (443,306 cu m/yr)

[4] http://www.iwr.usace.army.mil/NDC/data/datadrg.htm , updated 25 July 2006, accessed 13 December 2006.

Table 3.3-1.
Summary of Dredging Rates for Navigation Channels Adjacent to Barrier Islands
(modified from Byrnes and Griffee 2007)

Date	Description	New Work (cy)	Maintenance (cy)
1899 to 2003	**Total Dredging**	**13,538,433**	**28,683,888 (275,807 cy/yr) (210,992 cu m/yr)**
Horn Island Pass/Pascagoula Bar Channel (Data from 1881-2005)			
Feb 1897–Mar1948	25-ft deep, 300-ft wide channel	896,748	1,735,817 (34,000 cy/yr) (26,010 cu m/yr)
Mar 1948–Jan 1965	38-ft deep, 325-ft wide, 2.8 mile length	2,910,835	2,711,925 (161,104 cy/yr (123,245 cu m/yr)
Jan 1965–Sep 1993	40-ft deep, 350-ft wide; Impoundment area along the western end of Petit Bois Island	1,305,589	14,772,517 (515,320 cy/yr) (394,220 cu m/yr)
Sep 1993–Nov 2005	44-ft deep, 550-ft wide; Impoundment area along the western end of Petit Bois Island	3,117,658	2,986,712 (245,483 cy/yr) (187,690 cu m/yr)
1897 to 2005	**Total Dredging**	**8,230,830**	**22,206,971 (205,600 cy/yr) (157,284 cu m/yr)**

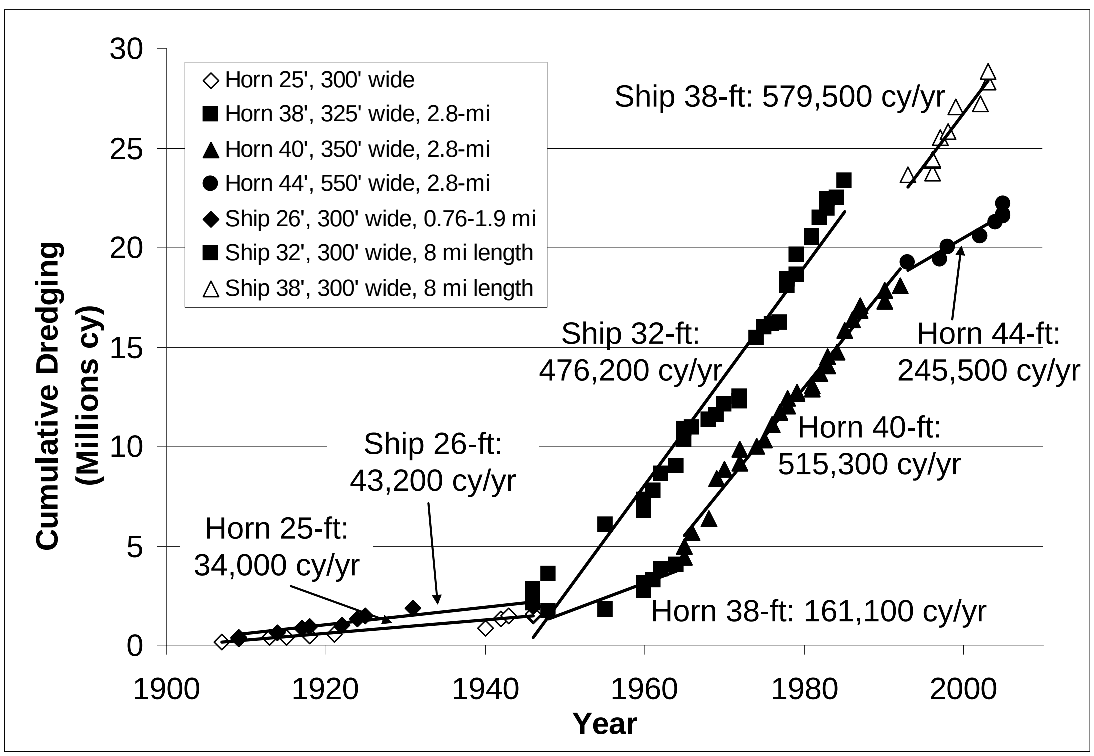

Figure 3.3-1. Cumulative maintenance dredging volumes and associated dredging rates for Horn Island Pass (Pascagoula Bar Channel) and Ship Island Pass (Gulfport Bar Channel)

These data indicate that deepening Ship Island Pass in 1948 by 23% (from 26 to 32 ft depth) and lengthening the channel (from 0.76 and 1.9 miles to 8 miles) increased the maintenance dredging rate by more than an order of magnitude (from 43,200 to 476,200 cy/yr). Dredging rates also increased more than an order of magnitude at Horn Island Pass through several depth increases from 25 to 40 ft, an increase in width from 325 to 350 ft, and length to 2.8 miles (dredging increased from 34,000 to 515,300 cy/yr). However, the dredging rate at Horn Island Pass decreased most recently when the channel was deepened to 44 ft and widened to 550 ft. This decrease in shoaling is opposite to what would be expected and possibly indicates a change in dredging or placement practices at Horn Island Pass. As these channels were deepened, they were also lengthened to provide safe navigation from a similar depth contour offshore. Thus, the deeper channels not only provided a better trap for sand moving alongshore but also resulted in longer channels which captured more of sand that is being transported in the offshore zone.

As mentioned previously, dredging for channels in the Sound do not modify the sediment budget for the barrier islands and mainland coast. The NDC's dredging database has been evaluated to provide a complete regional sediment budget as shown in Table 3.3-2.

Table 3.3-2.
Dredging Rates for Navigation Channels in Mississippi Sound (from SAM and NDC Database)

Location	Dates	Duration (years)	Shoaling Rate (cu yd/yr)	Notes
Gulfport Harbor Channel[1]	Jul 1991 – Sep 2004	8.3	1,151,000	Assume includes GIWW dredging
Biloxi Harbor Channel	Dec 1991 – Aug 2003	12.5	43,600	
Pascagoula Harbor Channel	Aug 1992 – Jan 2005	13.5	3,074,600	Assume includes GIWW dredging in vicinity of Pascagoula
Bayou Cassotte	Sep 1992 – Sep 2000	8	248,500	
Bayou La Batre	May 1996 – Sep 2004	8.3	732,400	Assume includes GIWW dredging

[1] Omitted Gulfport deepening in 1992.

3.4 Historical Data Analysis

A second phase of this study developed a historical sediment budget for the barrier islands and adjacent passes based on bathymetric change, shoreline position change, and dredging and placement data. The historical sediment budget is utilized to develop the present-day sediment budget. In this chapter, historical volumetric change, shoreline position change, and dredging data are reviewed. This portion of the study was conducted by Byrnes and Griffee (2007).

Shoreline and bathymetric data were compiled within a Geographic Information System (GIS) for the Mississippi Sound region. This database has associated metadata specifying the coordinate system, vertical datum, measurement units, and timing of data collection for each data set. Data are available for 1846/57, 1916/21, and 1960/71 periods, with coverage of the eastern portion of the study area available for 1984/89.

The primary goal of bathymetric change analysis is to identify regional sediment transport pathways and quantify net sediment volume changes associated with the historical evolution of nearshore morphology and adjacent beaches. Table 3.4-1 provides a summary of bathymetric data available for the Mississippi Sound area. Initial bathymetric surveys of the area were completed for the period 1847/56. All data have been compiled within a GIS framework, so metadata regarding coordinate system, vertical datum, measurement units, and timing of data collection are provided in the attribute table for each data set. These data, in addition to recorded shoreline changes, have been used to quantify regional sediment dynamics throughout the study area and evaluate the historical sediment budget for the period 1917/21 to 1960/71. Limited coverage offshore of Horn, Petit Bois, and Dauphin Islands for the 1960/71 period limits volumetric change calculations and, ultimately, the historical sediment budget.

Table 3.4-1.
Bathymetry Source Data Characteristics (from Byrnes and Griffee 2007)

Date	Data Source	Comments and Map Numbers
1847/56	USC&GS Hydrographic Sheets 1:20,000	First regional bathymetric survey within the study area. 1847 - H-00191; 1847/48 – H-00192; 1848 – H-00193, H-00194; 1851 – H-00256, H-00261; 1852 – H-00329; 1853 – H-00328, H-00365; 1854 – H-00430; 1855 – H-00485, H-00488, H-00489; 1856 – H-00546.
1916/20	USC&GS Hydrographic Sheets 1:40,000 (all others) 1:80,000 (H-4171)	Second regional bathymetric survey in the study area. 1916/17 – H-03960; 1917 – H-04000; 1917/18 – H-04020, H-04021, H-04023; 1920 - H-04171.
1960/71	USC&GS Hydrographic Sheets 1:10,000 (H-08524, H-08525, H-08560, H-08561, H-08562, H-08642, H-08643, H-08644, H-08645, H-08646, H-08649 to 08652, H-08922, H-08923, H-08925, H-08970, H-09156, H-09177) 1:20,000 (all others)	Third regional bathymetric survey in the study area. 1960 – H-08524, H-08525, H-08562, H-08563); 1960/61 - H-08560, H-08561; 1961 – H-08642; 1961/62 - H-8643 to 08648; 1962 – H-08649 to 08652; 1966/68 – H-08922, H08923; 1967/68 – H-08924, H-08925; 1968 – 08970, H-08971; 1968/69 – H-09004; 1970 – 09103, H-09109; H-09028, H-09156, H-09177; 1971 – H-09200.
1984/89	USC&GS Hydrographic Sheets 1:20,000 (D-00079, F-00324, H-10179, H-10208, H-10226, H-10247, H-10261) 1:40,000 (D-00078, H-10206) 1:80,000 (D-00065)	Survey covering eastern portion of the study area; 1984/87 - D-00065, D-00078; 1985/87 - H-10179; 1985 - H-10206, H-10208; 1986/88 – H-10226; 1987 - H-10247, H-10261; 1988 - D-00079; 1989 - F-00324.

Several insights into forcing processes and engineering activities were observed from the bathymetric change data.

(1) Overall, the barrier islands have eroded on the eastern regions and accreted to the west, indicating the dominant direction of longshore sand transport from east-to-west. Similarly, the Passes between barrier islands have also migrated to the west, as noted by the ebb shoal that erodes to the east and reforms to the west. Thus, the migrating barrier islands naturally “push” the Passes to the west.

(2) Dredging of the ship channels in Mississippi Sound is readily observed in the bathymetric change maps that include the 1960/71 surface, with side-casting and placement of the dredged material shown on either side of the channels. This side-cast sediment does not appear to move within Mississippi Sound.

(3) As the barrier islands have eroded, portions of the barriers have rolled over towards the Sound. For example, East Ship Island and western Dauphin Island have eroded on the Gulf side and reformed in a more northerly location further into the Sound. The processes transporting sand into the Sound is a combination of overwash during storms and inlet formation and possible subsequent closure.

(4) Portions of the barrier islands are relatively stable and maintain position through time (this is observed in Byrnes and Griffee’s (2007) shoreline position data). Examples of these locations are

the widest portions of Horn, Petit Bois, and Dauphin Islands. These areas are likely more stable ancient Pleistocene formations along which the sand spits which comprise the rest of the barrier island morphology form.

(5) Initial studies on the barrier island sediment budget indicate Cat Island is not part of the sand-sharing system that comprises Dauphin, Petit Bois, Horn, and Ship Islands and the Passes that separate these barrier islands. Cat Island appears to be a separate entity and the bathymetric change maps do not indicate that sand from Ship Island naturally bypasses or transports to Cat Island. If there were connectivity between Ship and Cat Island, it would be evidenced by erosion or accretion of morphologic features between the islands.

(6) From the historical shoreline position data (Byrnes and Griffee 2007), it is evident that the barrier islands have experienced cycles of breaching and mending throughout history. For example, Dauphin Island breached in 1917 in response to the 1915 hurricane, and reformed by 1957 slightly further northward (into the Sound) at the location of the washover deposit. Dauphin Island again shows a breach in the 2006 shoreline position data. Similarly, Ship Island breached in response to the 1947 hurricane and the barrier had reformed by 1950. Ship Island has been divided into East and West Ship Islands since another breach formed in the 1960s. These cycles of breaching and reformation indicate that breaches will naturally mend through the dominant longshore sand transport direction to the west, if a sufficient source of sediment is available. The historical data analysis is further discussed in Byrnes and Griffee (2007) and Rosati et al. (2007).

3.4.1 Numerical Modeling

Two numerical models were applied to develop estimates of sediment transport magnitudes and pathways. First, GENESIS shoreline change modeling that was conducted as a part of a larger regional study was incorporated to provide potential longshore sand transport rates for the Gulfside of the barrier islands for representative yearly waves. This model used pre-Katrina shoreline positions. Next, regional wave transformation modeling was conducted with STWAVE to estimate breaking wave height and direction magnitudes for the Gulfside and mainland coast beaches. These wave parameters and the shoreline orientation for sections of the Gulf barrier beaches and mainland coast were used to calculate potential longshore sand transport rates. Potential longshore sand transport rates are those estimated to occur if a sufficient quantity of sand were available for transport. Thus, these calculations do not apply to muddy coastlines or wetland regions of the study area. Finally, STWAVE was also applied to estimate wind-induced wave parameters for the Sound side of the barrier islands and subsequent sand transport on the Sound barrier coast. The methodology and results for this numerical modeling are discussed in Rosati et al. (2007).

3.4.2 Sediment Budget

Using the calculated and historical sediment budgets, and dredging and placement practices from 1993-2005 as presented by Rosati et al. (2007), a present-day (post-Katrina shoreline position) sediment budget has been hypothesized. In formulating this budget, several assumptions were made as follows:

(1) The historical sediment budget (1917/20-1960/71) was weighted more heavily than the calculated sediment budget, because the historical budget is based on actual measured changes in the region. However, for portions of the barrier islands that have changed morphology since the 1917/20 to 1960/71 period, or would be modified by a change in dredging or placement practices, the calculated sediment budget was given preference. The calculated sediment budget was adopted for eastern Dauphin Island because volume change data have not yet been released, pending acceptance of the Dauphin Island mitigation study.

(2) In the absence of historical data, the calculated sediment budget and observed morphologic response were adopted for the mainland coast.

(3) Dredging and placement practices from 1993 to 2003/2005 were adopted for Ship Island Pass and Horn Island Pass, and the barrier island response to these activities was hypothesized. Dredging rates for Gulfport, Biloxi, and Pascagoula Harbor Channels, and Bayou Cassotte and Bayou La Batre were adopted as shown in Table 3.3-2. The source of sediment for these channels in Mississippi Sound was assumed to be fine-grained sediment that is mobilized during storms and wind events.

The hypothetical present-day sediment budget is shown in Figures 3.4-1 through 3.4-10, in which P=placement of dredged material, R=dredging or removal of sand, and sand fluxes are shown in thousands of cubic yards per year. It is emphasized that this sediment budget is only one of many possible solutions that could represent typical present-day conditions.

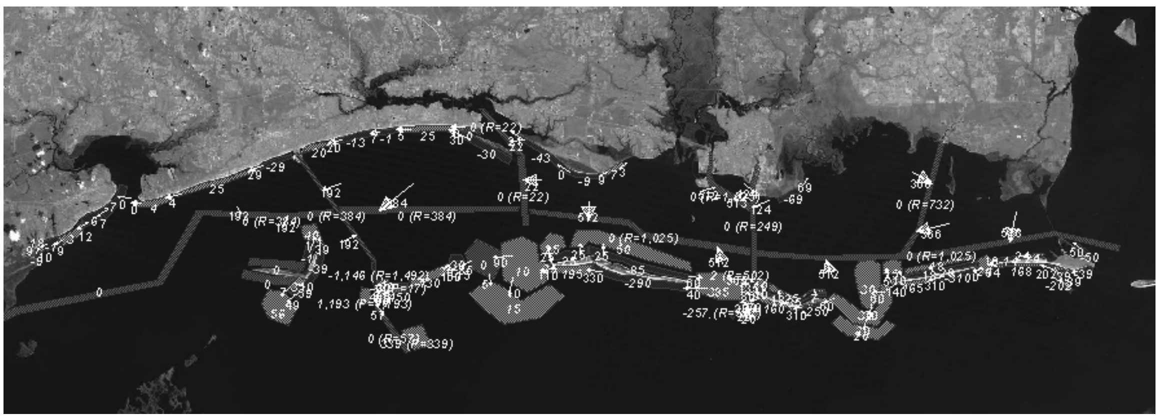

Figure 3.4-1. Overview of hypothetical present-day sediment budget (thousands of cy/yr)

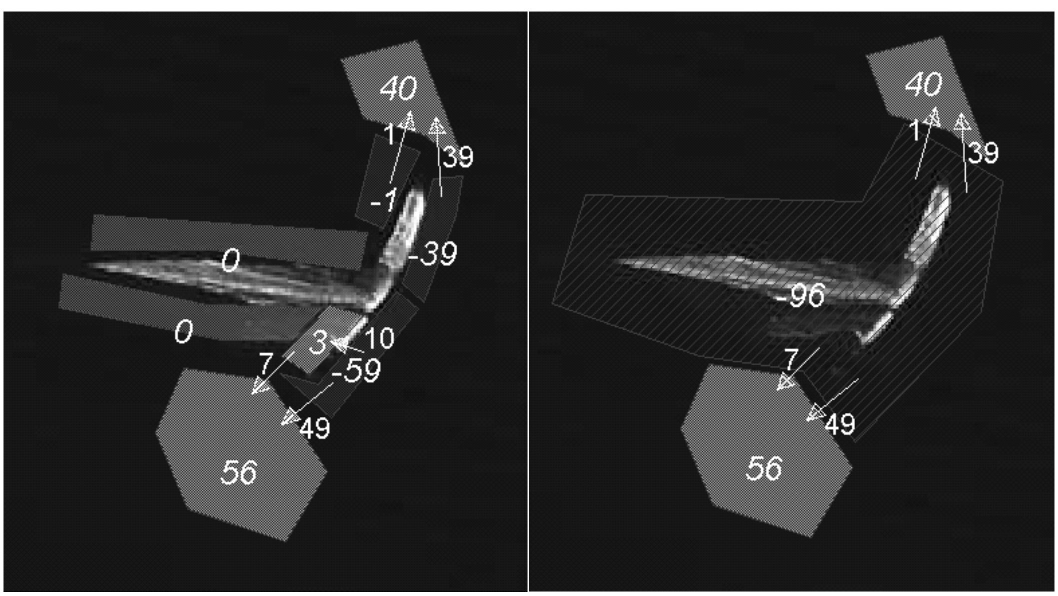

Figure 3.4-2. Hypothetical present-day sediment budget and macrobudget: Cat Island thousands of cy/yr).

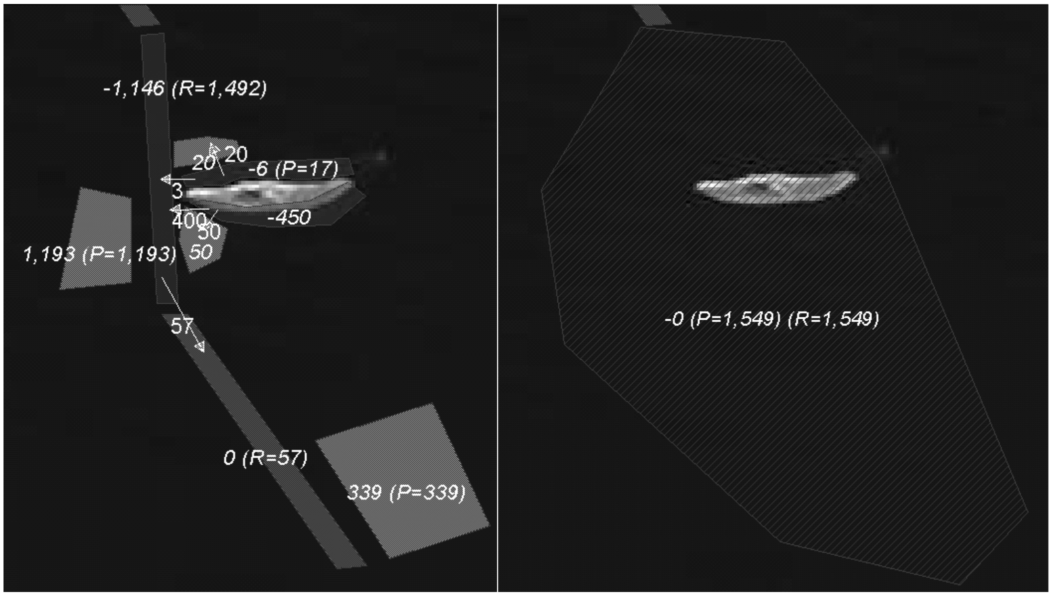

Figure 3.4-3. Hypothetical present-day sediment budget and macrobudget: West Ship Island and Ship Island Pass (thousands of cy/yr).

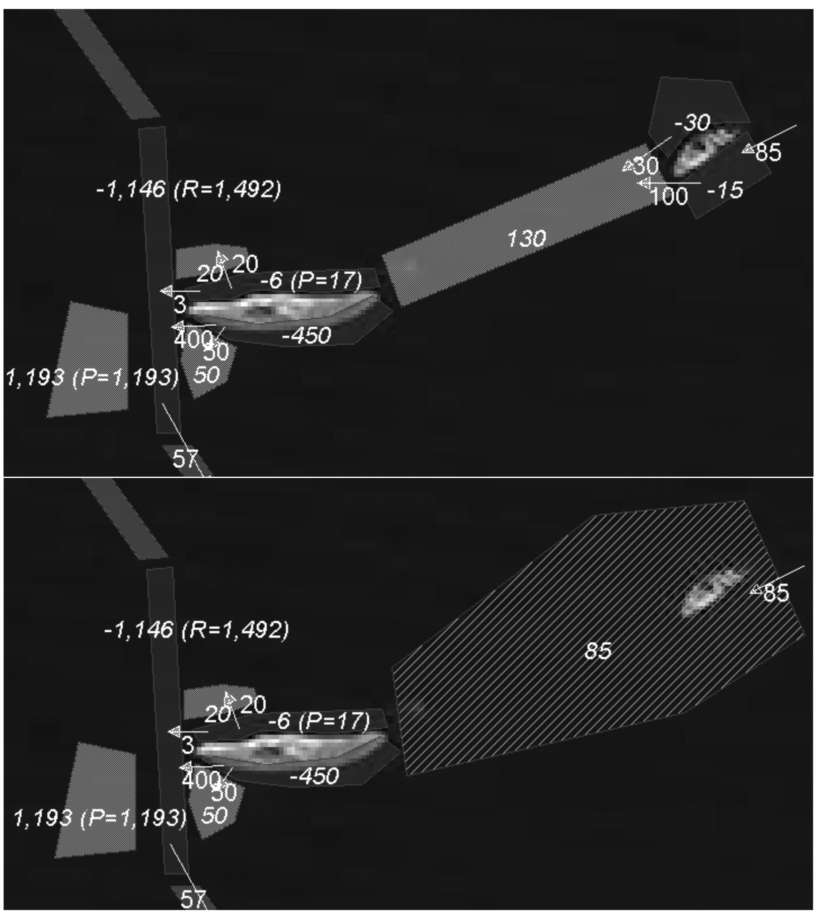

Figure 3.4-4. Hypothetical present-day sediment budget and macrobudget: East Ship Island and Camille Cut (thousands of cy/yr).

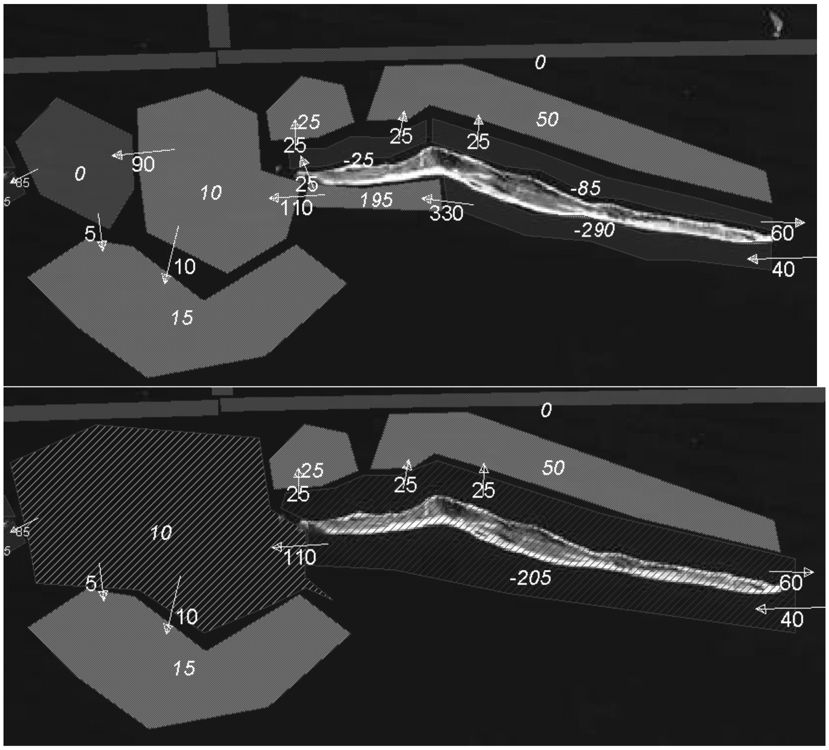

Figure 3.4-5. Hypothetical present-day sediment budget and macrobudget: Horn Island and Dog Keys Pass (thousands of cy/yr).

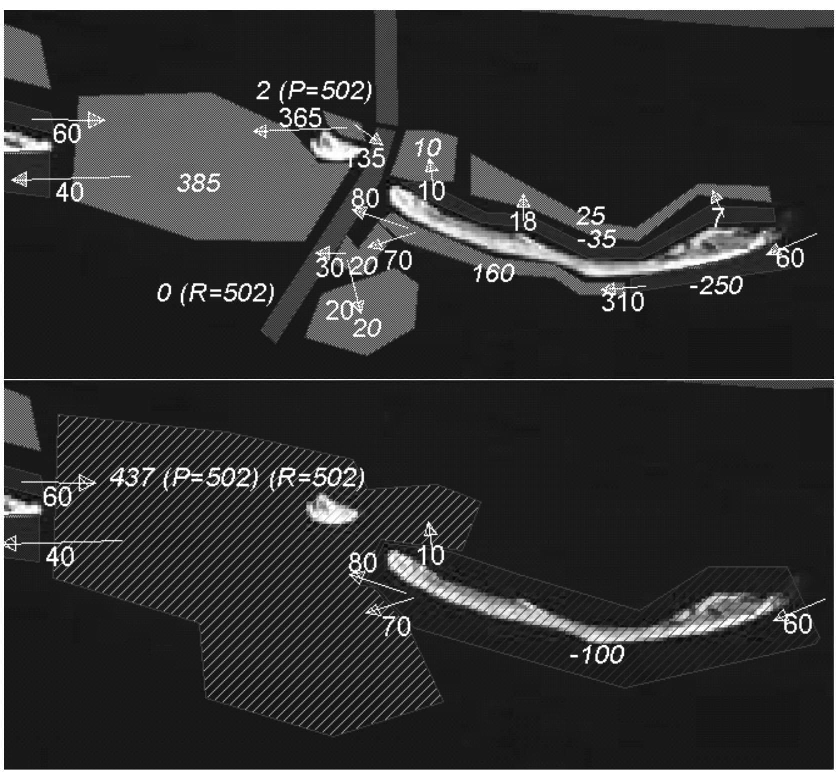

Figure 3.4-6. Hypothetical present-day sediment budget and acrobudget: Petit Bois Island and Horn Island Pass (thousands of cy/yr).

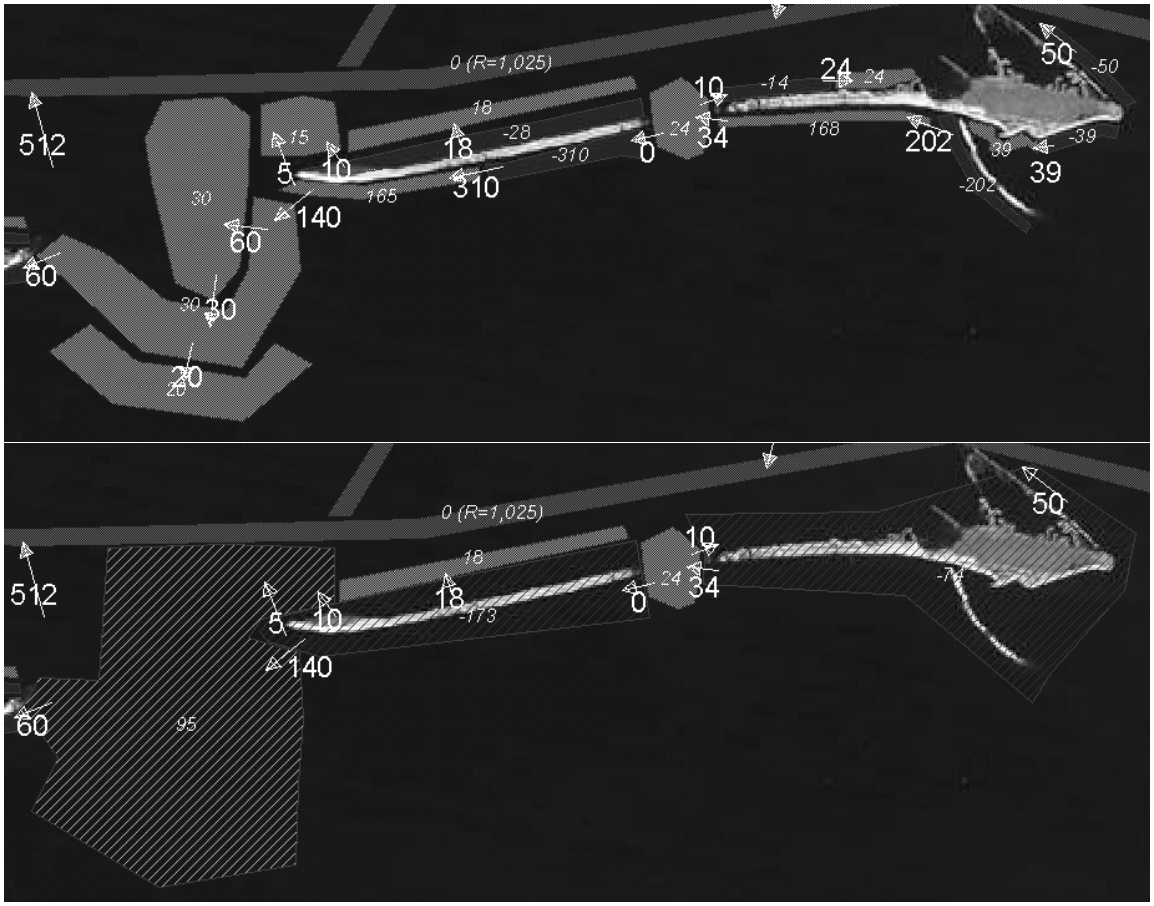

Figure 3.4-7. Hypothetical present-day sediment budget and macrobudget: Dauphin Island and Petit Bois Pass (thousands of cy/yr).

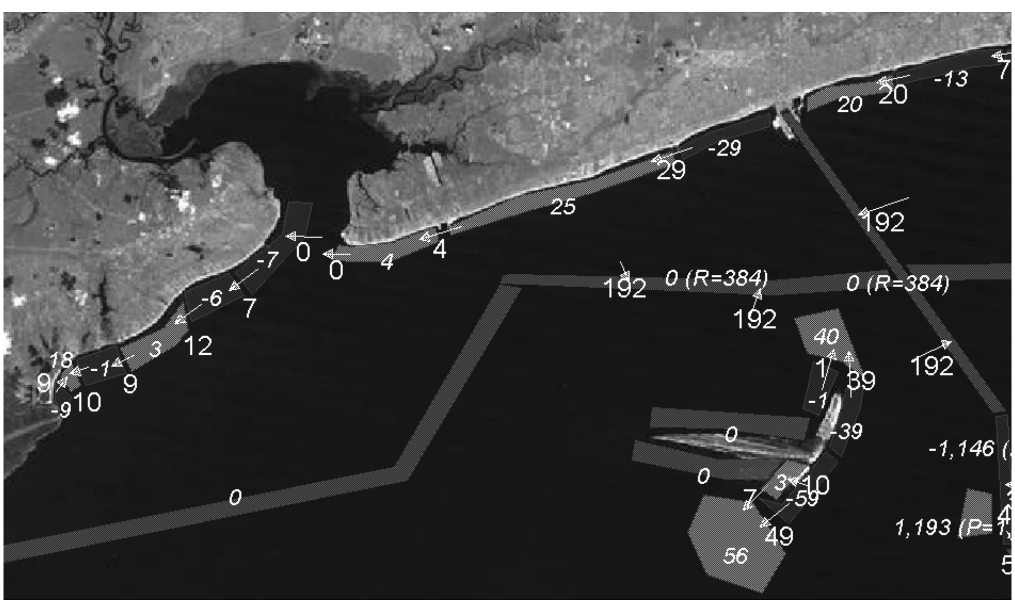

Figure 3.4-8. Hypothetical present-day sediment budget: Hancock County, Gulfport Harbor Channel, and a portion of the Gulf Intercoastal Waterway (thousands of cy/yr).

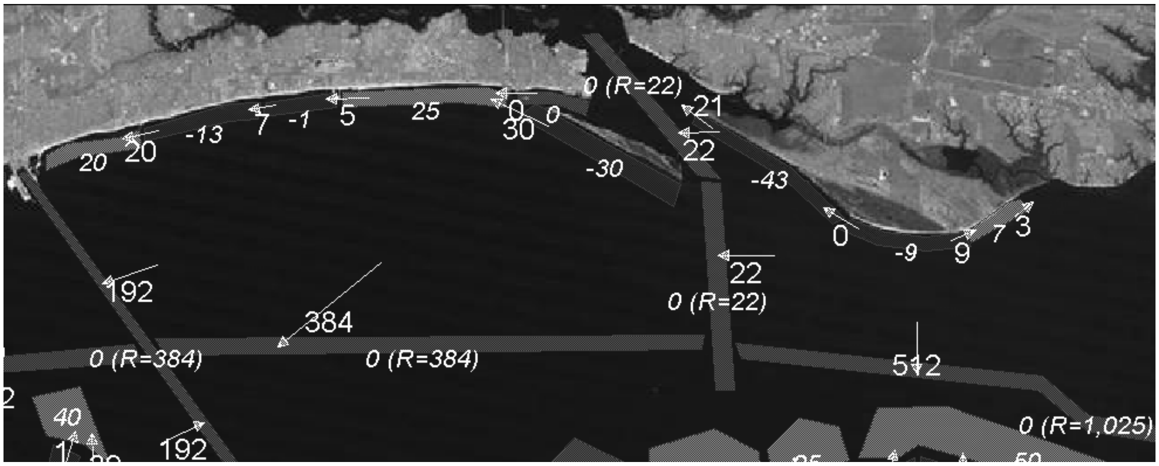

Figure 3.4-9. Hypothetical present-day sediment budget: Harrison County, Pascagoula Harbor Channel, and a portion of the Gulf Intercoastal Waterway (thousands of cy/yr).

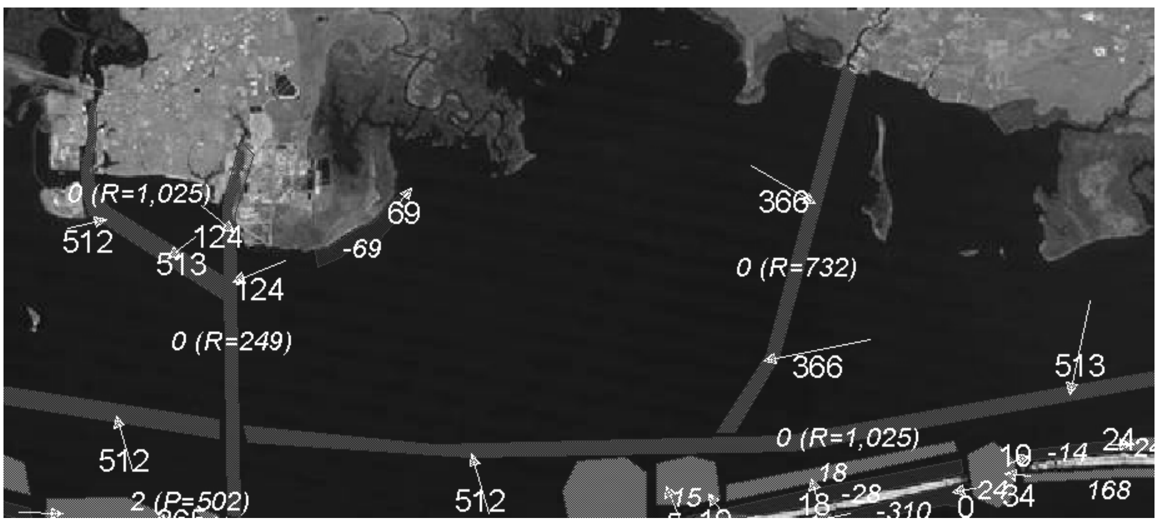

Figure 3.4-10. Hypothetical present-day sediment budget: Jackson County, Bayou La Batre, and a portion of the Gulf Intercoastal Waterway (thousands of cy/yr).

Knowledge gained through this study and recommendations that follow include the following:

(1) Cat Island is not a part of the barrier island littoral system represented by Dauphin, Petit Bois, Horn, and East and West Ship Islands. Cat Island is a separate morphologic feature that is naturally eroding due to waves, storm surge, and relative sea level rise in the region. Dredged sand that is placed in the littoral zone to the west of Ship Island Pass most likely will not be transported to Cat Island. Even in the absence of any engineering activities in Mississippi Sound, there is no evidence that sand from Ship Island would ever reach Cat Island.

(2) The net longshore sand transport rate for the barrier islands is from east-to-west. The barrier islands are migrating towards the west and, as they move west, also move the Passes between islands in a westerly direction. The source of sand for this region is the Mobile Pass ebb tidal shoal and the sandy shelf and shoreline to the east of Mobile Pass. This study has shown Ship Island is the terminus of the longshore sand transport system in this region. Thus, the regional shortage of littoral sand will be most profoundly observed at Ship Island. Disintegration of this barrier island, especially since Hurricane Katrina in 2005 has been observed. It is also recommended that

restoration of any barrier islands in Mississippi Sound begin with Ship Island. Also recommended is utilizing sand dredged from Ship Island Pass, placing this sand either in Camille Cut, near East Ship Island, or in Dog Keys Pass or other littoral zones based on additional sediment transport modeling. Sand can be placed in the surf zone (3 to 6-ft depths) and the natural longshore sand transport process will rebuild the island and begin to mend breaches.

(3) The historical sediment budget from 1917/20 to 1960/71 includes bathymetry change, shoreline position change, and dredging and placement practices representative of this period. However, data for the 1960/71 period are very sparse offshore of the barrier islands. This lends some uncertainty to the historical budget. In addition, Ship Island Pass and Horn Island Pass were deepened (and Horn Island was widened) in 1992/1993. Since that time, dredging rates have increased from those that occurred during the 1917/20 to 1960/71 period. Thus, the historical sediment budget is not representative of present-day dredging and placement activities, and has uncertainty with respect to bathymetric change offshore of the barrier islands. We recommend measurement of modern bathymetry (to 30 or 40-ft depths) and formulation of a sediment budget characterizing the period from 1917/20 (which has sufficient bathymetric coverage) to present-day.

(4) The historical analysis indicated that Horn Island has not experienced wash-over deposition across the entire island and has only been breached on a part of terminal spit during Hurricane Katrina (personal communication, Ms. Linda Lillycrop, May 2005). This cross-shore stability implies that the elevation and width of this barrier island might be a good template to evaluate for possible future restoration of the Mississippi Sound barrier islands.

(5) Wave modeling indicated that the mainland coast experiences a greatly reduced wave climate due to sheltering by the barrier islands fronting Mississippi Sound, as well as the Chandeleur Islands, and the Mississippi River's Bird's Foot delta. Restoration of the barrier islands could also consider lengthening the islands to recreate a previous historical footprint to provide additional wave protection for the mainland coast.

CHAPTER 4 INLAND RIVER SAND SOURCES FOR USE AT BARRIER ISLANDS

4.1 General Information

While off-shore sources of good quality sand exist, other inland sources of sand exist that will be used for barrier island littoral zone restoration will be subject to additional study. After the construction of inland waterways in Alabama and Mississippi, maintenance dredging is required to maintain the channel depths and alignments. This material is typically moved to disposal areas along the banks of the river where it accumulates in diked areas. Dredging of some of the areas along the river produces large quantities of sand that have potential use for beach nourishment. An inventory of current disposal sites indicates that approximately 30,000,000 cubic yards of sand may be available. Only disposal sites that contain a minimum of 100,000 cubic yards of sand were included in the inventory. Of interest to this study are disposal sites that are located along the Black Warrior–Tombigbee River system and the Tennessee-Tombigbee Waterway. Figure 4-1 shows the relationship of these disposal areas to the project sites along the Mississippi coast. Material from these sites could easily be transported by barge down the river system for use along the beaches or added to littoral zones.

4.2 Prior "Beneficial Use of Sand" Studies

Because of the shortage of additional disposal areas, the Corps of Engineers' Operations Division has contracted for several studies on the beneficial use of the sand. Some of these studies have been targeted at using the sand for beach nourishment, (Thompson Engineering, 2001). Using sand samples from some of the inland disposal areas along the Black Warrior – Tombigbee River, a series of analyses were conducted on the samples. For comparison purposes, several samples of actual beach sand and from the littoral drift zone from coastal Alabama were taken and subjected to the same tests. These tests included grain size distribution (gradation), color and roundness. The results of the tests indicated that some of the samples may be suitable for beach nourishment. The sand samples from the river were typically a finer grain size that the beach sand with the predominant river size being a fine sand while the beach sand was mostly medium sand. It was also noted that the beach sand was slightly more rounded than the river sand.

The one factor that warranted further analysis was the color difference of the river sand as compared to the beach sand. All of the river sand had a brown tint described as "very pale brown" or "light yellow brown". This compared to the beach sand samples which were described as "pale olive, white or light grey". These colors were assigned along with evaluations for hue, value and chroma from a Munsell Soil Color chart which provides a standard method of assigning color to soils. These reports also indicated that the color may be due to staining on the sand grains and not included in the mineral structure of the sand itself. The report also noted that beach sand came from a higher energy environment where any staining due the depositional environment may have been removed by abrasion due to wave action. It also noted that the sand might undergo bleaching from the ultraviolet radiation from the sun if the color was caused by a mineral staining. To test these conditions that may change the color of the sand, a series of tests were conducted on samples from the same areas that were used during the initial analyses, (Thompson, 2002). The samples were subjected to two tests. The first involved actual bleaching of the samples using a chemical oxidizer, hydrogen peroxide, for different periods of time. These tests did indicate that the bleaching process was detectable after 72 hours. Other tests were conducted to simulate the process of wave action causing an agitation of the particles which may remove any mineral coating or staining along with exposure to ultraviolet light. This process was conducted for 144 hours without a notable difference in color.

Other studies on the dredge disposal areas by the Bureau of Mines, U.S. Department of the Interior were conducted to characterize the sand for use as an aggregate in making concrete (Smith, 1995). While these tests were not directed at use of the sand for beach nourishment, they did supply information on chemical and physical characteristics of the materials from several locations. These tests provided data that shows the sand to be clean, mostly fine grained, quartz sand with little of no fines, to be non-toxic based on Toxic Characteristic Leachate Procedure (TCLP) and to contain very little heavy minerals. All of these tests would indicate the material would be safe to place on a beach.

Review of the documents referenced above indicated that the color issue was not resolved and this would be an important factor in the use of the sand on the barrier island beaches. The methods employed, bleaching and agitation with exposure to ultraviolet light, were not considered to be effective in removal of what is suspected to be the basis of the color on the sand grains, amorphous iron oxide more commonly referred to as rust. Hydrogen peroxide is a common household bleaching agent that is effective in oxidation of organic matter, but would no effect iron oxide through chemical removal. The same is true for the effects of ultraviolet light on iron oxide. The idea of using agitation would be the most effective of the methods attempted if the color was a coating on the mineral grains, but the test, as conducted, was not conclusive.

4.3 Additional Studies

With the renewed interest in the possibility of using the sand as a source of material for the littoral zone associated with the Mississippi barrier islands, the disposal areas warranted further study. Again the color of the sand is a concern that has been raised by the National Park Service who has control of the Mississippi Barrier Islands. This concern has both aesthetic and environmental aspects. Aesthetically, the beaches on the barrier islands are composed of relatively white sand. Numerous studies have indicated that the primary source of this sand is an Appalachian origin probably associated with river systems discharging onto the Continental Shelf of present-day Florida (Stone and Others, 2004). This sand is transported westward from the discharge of the river into the Gulf of Mexico. Transport of this sand along the prevailing littoral current has created the white beaches and barrier islands that extend from Florida westward across Alabama to Mississippi as shown in Figure 4-2.

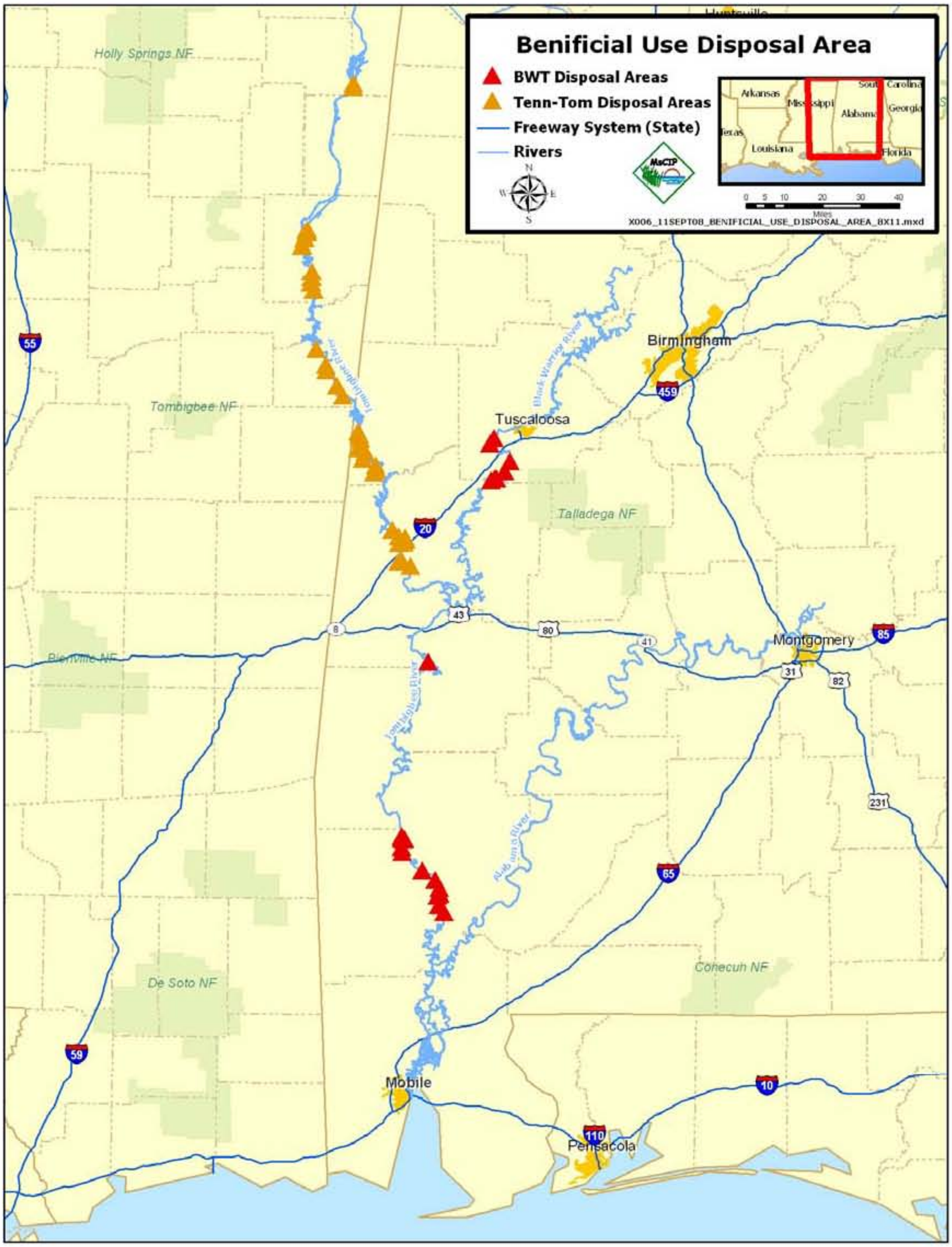

Figure 4-1. Location of Disposal Areas Along the Black Warrior–Tombigbee River System and the Tennessee-Tombigbee Waterway

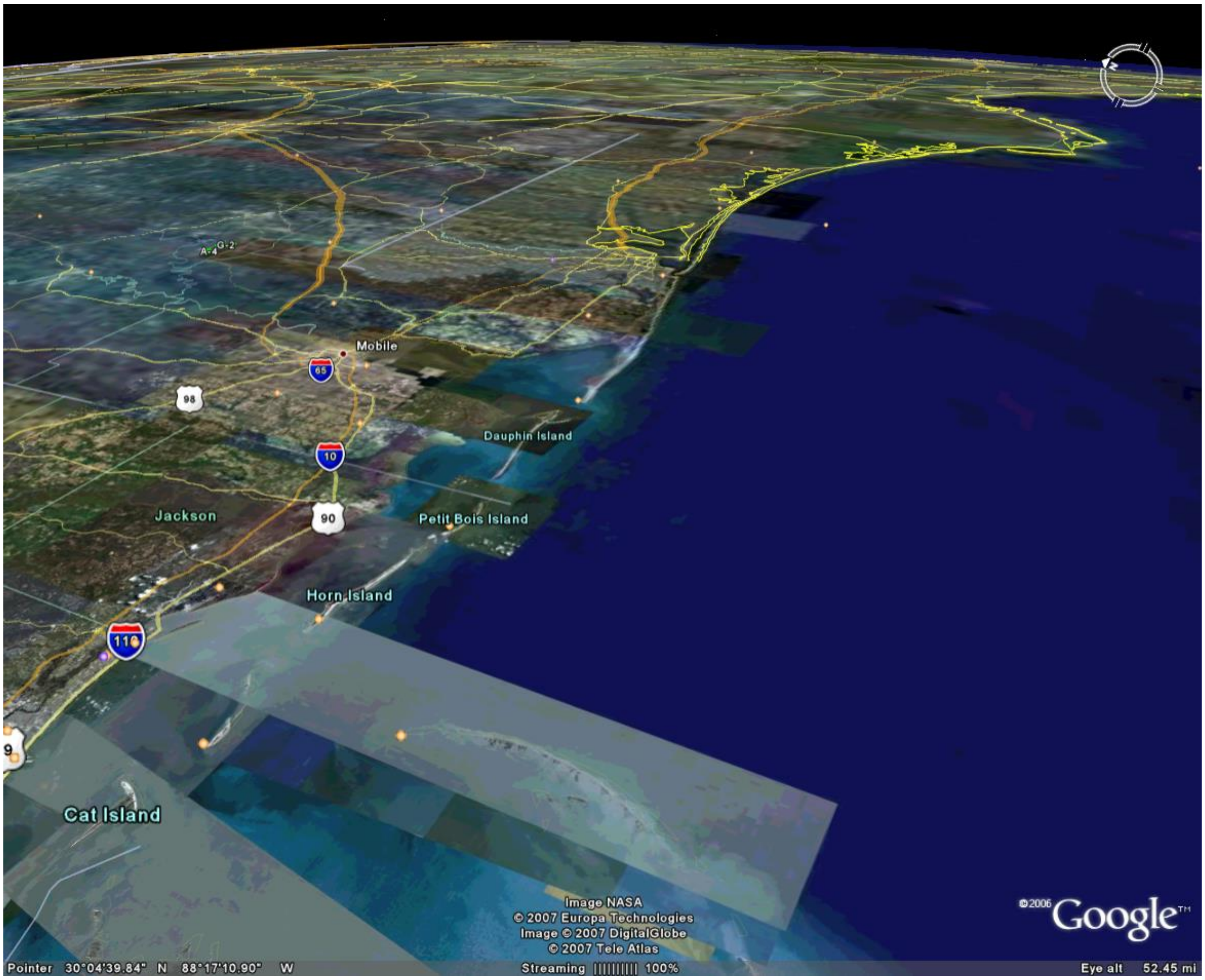

Figure 4-2. Littoral zone (white beaches and islands) along Central Gulf Coast extending from Bay County, Florida (top of picture) to Mississippi Barrier Islands (lower left), looking east.

Looking at the color differences of the sand along this system reveals a definite change as shown in Figure 4-3. The sample on the left was taken from sand dredged from the Chattahoochee River which is a major tributary of the Apalachicola River. This sampling location is approximately 150 river miles above the Gulf. The middle sample was taken from Disposal Area 39 on the Apalachicola River approximately 37 river miles above the Gulf. The sample on the right was taken from the south beach of Petit Bois Island in Mississippi. Note the progressive change in color from brown to tan to white.

Geochemical processes could account for the consistent staining of the sand grains while in the river system. As the sand entered the Gulf's littoral system, changes in the geochemical process would not allow additional staining of the sand and any removal of the coating would allow the underlying sand grain to display its true color. The mechanical process of abrasion would occur both in the river system and the littoral system, but if the iron oxide staining was continuously reoccurring in the river system, the resulting color would remain. As the sand grains entered a different geochemical environment where re-staining did not occur, it would account for the difference where the color was a coating. Review of selected sand samples taken from the Black Warrior– Tombigbee River system disposal areas the reveal the same general color that is characteristic of the Chattahoochee-Apalachicola River system. Figure 4-4 is a photograph of five samples that include the same samples used in Figure 4-3 plus two additional samples, one from the Black Warrior River and another from the Tombigbee River. Note the similarities in color of the Apalachicola River (second from left), the Black Warrior (third from left and marked BWT North Star), and the Lower Princess (forth from left, Lower Tombigbee River).

Figure 4-3. Samples of Sand taken from (left to right) Chattahoochee River Mile 150, Disposal Area #39 on the Apalachicola River, and Petit Bois Island

Figure 4-4. Samples of Sand taken from (left to right) Chattahoochee River Mile 150, Disposal Area #39 on the Apalachicola River, North Star Disposal Area on the Black Warrior River, Lower Princess Disposal Area on the Tombigbee River, and Petit Bois Island in Mississippi

Assuming that the previous testing was not effective at removing the iron oxide staining on the sand grains, a different bench-top test was performed. If iron oxide is only a coating on the sand grains and occurs as a stain, abrasion would be effective in the removal. The addition of a week acid would also aid in keeping the iron oxide from re-coating the sand grains as it is being removed. For the experiment, I used a small “rock tumbler” of the type used to polish small stones. Into the chamber of the rock tumbler was added a small quantity of sand obtained from the Lower Princess disposal area on the Tombigbee River, enough water to just cover the sand and a tablespoon of “Zud”. Zud is a household cleaning product that is composed of oxalic acid and abrasives. Oxalic acid is a weak acid commonly used to remove rust stains. Zud contains about 10% oxalic acid and 90% fine abrasives. The tumbling chamber was closed and placed the tumbler. An electric motor spins the chamber which allows the contents to tumble. This process would mimic the process of sand grains being transported along the littoral zone with the sand grains being abraded as they strike each other. In the almost infinite volume of water in the Gulf, any iron stain that was removed would not re-coat the sand, but be diluted away. This process started on 4 October 2007 and concluded 10 October 2007. The tumbler did not run over the included long weekend, but did operate for about 4 days. At the completion of the tumbling process, rinse water was added and decanted several times until the turbidity levels dropped and the fines were removed. The remaining sand was air dried and placed in a clear plastic bag for comparison with sand from the same parent sample. As shown in Figure 4-5, the results of the experiment are quite dramatic. The tumbled sand lost most of the tan color and is approaching white. This supports the process that occurs with the tan sand from the Apalachicola River system becoming the white sand so familiar to beach-goers along the central Gulf Coast.

Figure 4-5. Samples of Sand taken from (left to right) North Star Disposal Area on the Black Warrior River, Lower Princess Disposal Area, and “Tumbled Lower Princess Disposal Area”

Adding the sand into the littoral system along the gulf coast could provide the proper geochemical and mechanical processes to remove the iron staining and provide the quality of sand that is desired as it is transported along the littoral drift zone which contain the Mississippi Barrier Islands. Littoral zone placement will also allow additional sorting by the currents and rounding of the sand grains through continued abrasion during transport. Additional research and testing will be performed to support this process prior to any use of any sand from disposal areas.

4.4 References

Smith, C. W., 1995, Characterization of Dredged River Sediments in 10 Upland Disposal Sites in Alabama, Report of Investigations 9549, U.S. Department of the Interior, Bureau of Mines.

Stone, Gregory W.; Liu, Baozhu; Pepper, David A.; Wang, Ping; 2004, The Importance of Extratropical and Tropical Cyclones on the Short-term Evolution of Barrier Islands along the Northern Gulf of Mexico, USA, Marine Geology 210, pages 63-78

Thompson Engineering, 2001, Dredged Material Suitability Analysis - BWT River Sediments, Project 01-2116-0102.

Thompson Engineering, 2002, Sediment Bleaching Analysis from Disposal Sites Along the Alabama, Black Warrior and Tombigbee River Systems in Alabama, Project 02-2116-0030.

CHAPTER 5 OVERVIEW OF ALL BARRIER ISLAND OPTIONS (LINE OF DEFENSE-1) FROM ENGINEERING APPENDIX

5.1 Line of Defense 1 – Offshore Barrier Islands

5.1.1 General

The coastline of mainland Mississippi is bordered on the south by the Mississippi Sound, a shallow body of water that separates the coast from four barrier islands that lie several miles to the south as shown in Figure 5.1.1-1. These barrier islands are located along a littoral drift zone that moves sand westward creating three elongated islands and then westward toward Cat Island, where littoral currents are not as well defined. The birds-foot delta system from the Mississippi River has extended through the historic littoral system, cutting off the sediment transport. Cat Island had the same origin than the other islands, but now being re-shaped by wave action and lack of new sediments moving into the system. Wave action has created a beach on the eastern side of the island forming a distinctive T-shape. From west to east, the islands are Cat, Ship (now actually two islands, West and East Ship Island), Horn and Petit Bois. As noted above, Ship Island has been breached by prior hurricanes and now is actually two small islands, West Ship Island and East Ship Island, with a shallow sand bar between the two. Since Hurricane Camille in 1969, this breach has existed with varying amounts of natural rebuilding between later storms and is now known as Camille Cut. The western ends of both Petit Bois and West Ship Islands have migrated westward and are now against maintained deep-water navigation channels and the continuing littoral drift of the sand into the channels is causing an artificial termination of the migration. A small, new island has emerged on the west side of the channel from Petit Bois Island, created from the dredged sand that is disposed of on the west side of the channel. This small island can be seen in Figure 5.1.1-1 as the small island just west of and across the channel from Petit Bois Island.

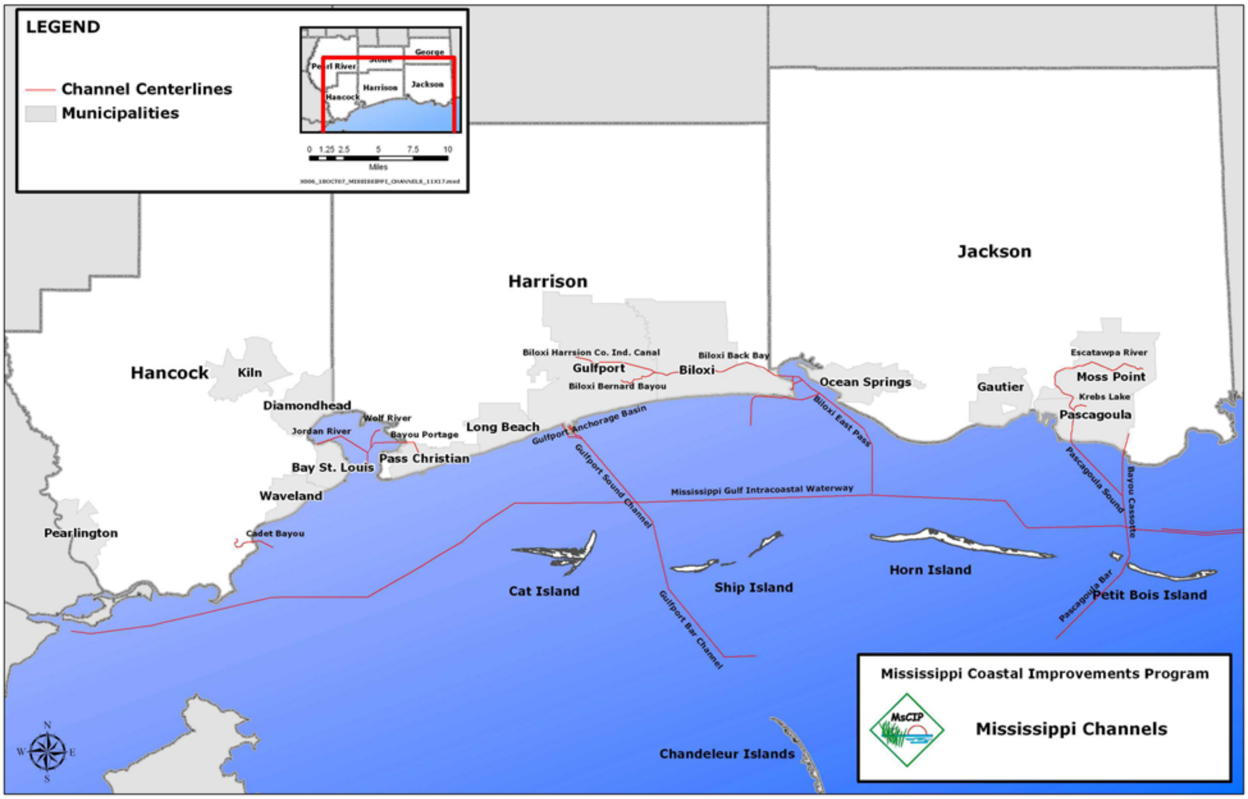

Figure 5.1.1-1. The Mississippi Barrier Islands shown in relationship to the numerous navigation channels near the islands

Immediately following Hurricane Katrina, most of the effort was spent protecting human life and securing structures throughout the impacted areas on the mainland; therefore, few assessments of the vegetation impacts exist, especially on the barrier islands. For the barrier island system, most all of the marsh vegetation recovered several months following Hurricane Katrina. The predominant vegetation that has long-term impacts consists of those pines found in the maritime forests. It is estimated that about 75% of these pine species were killed following the hurricane season of 2005, with most that attributable to Hurricane Katrina. Figure 5.1.1-2 is a photograph taken on Horn Island after Hurricane Katrina that shows the loss to the pine trees. The emergent marsh habitat is thriving so well it actually looks as though hurricanes never past through the barrier island system. The sea oats are still found in small patches due to the reduced dune system. Any option that includes the planting of marsh vegetation will have to consider the current population of nutria that inhabits the islands. These exotic animals from South America can destroy attempts to establish marsh planting and any program should include the control of these rodents.

In 1998, Hurricane George played a role in destroying many of the sand dunes on the islands. Although a relatively small storm, the constant pounding of the waves along the beaches eroded most of the dunes on the southern shores which were the higher elevations on the islands. Along with the destruction of the dunes was the loss of the associated vegetation and habitat. Figure 5.1.1-3 is a photo of the south beach of Horn Island where hurricanes have destroyed the dunes system.

Figure 5.1.1-2. Photo of interior of Horn Island. Note the mature pine trees that were killed from the effects of salt water that covered the island during Hurricane Katrina.

Figure 5.1.1-3. Photo of the south beach at Horn Island. Pre-existing dunes have been destroyed by numerous hurricanes over the last several years.

Prior to Hurricane Katrina, the State of Mississippi was working on a coastal storm protection plan that included restoring the barrier islands to the condition that existed prior to Hurricane Camille. The general assumption was that there would have been less damage along the coast from Hurricane Katrina if the islands had been in this improved condition. This was also included in the Mississippi Governor's Hurricane Katrina Recovery Plan which called for restoring the islands to a pre-Camille footprint. This concept was included in the hurricane protection study as LOD-1.

To determine the effects of the islands in reducing the surge damage to the mainland, a number of storms were selected to model against the chain of islands in a pre-Camille and a post-Katrina configuration. The post-Katrina condition can be considered a baseline condition for the modeling and the pre-Camille condition would be an improved condition. The pre-Camille footprint of the islands was obtained from historical records and an assumption was made as to a top of dune elevation and a typical island width. During the modeling process, the island sizes were held constant and not allowed to be destroyed. It should be noted that some of the islands have migrated and any reconstruction would be to increase their footprint at their present location and not move them back to historical locations. In general, the islands were modeled with a 2000-foot width and with an elevation 20.0 dunes, but may be in a slightly different position. Modeling efforts have concluded that over a wide range of storms, there would be some protection provided to the eastern coast of Mississippi along the Jackson County shoreline if the islands are in the pre-Camille condition. This area is the most protected from the restored islands and this protection may result in only up to a 10% reduction in storm surge. The effect of this protection diminishes rapidly to the west from Jackson County. An important aspect of the islands shown by the modeling is the reduction of the large sea waves as they advance towards the mainland. Reduction in wave height up to several feet is realized by the presence of the islands. Loss of Ship Island would leave a portion of the heavily developed Harrison County shoreline subject to these larger waves.

All of Petit Bois, Horn, and Ship Islands and part of Cat Island are within the boundaries of the Gulf Islands National Seashore under the jurisdiction of the National Park Service. The park boundaries are shown in Figure 5.1.1-4. In most cases, the boundary extends one mile from the shore of the island. Petit Bois and Horn Islands have also been designated as Wilderness Areas by the U.S. Department of the Interior and have a higher degree of protection than the other islands.

The formation of Camille Cut has created problems for the National Park Service due to the location of two historically important sites. Fort Massachusetts is located on the northern shore of West Ship and the French Warehouse is located on the northern shore of East Ship Island. Both of these sites are endangered by on-going erosion of the shoreline with Mississippi Sound. Another site known as the Quarantine Station has already been lost to erosion. These sites are shown in Figure 5.1.1-5. This photo was taken after Hurricane Katrina, but would be similar to conditions after Hurricane Camille.

Figure 5.1.1-4. Boundaries of the Gulf Islands National Seashore

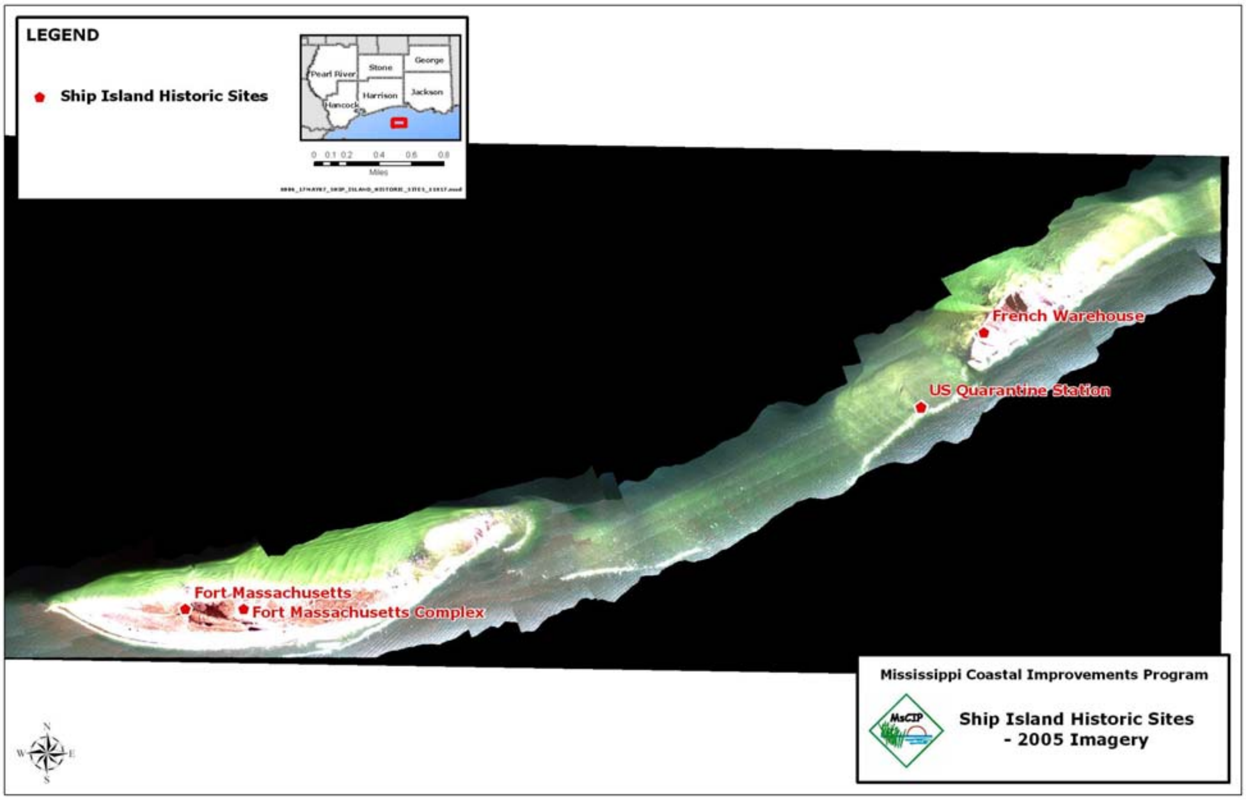

Figure 5.1.1-5. Aerial photo of West and East Ship Island taken in 2005 after Hurricane Katrina showing the locations of listed historical sites separated by Camille Cut

Fort Massachusetts was originally built on the western tip of Ship Island. The westward migration of sand along the southern shore and erosion of the northern shore now has put the fort almost a mile from the western tip of the island, but dangerously close to being in the Sound. Several emergency beach re-nourishments have taken place over the last 35 years to protect the fort from wave action during winter storms. At present, the NPS is again requesting that the Corps place sand along the shore near the fort in conjunction with dredging operations at the Gulfport navigation channel. This emergency placement of sand is being repeated about every five to six years.

The French Warehouse site has not had any sand placement on its shoreline in the past. The erosive process is slower at that location, but now there are concerns from the NPS about the integrity of the site. Unlike the location of the fort, the warehouse site is covered by maritime forest which may be added in slowing the erosion of the shore.

The Corps was asked to visit Fort Massachusetts with the NPS during July, 2007 to look at the present erosion problem and to discuss any possible long-term solutions to the loss of sand along the shoreline. The immediate erosion problem will require re-nourishment of the beach adjacent to the fort similar to the past protection projects. Any type of hardened structural feature as protection for the fort was not desired by the NPS nor was this recommended by the Corps. There was a breakwater placed north of the fort in the past (prior to the barrier islands becoming a National Seashore under the NPS) and seems to be compounding the erosion problems. The problem of a long-term fix may be tied to closing the three mile wide breach known as Camille Pass between West and East Ship Island. Review of historical footprints of the islands indicates that after the breach caused by Hurricane Camille, the westward migration of sand was continuing, but that the sand supply was being depleted before it reached West Ship Island. Aerial photos show the formation of a sand spit that extends westward from East Ship Island. The volume of sand that is creating this spit is being depleted before it reaches West Ship Island. The photos also show that a deeper channel has formed a pass between the eastern end of West Ship Island and the western end of the spit. It appears that an ebb tidal delta at this pass moves the sand southward where it is removed from any migration along the northern shore of West Ship Island. The sand continues to supply the south beach and extends the western tip of the island in its migration. The loss of the sand from the littoral drift along the northern shore of West ship Island has resulted in erosion of that shoreline. Figure 5.1.1-6 shows an excellent aerial view of this process. Note the boat on the northern side of the pass.

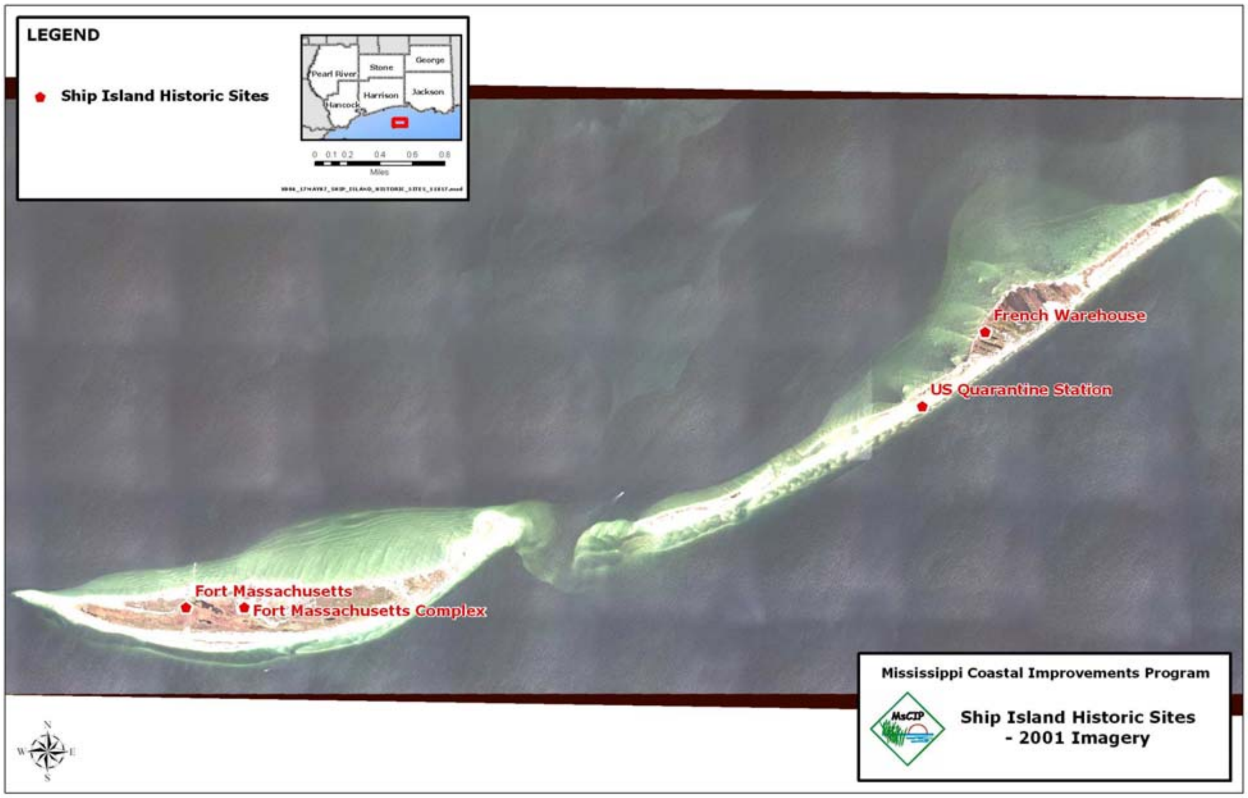

Figure 5.1.1-6. Aerial photo of West and East Ship Island taken in 2001. Note the sand spit extending westward from East Ship Island and the pass between the two islands.

A positive by-product of filling of the Camille Pass would be to provide a longer term solution to the erosion on the northern shores of West Ship Island. This will require modeling to better understand the benefits that are believed to be associated with this plan. The costs will be substantial due to the large quantities of sand high quality sand that will be required to fill the breach. Initial estimates for sand requirements are approximately 13 million cubic yards. The fill would be expected to prevent the continuing loss of sand to West Ship Island, but it is also understood that the islands are a dynamic system, ever changing to nature’s forces. Different types of dune vegetation planting would also be included to restore habitat on the newly created land.

5.1.2 Restoration of the Offshore Barrier Islands

5.1.2.1 General

Soon after Hurricane Katrina, it was reported that many residents in Mississippi were of the opinion that if the islands had been in the condition that existed prior to Hurricane Camille, there would have been less damage along the coast from Hurricane Katrina. This initial concept was also included in the Mississippi Governor's Restoration Plan which called for restoring the islands to a pre-Camille footprint. Changes in the footprints are shown in Figures 5.1.2.1-1 through 5.1.2.1-4.

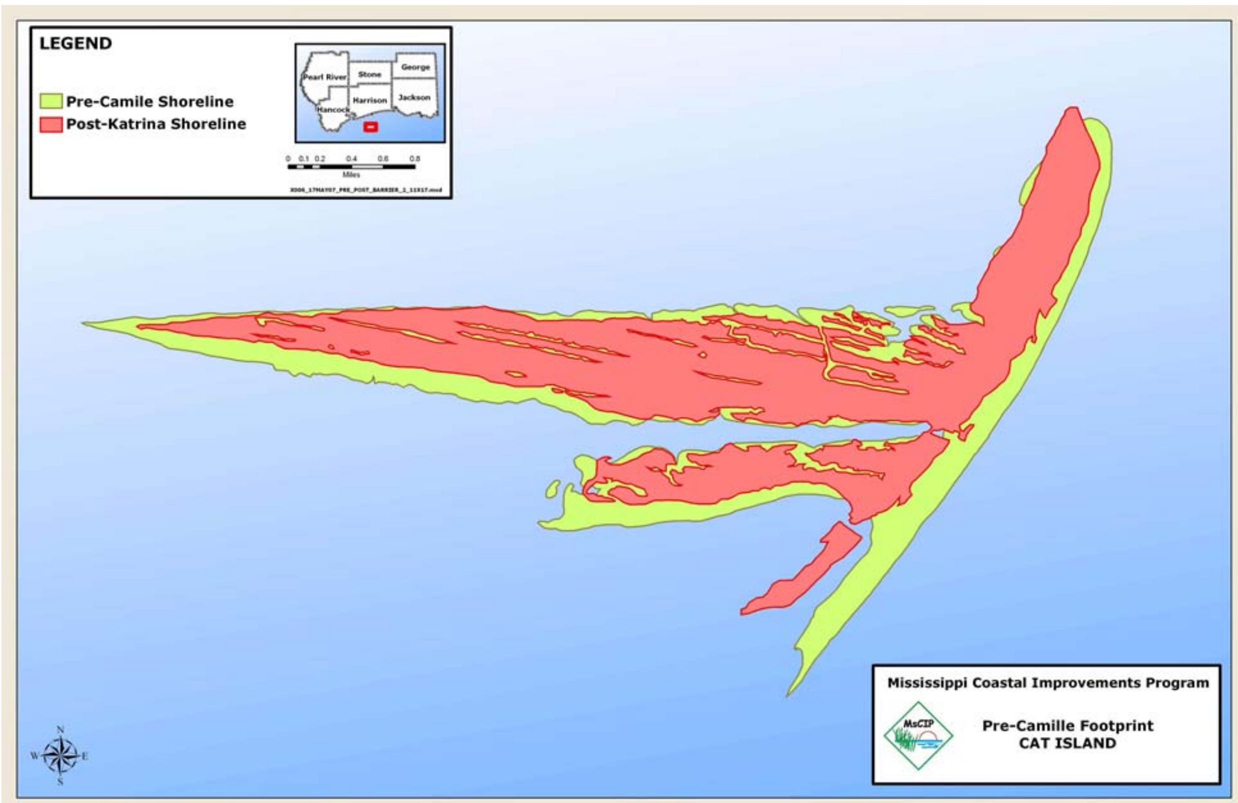

Figure 5.1.2.1-1. Changes in footprint of Cat Island from pre-Camille to post-Katrina

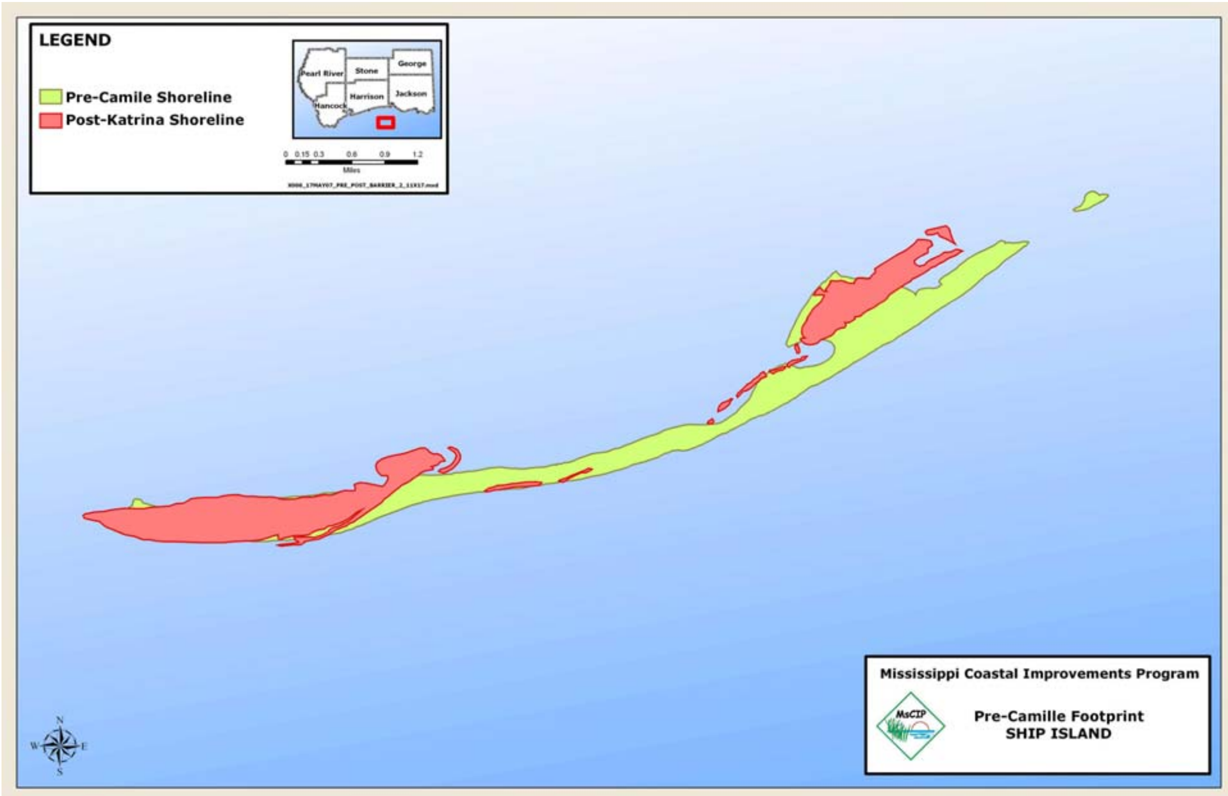

Figure 5.1.2.1-2. Changes in footprint of Ship Island from pre-Camille to post-Katrina

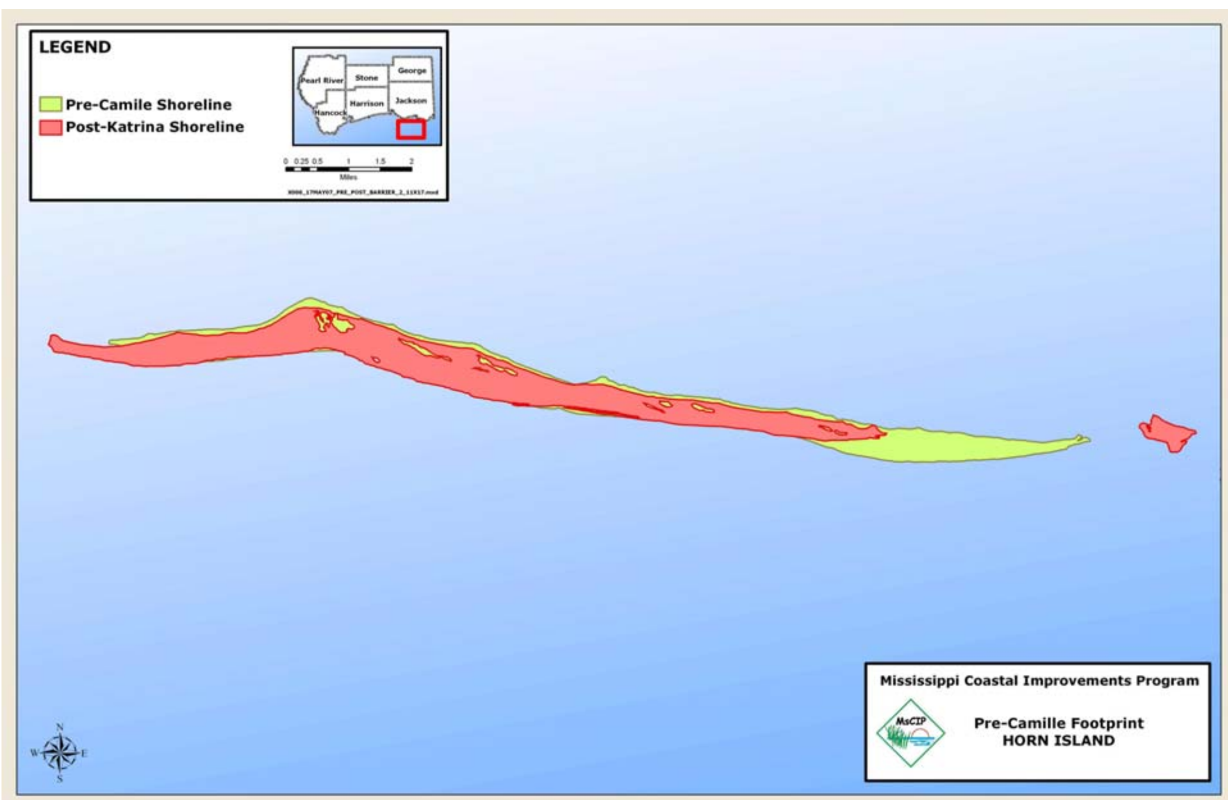

Figure 5.1.2.1-3. Changes in footprint of Horn Island from pre-Camille to post-Katrina

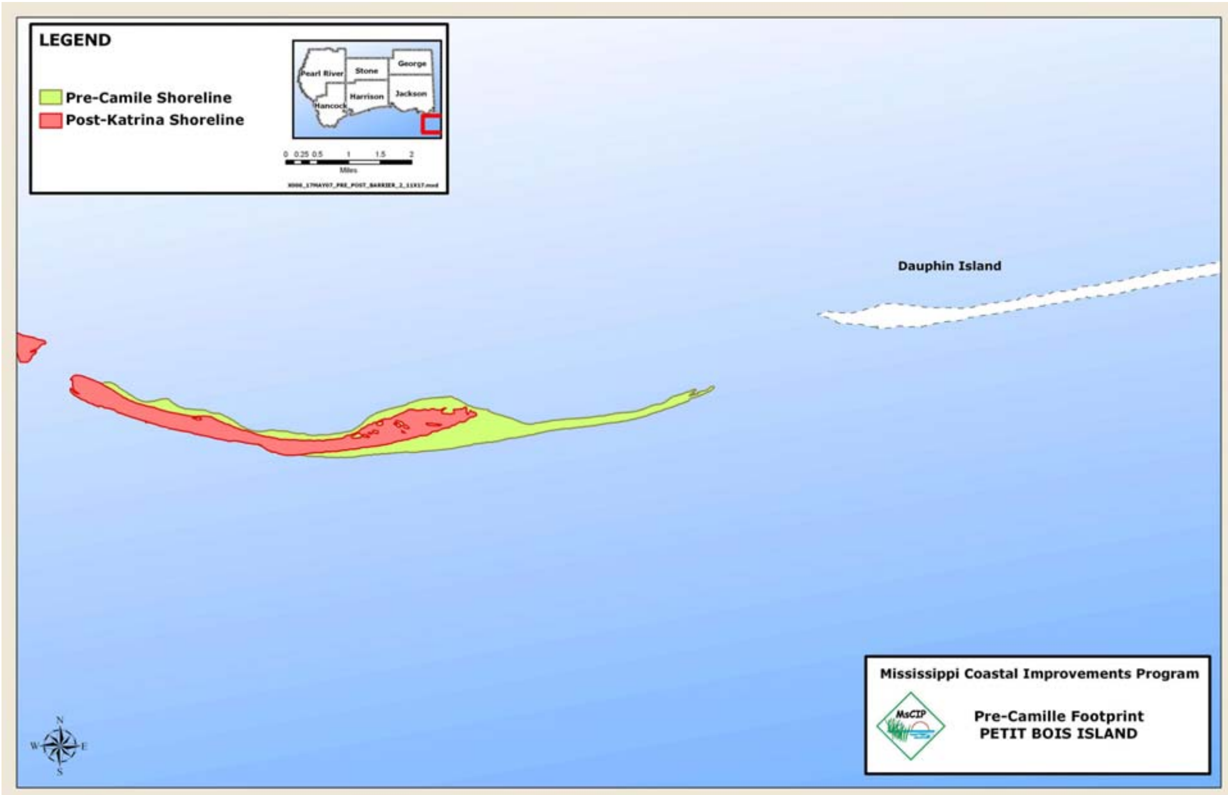

Figure 5.1.2.1-4. Changes in footprint of Petit Bois Island from pre-Camille to post-Katrina

As discussed in the Engineering Appendix, Part 2, a number of storms were selected to model against the chain of islands in a pre-Camille and a post-Katrina configuration. The post-Katrina condition can be considered a baseline condition for the modeling and the pre-Camille condition would be an improved condition. The pre-Camille footprint of the islands (USGS, 2007) was obtained from historical records and an assumption was made as to a top of dune elevation of 20 feet. It should be noted that some of the islands have migrated and any reconstruction would be to increase their footprint at their present location and not move them back to historical locations. This increase in size generally increased their length and maintained their typical width.

Modeling efforts have concluded that over a wide range of storms, there would be some protection provided to the eastern coast of Mississippi along the Jackson County shoreline if the islands are in the pre-Camille condition. This area is the most protected from the restored islands and this protection may result in only up to a 10% reduction in storm surge. As was shown in Figure 5.1.2.1-5, the effect of this protection diminishes rapidly to the west from Jackson County. With the consideration that these islands are within the National Park Service and that Petit Bois and Horn Islands are designated Wilderness Areas, any extensive restorations to these islands may not be feasible based on the limited reduction in storm surge.

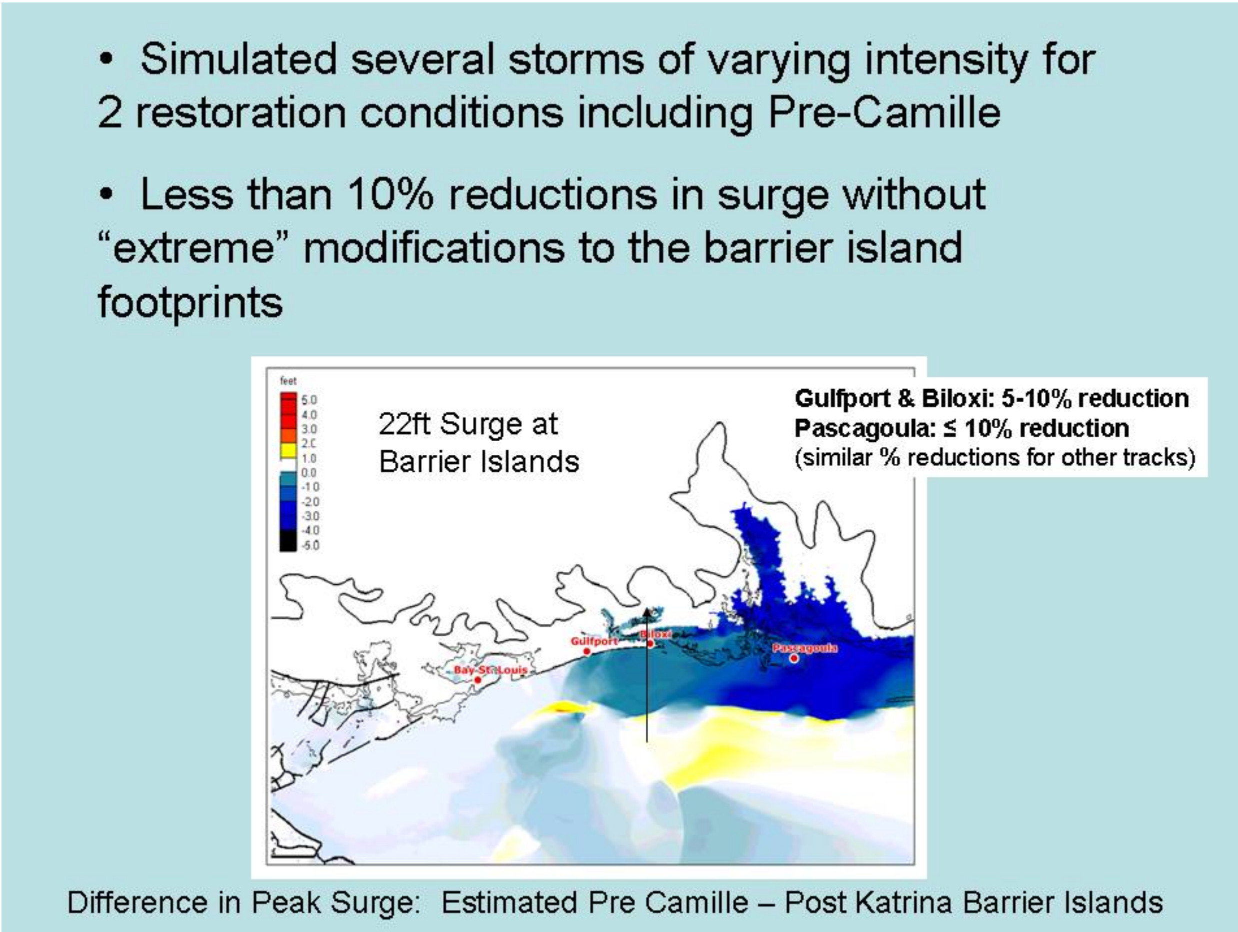

Figure 5.1.2.1-5 Difference in Peak Surge between pre-Camille and post-Katrina barrier islands

Another consideration to help restore the islands is to supplement the sand into the littoral system. This could be accomplished by adding sand in specific locations based on sediment transport modeling. This sand would not be put on the islands, but in areas between the islands where the currents that make up the littoral drift zone could transport the sand to the islands where the natural process of island building could take place. There, waves and wind could cause accretion on the islands. This may mitigate the loss of land mass at the islands that has been occurring since Hurricane Camille. The source of these sands may be from inland sources or from offshore borrow areas. This would not directly affect the present-day islands and would help mitigate any effects of dredging the ship channels that pass through the chain of islands where sand may have been lost from the system.

A positive affect that the islands have is to provide a natural off-shore breakwater for the large sea waves that are generated from hurricanes. For this to occur, the islands only need to be a low stretch of sand or even a shallow sandbar. The presence of the islands and the relatively shallow water of the Mississippi Sound between the islands and the mainland prevent the sea waves from maintaining their considerable size as they move towards the mainland. Sea waves, often reported at heights of 40 feet and higher in large storms, would break as they approach the chain of islands. The open water between the islands and the mainland, generally ten miles or more, would have enough fetch for waves to regenerate, but at a much lower height do to the shallower water. The generally accepted relationship between water depth and wave height is that the wave can sustain itself at a height that is one half the depth of the water.

An environmental impact of the islands continuing to diminish in size is to allow salinity increases in the Mississippi Sound. Under current conditions, the islands provide a boundary condition between the sea water salinity of the open Gulf of Mexico and the brackish water found in the Sound. Loss of the islands would allow the salinity in the Sound to increase and result in a change of the ecological habitats that exist now. This would impact shellfish and other forms of marine life. This occurred at the Chandeleur Islands near the Mississippi barrier islands when almost the entire island structure was eroded away by Hurricane Katrina (see Figure 5.1.2.1-6). Mississippi Sound is classified as a 'bar-built' estuary as opposed to 'drowned river valley' (like Mobile Bay). The physics of bar-built estuaries is very different from others and you would expect to see broad zones of 'salinities' with the estuary which respond greatly to both river flow and wind conditions. Should the 'bars' go away then the estuary is totally lost because in general an estuary is considered part of the coast as opposed to forming the coast.

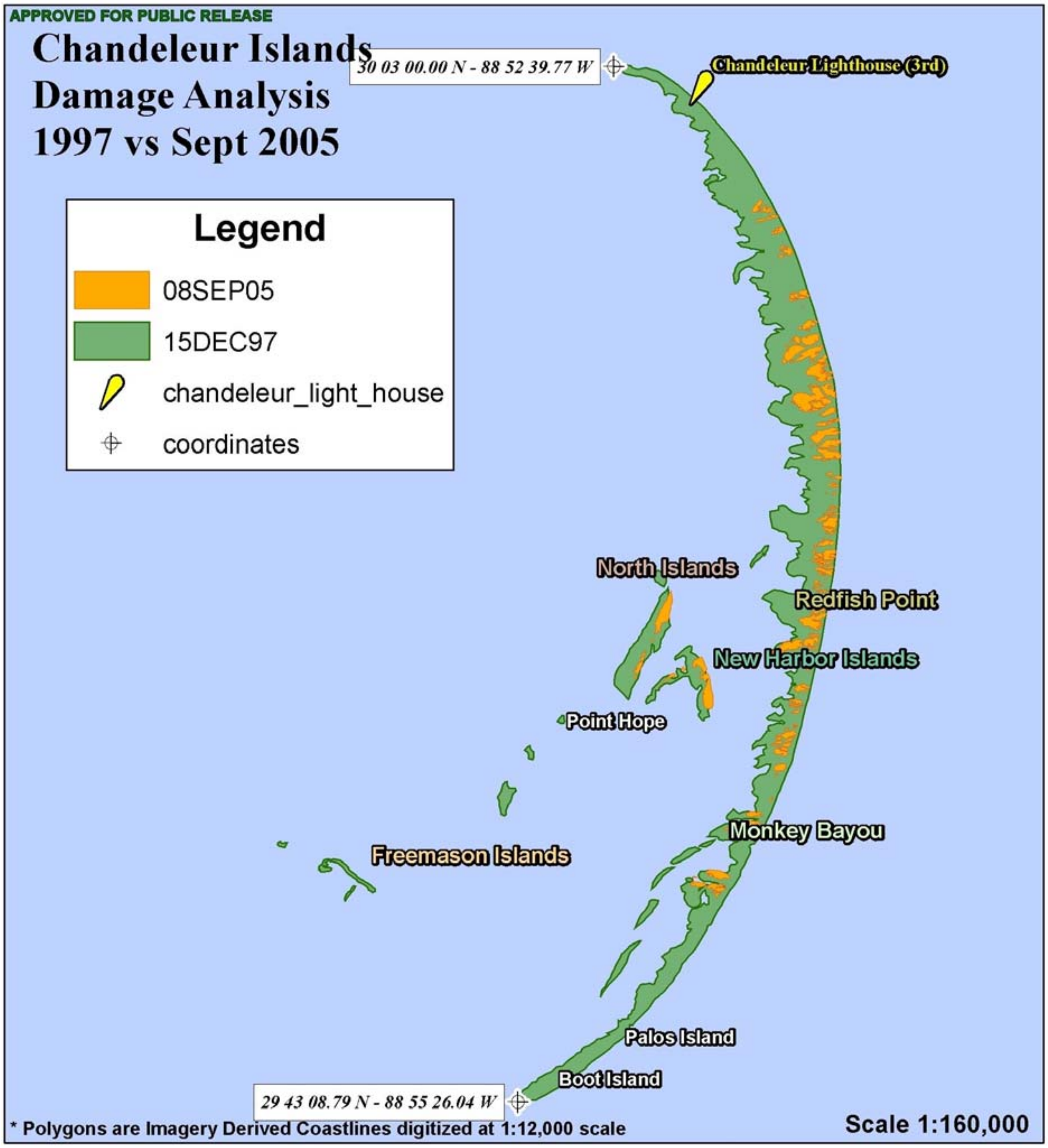

Figure 5.1.2.1-6. Loss of land mass from storm erosion at the Chandeleur Islands, 1997 to 2005. (US Navy)

One restoration option for the barrier islands would be to re-establish the vegetation that was destroyed by Hurricane Katrina. This option could involve environmental restoration of the existing islands through adding sand dunes on the beaches along with planted vegetation, planting of marshes and maritime forests, and planting sea grasses in the near-shore areas of the islands. This plan would not involve adding any land mass to the islands other than the possibility of adding to the dune system. The addition of vegetation from sea oats up to trees would aid in reducing erosion of the sand from wind thus helping in maintaining the stability of the islands. The vegetation would also aid in preventing erosion by water in the event that the islands gets overtopped by storm surge in a large hurricane. Sources of this sand could be from the beach area behind the dunes or from sources off the island. Historically, large areas of sea grass existed north of the islands. Much of this sea grass is now gone and the loss of these areas have been mapped. Replanting the grasses and other vegetation will aid in establishing valuable habitat that was lost from the ecological system. Figure 5.1.2.1-7 shows the extent of vegetation on Horn Island prior to Hurricane Katrina.

Figure 5.1.2.1-7. Aerial photo of Horn Island. The darker areas are vegetation consisting of maritime forest and marsh grasses.

As was mentioned at the end of Section 5.1.1 and will be discussed in more detail in Chapter 7 of this Appendix, an additional restoration option was added that will fill and close Camille Cut between West and East Ship Island. In addition to providing some storm damage reduction, this option will provide some protection to two historical sites on West and East Ship Island, respectively. This degree of protection is desired by the NPS and meets the goal of storm damage reduction and helping maintain the integrity of the Mississippi Sound estuary. This option will require additional study to model the desired results of slowing erosion near the two sites. These proposals have been incorporated into LOD-1 under Options C and G by adding sand into the littoral zone and closing the breach between West and East Ship island. A working paper that documents the NPS position on the barrier islands (NPS, Sept. 2007) along with other cooperating agencies is included in Chapter 6 of this Appendix. An important result of the NPS agreement was that any work that involved direct placement of sand into Camille Cut would be a one-time event without additional O&M sand placement. In accordance with 2006 NPS Management Policies (see Chapter 2, the NPS Vision Statement Section III), the NPS has concluded that this one-time placement of sand would mostly directly counteract the long-term reduction in sand supply which has resulted in Ship Island being diminished to the point where it may have lost the ability to restore and maintain itself as in the historical past. Natural re-building and maintenance of the barrier islands in the long-term would then be supported by the continuing placement of sand back into the littoral zone during future maintenance dredging of navigation channels under revised Regional Sediment Management

Practices. Two important areas where this will be employed is the Pascagoula Navigation Channel and the Gulfport Navigation Channel.

5.1.3 Location

The barrier islands of Mississippi are located 10 to 15 miles south of the mainland as shown in Figure 5.1.1-1. Currently, there are five islands in the chain that extends for 45 miles west from a point south of the Alabama – Mississippi state line along the coast. Currently, Ship Island exists as two islands separated by Camille Cut. It was breached during Hurricane Camille in 1969 and remains today as West and East Ship Island. Two maintained navigation channels pass through the chain of islands. The Gulfport channel passes near the west end of West Ship Island and the Pascagoula channel passes near the end of Petit Bois Island. The present day location of the channels prevents any further westward migration of either island.

5.1.4 Existing Conditions

As is typical of most barrier island systems, the Mississippi islands are an ever-changing and dynamic landscape. Data shows that the islands have lost approximately 20 to 25 percent of their land mass since pre-Camille times. The islands have been heavily influenced by the various hurricanes including even the lower intensity ones. Hurricane George, in 1998, even though a small hurricane, proved to be devastating to the islands due heavy erosion from waves. Many of the higher dunes systems on the islands were destroyed and much of the elevation the islands once had is gone. Most of the islands are now very susceptible to over-wash during storms. Another result of being submerged during Hurricane Katrina was the loss of much of the maritime pine forest that existed on the islands. The trees, mostly now dead from the salt water submergence, played a major role in preventing erosion both from wind and any surges against the islands.

The westernmost island, Cat Island, has a similar origin from the other islands in the chain, but isolated from the littoral current by a historical birds-foot delta from the Mississippi River that cut off the path of the historical littoral zone. A change in wave climate has formed a T-shaped configuration. Sorting of the sediments has created a beach on the east facing portion of the island. Results of the sediment budget completed as part of this study indicates that little or no sand is being added to Cat Island from the littoral drift system that supplies sand to the other islands in the chain. The remainder of the islands have a westward drift that is more pronounced from the eastern-most Petit Bois Island and decreasing respectively to the west to West Ship Island.

5.1.5 Coastal and Hydraulic Data

The barrier islands protecting the 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 45 ft depth) averaging 2.0 and 1.3 feet in the winter and summer months, with associated average peak wave periods of 4.0 to 3.5 s, respectively. Wave transformation modeling by Cipriani and Stone (2001) indicated that breaking wave heights on the barrier islands range from 1.0 to 2.0 feet. Waves in the Mississippi Sound are fetch and depth-limited. The Coastal Studies Institute's Wave-Current Surge Information System (WAVCIS) gage CSI-13 located at Ship Island Pass (23 foot depth) from June 1998 through July 2005 measured an average significant wave height of 0.3 feet and associated average wave period of 2.5 sec.

Tides in the Mississippi Sound are diurnal, with a tidal range of 1.5 and 2.8 feet for the mean and spring tides at Biloxi, Mississippi, respectively. However, the relatively shallow and large area of the Mississippi Sound create strong currents in the tidal passes between the barrier islands, ranging from 1.6 to 3.3 feet/sec and 6.0 to 11.5 feet/sec on flood and ebb tides, respectively (Foxworth et al.

1962). In the 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 3.6 to 2.0 feet (U.S. Army Corps of Engineers Mobile District 1984).

For the Gulf barrier island beaches, net longshore sediment transport is from east to west, although local reversals in the net transport occur adjacent to the tidal passes. The primary sources of sediment are longshore sediment transport from east to west, and, potentially, the offshore shelf (Otvos 1979, Cipriani and Stone 2001). Cipriani and Stone (2001) discussed that a well-defined cellular structure exists for each barrier island in which, over historic times, 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 of sand from adjacent barrier islands occurs, indicating the potential for transport of sand between islands. Eastern Dauphin Island, with a Pleistocene core, is more stable than the other barriers although eastern Dauphin Island has been eroding in response to the dominant westerly-directed transport. Based on grain size analysis, Cipriani and Stone (2001) inferred that offshore sources may provide some sediment to central Petit Bois Island. The Mississippi Sound barrier islands range from very well vegetated, with maritime forests on east Dauphin Island, to low elevation barriers that are overwashed and breached during hurricanes. Long-term relative sea level rise for Dauphin Island, Alabama from 1966 to 1997 was 0.12 inch/year +/- 0.02 inch/year.

5.1.6 Engineering Options

5.1.6.1 General

Seven separate options were included in the Engineering Appendix. All were based on some variation of direct sand placement and shaping, establishing vegetation and littoral zone sand additions. Each of the LOD-1 Options, A through G, are briefly described below. Full descriptions of each option can be found in the Engineering Appendix.

5.1.6.2 LOD-1, Option A

This option will only include new land mass that is being added to the islands by using sand dredged and transported from an off-shore location. The shaping of the sand into beaches, dunes and marsh areas will not affect the existing islands other than that narrow strip of land that will form the boundary between the existing island and the new land mass. This option can be used in combination with other options under this line of defense should it be desired to restore habitat on the existing islands.

5.1.6.3 LOD-1, Option B

Another consideration to help restore the islands is to supplement the sand in the littoral system. This could be accomplished by adding sand in specific locations based on sediment transport modeling. This would allow the littoral currents to move the sand onto the islands where the natural process of island building could take place. This would not directly affect the present-day islands and would help mitigate any effects of dredging the ship channels that pass through the chain of islands where sand may have been lost from the system. This option would obtain the sand from the beneficial use of dredged material from an inland river source.

5.1.6.4 LOD-1, Option C

Another consideration similar to Option B is to help restore the islands is to supplement the sand in the littoral system. Initial studies indicate areas east of Petit Bois and Ship Island are the best locations, but additional modeling will be completed that could add other areas within the barrier islands chain. Sand will be obtained from offshore sources (same as Option A) for Ship Island and from inland river sources (same as Option B) for Petit Bois Island based on sand quality and compatibility requirements. Like Option B, this could be accomplished by adding sand in specific locations based on sediment transport modeling.

5.1.6.5 LOD-1, Option D

This option would involve environmental restoration of the existing islands. This would consist of shaping existing beach sand into low, 2-foot high dunes on the beaches. This would be along with planted vegetation on the dunes and planting of maritime forests in the inland's interior where they were mostly destroyed by Hurricane Katrina.

5.1.6.6 LOD-1, Option E

This option would involve environmental restoration of the islands consisting of placing and shaping sand into 6-foot dunes on the beaches with planted vegetation and planting of maritime forests on the existing islands where they were mostly destroyed by Hurricane Katrina. The sand required to construct a dune of this size would be more than could be removed from the existing beach berm and would come from the same offshore borrow area as the sand used in Option A. Placement of the sand would require moving the sand from a hopper dredge to a staging area on the beach, then moving the sand to the area of placement along the beach.

5.1.6.7 LOD-1, Option F

This option would involve environmental restoration of the sea grass beds that have historically existed on the north side of the islands in the Mississippi Sound. Despite continual changes that occur, the barrier islands remain to buffer the mainland from storms and provide habitat for the rich, diverse wildlife residing within the area.

5.1.6.8 LOD-1, Option G

The pre-Camille footprint of Ship Island was obtained from historical records. This data showed the area that was breached during Hurricane Camille forming two separate islands. West and East Ship Island has two major historic sites that are in danger from the continuing erosion of the barrier islands. Current studies by the Corps indicate that restoring the two islands to a single island, pre-Camille condition may prevent the rapid erosion of the beaches that is now occurring. Estimates indicated that the restoration of Ship Island to a single land mass off the Mississippi coast will involve approximately 13 million cubic yards of sand. As happened during Hurricane Camille, the breach was opened during Hurricane Katrina leaving two islands with approximately three miles of open water between the remaining portions. To mitigate this problem, the breach could be filled as single operation up to an elevation that would help withstand over-wash until planted vegetation could be come established and promote stable dunes.

CHAPTER 6 MULTI-AGENCY MISSISSIPPI BARRIER ISLAND RESTORATION RECOMMENDATION

6.1 General

To complete its recommendation for the barrier islands the National Park Service met and coordinated with many different agencies including the Corps of Engineers, United States Geological Survey, National Marine Fisheries Service, Environmental Protection Agency, National Oceanic and Atmospheric Administration, US Fish and Wildlife Service, and Mississippi Department of Marine Resources.

6.2 Introduction

The Mississippi barrier islands consisting of Petit Bois, Horn, East and West Ship Islands, and portions of Cat Island are located within Gulf Islands National Seashore (Seashore), a park unit managed by the National Park Service (NPS). The NPS also administers the 401-acre Davis Bayou area on the mainland near Ocean Springs, Mississippi. The Seashore's purpose is to preserve, protect, and interpret its Gulf Coast barrier island and bayou ecosystem and its system of historic coastal defense fortifications, while providing for public use and enjoyment.

The Mississippi barrier islands are dynamic coastal landforms that act as the first line of defense between the ocean and mainland coast, and bear the full impact of atmospheric and oceanic energy (Figure 6.5-1). In addition, the barrier islands contribute to the maintenance of the highly productive Mississippi Sound ecosystem. Hurricanes, variations in sediment supply, and relative sea level rise drive changes in island location and morphology, and effective barrier island management requires adaptation to their dynamics.

The Mississippi barrier islands have experienced substantial changes in shoreline position and island landmass since the mid-1800s. Lateral island migration (erosion along the eastern end of the islands and sand deposition to the west) has occurred, driven by dominant east-to-west longshore sand transport. The long-term and accelerating erosion and land loss experienced by the barrier islands is of major concern to the NPS.

Factors contributing to erosion of the barrier islands include storms, relative sea level rise, and anthropogenic activities, including dredging of sand from the Horn Island Pass Outer Bar Channel (Figure 6.5-1). Such activities have likely resulted in a progressive reduction in sand supply downdrift to Horn Island and Ship Island (now East and West Ship Island). Significant storm events and a reduction in sand supply has contributed to substantial upland land area losses between 1847 and 2005 ranging from 24% at Horn Island to 64% at the Ship Islands. In addition, Petit Bois Island, which is located east (updrift) of Horn Island Pass, has experienced a 56% reduction in upland land area between 1847 and 2005 (Morton, 2007).

The regional shortage of littoral sand for barrier island maintenance is most profound at the Ship Islands, located at the terminus of the sediment transport system along the Mississippi barrier islands. Cat Island, located west of the Ship Islands, is not part of the sand-sharing system that comprises the other barrier islands, and is considered to be a separate entity (Rosati et al., 2007). Consequently, the Ship Islands' vulnerability to breaching has progressively increased with time.

Because of the island's diminished state, it may now have lost the ability to restore and maintain itself as in the historical past (Morton, 2007), placing the island's cultural resources, historic Fort Massachusetts and the French Warehouse archeological site, at great risk (Figure 6.5-2).

Given the altered state of natural resource processes due in part to human-caused intervention, as well as the resulting threats to cultural resources, the NPS in collaboration with other agencies (USACE, USGS, NMFS, EPA, NOAA, USFWS, and MDMR) has concluded that specific emergency actions and long-term restoration of the sediment transport system and budget are crucial and necessary for preserving and protecting the Mississippi barrier islands' natural and cultural resources. This Mississippi barrier island restoration recommendation represents the results of extensive interagency consultation and collaboration.

6.3 Background

6.3.1 NPS Management of Mississippi Barrier Islands

Gulf Islands National Seashore includes outstanding natural, cultural, and recreational resources along the northern Gulf of Mexico coasts of Florida and Mississippi. These resources include several coastal defense forts spanning more than two centuries of military activity, archeological values, pristine examples of intact coastal barrier islands, salt marshes, bayous and submerged seagrass beds, complex terrestrial communities, emerald green water, and white sand beaches. The barrier islands within the Seashore are nationally significant for several reasons. Specifically, these islands:

- contain one of the most complete collections of publicly accessible seacoast defense structures in the United States, representing a continuum of development from early French and Spanish exploration and colonization through World War II;
- provide the public with recreational opportunities on natural and scenic island, beach, dune and water areas which possess the rare combination of remaining undeveloped and in a wilderness state, yet are located in close proximity to major population centers;
- provide habitat for several endangered species in diverse ecosystems, stop-over habitat for migratory birds, and critical nursery habitat for marine flora and fauna, and serve as an enclave for complex terrestrial and aquatic plant and animal communities that characterize the northern Gulf Coast, and fully illustrate the natural processes which shape these unique areas;
- contain land and marine archeological resources which represent a continuum of human occupation in a coastal environment and are important in enhancing the knowledge of the past including interactions between the earliest settlers and original inhabitants of this area of the Gulf Coast; and
- provide a benchmark to compare conditions in developed areas of the Gulf Coast to natural areas within the park.

The NPS's vision for management of the Mississippi barrier islands (Chapter 2) includes the preservation of natural biological and geological marine and terrestrial conditions and processes, and the preservation of cultural resources, consistent with peer-reviewed and documented scientific study. Horn and Petit Bois Islands, which are designated wilderness areas, receive an even higher level of protection. In these areas, the NPS vision and management focuses on providing park visitors with an undisturbed environment, a pristine and unencumbered viewshed, an atmosphere of solitude, an opportunity for primitive, unconfined recreation, and negligible evidence of resource impairment. The NPS implements this vision by controlling nonconforming uses, preventing unnecessary or undue reduction of wilderness values, and applying the “minimum requirement” concept of the 1964 Wilderness Act to all proposed projects involving these islands.

Based on federal statutes such as the National Park Service Organic Act and the Seashore’s enabling legislation, NPS Management Policies, and management plans, the NPS is mandated to preserve and protect the natural conditions and processes affecting the barrier islands, and to preserve the significant cultural resources existing on the islands. In addition, the Seashore’s enabling statute directs that beach erosion control measures and spoil deposition activities in the park undertaken by the U.S. Army Corps of Engineers must be carried out in a manner that is acceptable to the NPS and consistent with the park’s purposes (16 U.S.C. § 459h-5). NPS decision-making must also integrate the results of scientific study (16 U.S.C. § 5936).

6.3.2 Impacts to Mississippi Barrier Islands and Processes

Net longshore sand transport is from east to west along the Mississippi barrier islands, although local reversals in the net transport occur adjacent to the tidal passes. Based on analysis of historical shoreline and bathymetry data, Ship Island is the terminus to the longshore sand transport system in this region. Modern Cat Island beaches, located west of Ship Island, appear to be affected by littoral processes not directly related to those of the islands to the east. Thus, the regional shortage of littoral sand for barrier island maintenance is best observed at Ship Island (Rosati et al., 2007).

Between the late 1840s and 2005, all of the Mississippi barrier islands managed by the NPS have eroded and migrated appreciably. Petit Bois Island lost about 56% of its surface area, Horn Island lost approximately 24%, East and West Ship Islands have cumulatively lost about 64%, and Cat Island lost approximately 26% (Morton, 2007). Furthermore, island erosion rates have increased more than three fold between 1847 and 2000/2002. For example, Ship Island lost about 0.9 hectares/year between 1848 and 1917, increasing to approximately 2.5 hectares/year between 1917 and 2000 (Rosati, et al., 2007). Additionally, between 2000 and 2005, a period of significant storm events, the Ship Islands lost about 22 hectares/year (Morton, 2007). In 1847, Ship Island had a surface area of approximately 603 hectares (Rosati, et al., 2007), but by 2005 the total surface area for East and West Ship Islands had decreased to about 216 hectares (Morton, 2007).

The principal causes of Mississippi barrier island erosion and land loss are frequent intense storms, a relative rise in sea level, and a deficit in the sediment budget. Of these causes, the one that experienced the greatest change over the last 100+ years is the reduction in sand supply related to dredging of navigation channels through the outer bars of the tidal inlets near the islands (Morton 2007). According to Rosati et al. (2007), maintenance dredging operations conducted between 1897 and 1948 in the Horn Island Pass Outer Bar Channel removed sediment at a rate of approximately 34000 cubic yards per year (cy/yr). After the channel was modified to 38-feet deep by local interests in 1949 at their expense, maintenance dredging quantities continued to increase as authorized channel depths increased. Maintenance dredging rates increased to161,104 cy/yr in 1949-1965, increased again to 515,320 cy/yr in 1965-1993, and decreased to a rate of 245,483 cy/yr in 1993-2005.

Therefore, between 1909 and 2005, a total of approximately 22 million cubic yards of sand were removed from the Horn Island Pass Outer Bar Channel by maintenance dredging (Rosati et al., 2007). Much of the sand dredged from the outer bar channel during maintenance dredging operations likely originated from littoral zone transport east of the channel. Offshore disposal of sand dredged during channel maintenance operations conducted in the past may have removed such sand from the barrier island sediment budget downdrift of the channel. However, a detailed analysis of the dredging/placement records and the resulting impact on the barrier island sediment budget has yet to be determined. Additional investigations into past dredged material placement quantities and locations relative to the regional barrier island sediment budget need to be conducted.

Ship Island experienced breaching by hurricanes in 1852, 1916, 1947, and 1969 (Hurricane Camille). However, pre-Camille breaches eventually shoaled and the narrow, low-profile barrier beach reformed through natural processes. Since 1969, Ship Island has been separated into two islands (East and West Ship) by “Camille Cut.” Between 1969 and 2002, the average width of Camille Cut between the Ship Islands was approximately one mile. However, the breach widened to about three miles following the passage of Hurricane Georges in 1998, creating a shallow subaqueous shoal across the eastern one-mile of the breach area. Although precise depth measurements are not yet available, water depth across most of the breach area is estimated at 1 to 5 feet, and the channel that has formed adjacent to the east end of West Ship Island is about nine-feet deep (Figure 6.5-2).

Recent scientific reports present concerns regarding the existing condition of the Ship Islands and their ability to restore themselves to a single island once again based on current trends (i.e., accrete enough sand to shoal, closing the Camille Cut breach and channel, and redeveloping the narrow, low-profile barrier beach). Morton (2007) states “the historical record for Ship Island indicates that its vulnerability to breaching progressively increased with time and that because of its diminished state, the Camille Cut inlet will not shoal and East and West segments will not become reattached as in the past.” Rosati et al. (2007) also notes “disintegration of this barrier island (Ship Island), especially since Hurricane Katrina in 2005.”

Beach erosion along the Mississippi Sound (Sound) shoreline of East and West Ship Islands currently threatens the French Warehouse archeological site and historic Fort Massachusetts (constructed between 1859 and 1866), respectively. Relatively small-scale beach renourishment projects with sand volumes ranging from 44,346 to 160,566 cubic meters were authorized in 1974, 1980, 1984, 1991 and 2002 to advance the north shoreline on West Ship Island to protect Fort Massachusetts. Observations indicate that Camille Cut may be exacerbating erosion along the northeast shoreline of West Ship Island, and it may be interrupting sediment transport downdrift toward Fort Massachusetts.

The consequences of continued erosion of the Mississippi barrier islands affect not just the islands themselves, but the physical, chemical and biological integrity of the Sound and the Mississippi mainland coast. In the broader regional sense, the physical integrity of these barrier islands may provide the Sound and coastal counties some degree of protection from the energy generated by tropical storms and hurricanes. Ocean surge generated by hurricanes has been modeled with and without these islands for a variety of storm tracts, intensities and forward speed. As modeled, ocean surge protection provided by these islands is estimated between two (2) and four (4) feet, with a general tendency of greater protection toward the eastern area of the Mississippi mainland coast (Ty Wamsley, personal communication, Sept. 18, 2007).

Wave height modeling for a variety of storm tracts, intensities and forward speed also shows that the physical presence of the barrier islands may reduce expected wave height at the Mississippi mainland shoreline by four (4) to six (6) feet. Again, the barrier islands afford a greater degree of protection relative to wave height reduction toward the eastern area of the Mississippi mainland coast (Ty Wamsley, personal communication, Sept. 18, 2007). Furthermore, combining predicted surge and wave height modeling results shows that total loss of the Mississippi barrier islands may increase the elevation of adverse impacts on mainland coastal areas on the order of an additional six (6) to ten (10) feet.

The loss of any one barrier island would result in a more localized coastal impact. Localized increases in surge, wave height and current speeds would likely occur due north and west of a barrier island lost from the system. Additional modeling is necessary to determine the potential impacts to the mainland coastal area if the Ship Islands continued to erode to a shallow sand shoal.

Water chemistry within the Sound would be expected to change as well with the physical loss of any one or more of the barrier islands. Specifically, salinity gradients may increase in the Sound north of any area of greater exposure to Gulf of Mexico waters resulting from continued erosion and loss of the barrier islands, or the creation of additional water exchange pathways (passes, cuts, etc.). Baseline salinity modeling completed by USACE Engineer Research and Development Center demonstrates this potential gradient increase. Salinity gradient increases resulting from new or expanded passes or cuts would result in greater penetration of oyster drills into the Sound. The expansion of salinity gradients and related penetration of oyster drills increases potential adverse affects on Sound oyster beds.

Other biological communities, such as submergent and emergent grass beds, marshes, scrub/shrub and forest vegetation communities could be adversely affected by the continued erosion and land loss of the barrier islands. Predicted higher storm surge, waves and energy would likely shift these vegetation communities landward over time. Disruptions of these existing vegetation communities exposes highly erodeable soils, and when subjected to high energy, may increase water turbidity and decrease light penetration, reducing submergent vegetation and depositing sediment on existing oyster beds. Emergent vegetation in the Sound and along the coastline provides protection from storm surge and wave action. These components also provide significant benefits for aquatic and aquatic-dependent faunal species of this area. Food, cover, spawning and nursery sites for estuarine and marine organisms require some or all of these submergent and emergent vegetative communities during their life cycles. Coastal areas that have significant emergent marshes, scrub/shrub and forested vegetative communities in the tidal zone have significantly less wind and storm surge damage than coastal areas adjacent to open water.

Continued erosion and loss of the Mississippi barrier islands within Gulf Islands National Seashore could result in significant adverse consequences not only to the natural and cultural resources managed by the NPS, but also to the overall health of the Mississippi Sound ecosystem and mainland coastal communities. Under a no action scenario, barrier island land loss will continue to increase. At the current rate of erosion and land loss on East and West Ship Islands, these islands may be eliminated within a decade. If so, significant natural and cultural resources managed by the NPS, including Fort Massachusetts, will be in peril.

6.4 Barrier Island Restoration Strategy

Given the value of these barrier islands as natural habitat, recreation sites, and possible protection for the mainland to some degree, the following recommendations are designed to address chronic losses in surface area along the islands to restore the natural transport system and island habitat that existed historically. Priority is assigned to East and West Ship Island because these islands have recorded the greatest losses throughout the system and significant cultural resources on both islands are at risk.

6.4.1 Restoration Goals

The overarching goal is to restore the crucial sediment transport system and budget, including littoral zone geologic processes around the Mississippi barrier islands, to a natural state as much as possible given the realities of navigation channel dredging, climate change (sea level rise, increased frequency of storms, etc.) and other anthropogenic activities. Restoring the sediment transport processes of the Mississippi barrier islands to a condition similar to the natural system that functioned before human intervention offers the best opportunity to ensure the long-term viability of these islands.

The preferred restoration approach includes (1) littoral zone deposition of compatible sand, consistent with the quality, especially color, grain size, absence of contaminants, and angularity of sand that would be present in the barrier island system under natural conditions, in appropriate volumes and locations near Petit Bois, Horn and East Ship Islands; (2) up to two small-scale beach nourishment projects on the Mississippi Sound shoreline of West and East Ship Islands to protect historic Fort Massachusetts and the French Warehouse archeological site; and (3) the direct deposition of acceptable beach-quality sand in the area of chronic breaching and inlet formation at Camille Cut to reconstruct the narrow, low sand spit that historically connected East and West Ship Island. The primary objectives of this alternative are to restore the Mississippi barrier island sediment transport system and budget disrupted by anthropogenic activities conducted near these islands, facilitate the restoration of Ship Island to a natural condition, and reduce erosion threats to significant cultural resources.

This preferred restoration strategy would also provide for (1) additional scientific investigations and modeling on which project planning, restoration benchmarks, goals, monitoring protocols and adaptive management prescriptions will be based; and (2) restoration of the regional sediment transport processes, including at a minimum the bypassing of all beach-quality sediment dredged from the navigation channels near the Mississippi barrier islands, and the proper placement of such sediment in the littoral system to replicate natural coastal geologic processes and provide for the protection and preservation of these nationally significant islands.

The sand placement strategy considered for restoration of Ship Island is based on the general geomorphic characteristics of the circa 1916-1917 shoreline and island land mass. The 1916-1917 baseline condition represents the most recent shoreline data available which documents a continuous Ship Island (Rosati et al., 2007; Morton, 2007). Applying data presented in Rosati et al. (2007), this baseline condition also represents a time frame prior to significant increases in maintenance dredging rates and thus volumes of sand removed in the Horn Island Pass Outer Bar Channel which began to occur in 1949. The land mass that connected East and West Ship Islands in 1916-1917 was a narrow, low sand spit measuring approximately 1000-feet wide (north-south width) with a likely elevation of approximately five (5) feet.

The volume of sand necessary to achieve the prescribed “emergency actions” and “advanced engineering and design actions” described below is based on the premise that the 22 million cubic yards of sand removed from the Horn Island Pass Outer Bar Channel during the period of 1909-2005 should be properly placed back into the sediment transport system to restore the barrier islands. In addition, sand removed from the Horn Island Pass Outer Bar Channel during future maintenance dredging operations should be properly placed west of the channel to mimic the natural sediment transport system.

6.4.2 Emergency Actions

Emergency actions would include direct placement of compatible sand on the Sound shoreline of West Ship and East Ship Islands to protect the integrity of historic Fort Massachusetts and the French Warehouse archeological site, direct placement of compatible sand in Camille Cut to suture (fill-in) the existing gap between East and West Ship Islands to a circa 1916-1917 geomorphic condition, and concurrently placing compatible sand in the littoral zone near East Ship Island.

Beach renourishment to protect the integrity of Fort Massachusetts and the French Warehouse archeological sites would include the direct placement of approximately 100,000 cubic yards of beach-quality sand along the Sound shoreline of West Ship Island to protect Fort Massachusetts, and direct placement of about 100,000 cubic yards of beach-quality sand on the Sound shoreline of East Ship Island to protect the French Warehouse archeological site. Sand source locations, compatibility requirements, precise depositional locations, depths of sand deposition, etc., would be determined by the NPS and USACE. A second round of direct sand placement at the same volumes and locations is contemplated within five years following initial emergency beach renourishment to protect these significant cultural resources until such time as restoration of the barrier island sediment transport system and budget is achieved through additional planned actions described below.

In order to restore the 1916-1917 geomorphic condition of Ship Island, approximately 13 million cubic yards of compatible sand would be directly placed in the Camille Cut breach and inlet area to reconnect East and West Ship Islands (Figure 3). The proposed dimensions of the Ship Island breach restoration project are three (3) miles in length, 1000 feet wide (north-south width), with a proposed sand thickness of approximately six (6) to 14 feet to achieve the desired five (5) feet subaerial elevation across the restored spit reconnecting East and West Ship Islands. However, the anticipated volume of sand required to achieve these restoration dimensions could be slightly modified based upon the results of a planned bathymetric survey of the breach area by the USGS. The sand placement approach would be adaptively managed based on monitoring of project performance measures. The restored sand spit would be planted with native vegetation species (e.g., seaoats, bitter panicum, etc.) to hold the sand in place and to foster future entrapment of wind-blown sand and long-term island stabilization. Native vegetation species would be planted in 60 feet swaths and no closer than approximately 100 feet from both the Gulf and Sound shorelines.

Sand placement in the littoral zone near East Ship Island is essential for continued nourishment to the restored spit at the Camille Cut breach and inlet. Approximately 5 million cubic yards of beach-quality sand would be placed within water depths affected by normal to moderate wave action and no deeper than 15 feet, the USACE definition of maximum littoral zone depth for this area (Hallermeier, 1981 (USACE Coastal Engineering Tech. Aid No. 81-2)) over a large area on the south-southeast side of East Ship Island. This phase of restoration is essential for supplying sand to the beaches west along Ship Island, including those occupying the reconstructed connecting spit. Westward sand transport from the reconstructed spit will also nourish the shoreline near Fort Massachusetts through natural alongshore currents in the Sound. Detailed planning for such deposition in the littoral zone near East Ship Island would be subject to the results of additional research and modeling efforts, including near-shore bathymetry and numerical modeling of waves, currents, and sediment transport.

During and following the placement of sand in all the aforementioned restoration locations, the effectiveness of such placement should be evaluated for success as part of an adaptive management strategy. If metrics indicate successful performance for island restoration and littoral zone placement, projects will continue as planned. Otherwise, at the end of year one, a reassessment and potential change in location for littoral zone placement may be implemented. Successful performance should be based on several factors, including, but not limited to, proper sand placement to nourish the islands and to protect Fort Massachusetts and the French Warehouse archeological site for the next 20 years without a need for annual or repetitive maintenance. Additional sand placement and native vegetation replanting may be required, depending upon success rate, to achieve the desired percent cover.

6.4.3 Advanced Engineering and Design Actions

This restoration strategy will also include the proper placement of approximately 4 million cubic yards of beach-quality sand in the littoral zone updrift of Petit Bois Island in water depths affected by normal to moderate wave action and no deeper than 15 feet. In addition, this strategy proposes to place all sand removed during maintenance dredging operations from the Horn Island Pass Outer Bar Channel to the west of the channel and east of Horn Island so that the dredged sand remains within the littoral zone. The bypassed sand will also be placed in water no deeper than 15 feet. Such bypassing of sand transported to Horn Island is essential to the long-term health and maintenance of downdrift islands (Horn, East and West Ship Islands). It is estimated that approximately 1 million cubic yards of sand will be bypassed every 2.5 years.

Detailed planning for such deposition in the littoral zone near Petit Bois and Horn Islands would be subject to the results of additional research and modeling efforts, including near-shore bathymetry and numerical modeling of waves, currents, and sediment transport. During and following the placement of sand in the littoral zone near Petit Bois and Horn Islands, the effectiveness of such placement should be evaluated for success as part of an adaptive management strategy. If metrics indicate successful performance for littoral zone placement, projects will continue as planned. Otherwise, at the end of year one, a reassessment and potential change in location for littoral zone placement may be implemented.

6.4.4 Long-term Restoration Actions

Restoring and replicating the sediment transport processes and budget of the Mississippi barrier islands to a condition similar to the natural system that functioned before human intervention offers the best opportunity to ensure the long-term viability of these islands. Therefore, the best long-term restoration solution is to plan for the addition of compatible sand routinely dredged from navigation channels in the area that are located east of Petit Bois, Cat, and Horn Islands back into down-drift littoral zones including the Sand Island Beneficial Use Area. Appropriate volumes of sediment would then be available in the littoral zone transport system to replenish sand lost from all of the Mississippi barrier islands (including Dauphin Island) due to natural geologic processes. Any long-term planning to achieve this objective must be based on sound scientific information and understanding of the barrier island sediment budget and transport system, and must be consistent with NPS mandates.

6.4.5 Data Collection, Analysis and Modeling

Prior to implementing the recommended barrier island restoration actions presented above, additional data collection, analysis and numerical modeling must be completed to ensure that project design is based upon the most current scientific information and understanding of the sediment transport system and budget. Recommended data collection and analysis needs include:

- conduct bathymetric survey throughout the island chain and inlets to document water depth in Camille Cut between East and West Ship Islands, identify sand resource targets, and update the existing sediment budget related to island restoration (Figure 6.5-4);
- analyze U.S. Coast Survey topographic maps of Ship Island prepared in 1848, 1853, and 1917 to confirm the subaerial elevation of the narrow sand spit in the central part of the island during that period;
- obtain current orthophotography to document island geomorphology and vegetation characteristics as part of CHARTS data acquisition, and to derive high-water shoreline position for each barrier island;
- acquire seismic and vibracore data at dredged material disposal site locations identified by comparing the modern bathymetric survey to the 1917/18 survey;
- determine sedimentologic characteristics of existing dredged material disposal sites to verify the quantity of sand available for barrier island restoration;
- review past dredged material placement quantities and locations relative to the regional sediment budget; and

- review historical breaching and breach closure data for all islands, and assess available geologic and morphologic data for Ship Island relative to the other barrier islands, to determine why Ship Island has breached several times, whereas Horn Island and Petit Bois Island have not.

To adequately design sand placement throughout the system and to evaluate potential impacts of the no action and preferred alternative scenarios, numerical modeling of waves, currents, and sediment transport should be conducted. Modeling analysis will validate the regional beach response to evaluate dredging and placement alternatives, and restoration of East and West Ship Islands. All historical data since the mid-1800s will be utilized in developing and calibrating the model so that future evolution (decades to a century) can be estimated with and without anthropogenic activities. Recommended modeling tasks include:

- develop input data for the Cascade Model, including shoreline position, topographic cross sections, sediment sources and sinks, vegetation composition and density through time, aerial photographs, storm and typical wave, wind, and water level data, and incorporate spatial data into the existing MsCIP sediment budget GIS;
- calibrate and validate Cascade (including sub-modules: breaching, wind-blown sand and dune building);
- demonstrate application of Cascade for proper dredged material placement, interim beach fills, and large-scale renourishment;
- evaluate placement locations for dredged material disposal at Horn Island Pass and Ship Island Pass for effective bypassing of littoral sand to mimic the barrier island natural sediment transport processes;
- conduct wave climate and surge modeling with and without the Ship Islands to assess potential impact on the mainland; and
- conduct salinity modeling to predict change in the salinity regime under present conditions, without the islands, and with a restored Ship Island (continuous island across the present location of Camille Cut).

6.5 Adaptive Management Strategies for Mississippi Barrier Island Restoration

Adaptive management strategies employed during the restoration project will provide the means to monitor the progress of the project, to assess whether immediate or short-term impacts are those intended or unintended, and a means to halt or modify project activities, or to mitigate the effects of activities, should negative or adverse impacts to natural or cultural resources be noted during monitoring. Monitoring activities should be continued for a specified time period after project activities are completed to measure long-term or cumulative impacts, and whether the goals of the project have been met.

6.5.1 Monitoring Protocols

Monitoring during and following the implementation of the barrier island restoration actions described above is needed to assess the progress of the restoration and short- and long-term impacts to the barrier island system and cultural resources. Monitoring recommendations include:

- obtain orthophotography of each barrier island on an annual basis to determine shoreline position change;

- map bathymetry in the barrier islands area pre- and post-project, 1 year after project completion, 5 yrs after project completion, and immediately following passage of a tropical storm or hurricane to document movement of sand placed in Camille Cut and in the littoral system;
- use topographic, bathymetric and hyperspectral sensors on the Compact Hydrographic Airborne Rapid Total Survey (CHARTS) system to document land elevation and vegetation density change annually, and process and analyze acquired data in an efficient and timely manner to make adjustments in sand placement strategies if desired results are not being achieved; and
- obtain daily real-time water quality data adjacent to all beach renourishment, direct placement and littoral zone placement areas in coordination with EPA Gulf of Mexico, MS Department of Marine Resources and MS Department of Environmental Quality.

During the barrier island restoration process, information obtained through the adaptive management monitoring protocols outlined above will be reviewed by a committee consisting of representatives from NPS, USGS, USACE, NOAA and the State of Mississippi. This committee would determine whether the restoration objectives were being met, and if not, whether sediment placement strategies should be modified or terminated.

6.5.2 Barrier Island Restoration Success Benchmarks

Suggested benchmarks to use to measure the degree of success of the restoration project include:

- 80% vegetation survival in the Camille Cut fill area two (2) years following completion of replanting efforts;
- absent a storm of record, Ship Island should remain continuous for 20 years, and expected minor breaches that occur should heal within 10 years;
- rate of accretion along the western edge of Ship Island should respond as it did in the historical record based upon the best available scientific information; and
- sand placed in the littoral system east of Horn and Petit Bois Islands should result in restoration of the east ends of these islands as measured by an increase in the surface area or a significant decrease in the rate of surface area loss documented during the past two decades.

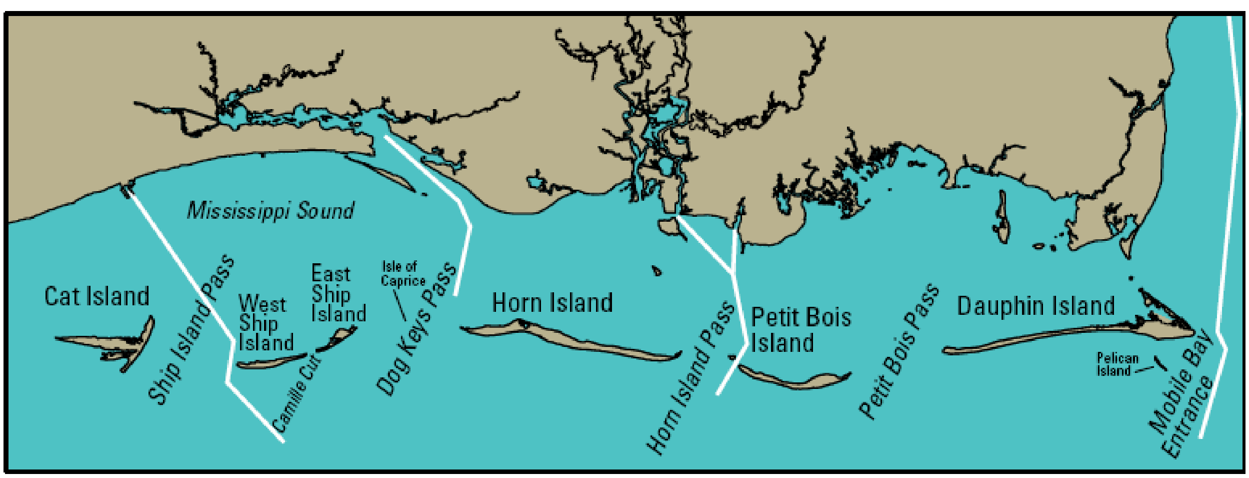

Figure 6.5-1. Locations of the Mississippi-Alabama barrier islands and associated tidal inlets. Deep draft shipping channels maintained by periodic dredging are show as white lines. (from Morton, 2007)

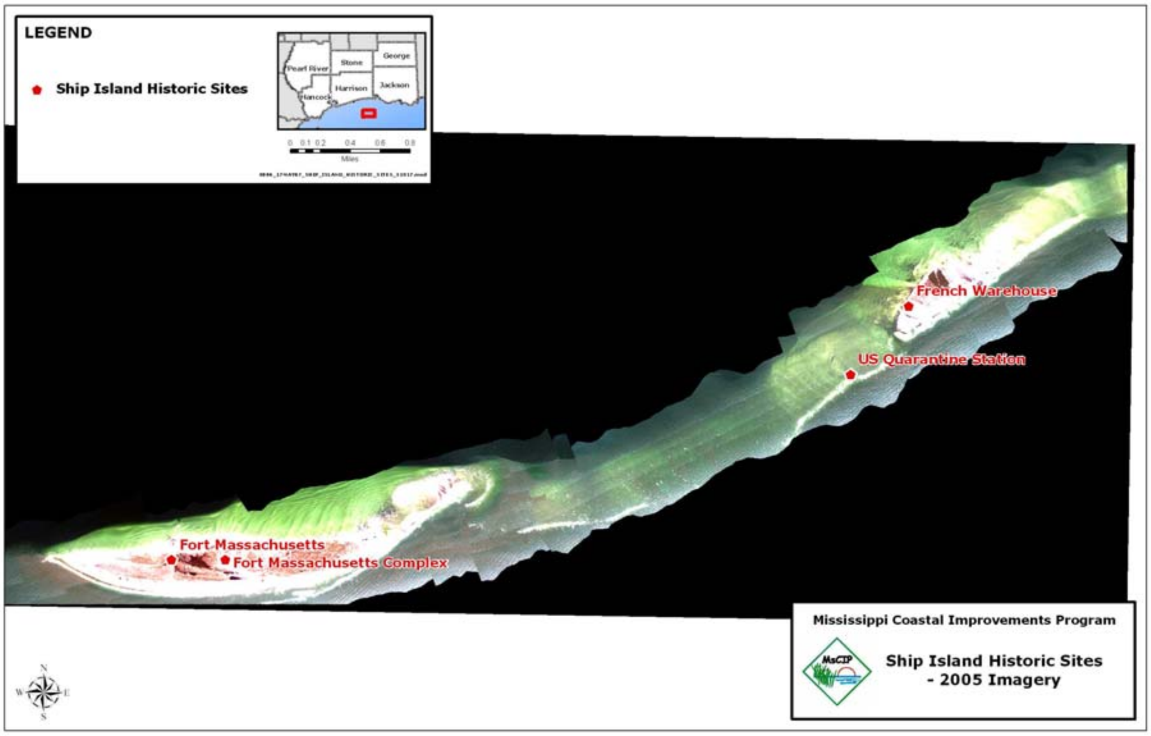

Figure 6.5-2. Aerial photo of West and East Ship Island taken in 2005 after Hurricane Katrina showing the locations of listed cultural resource sites. Note the presence of Camille Cut tidal inlet adjacent to the east end of West Ship Island.

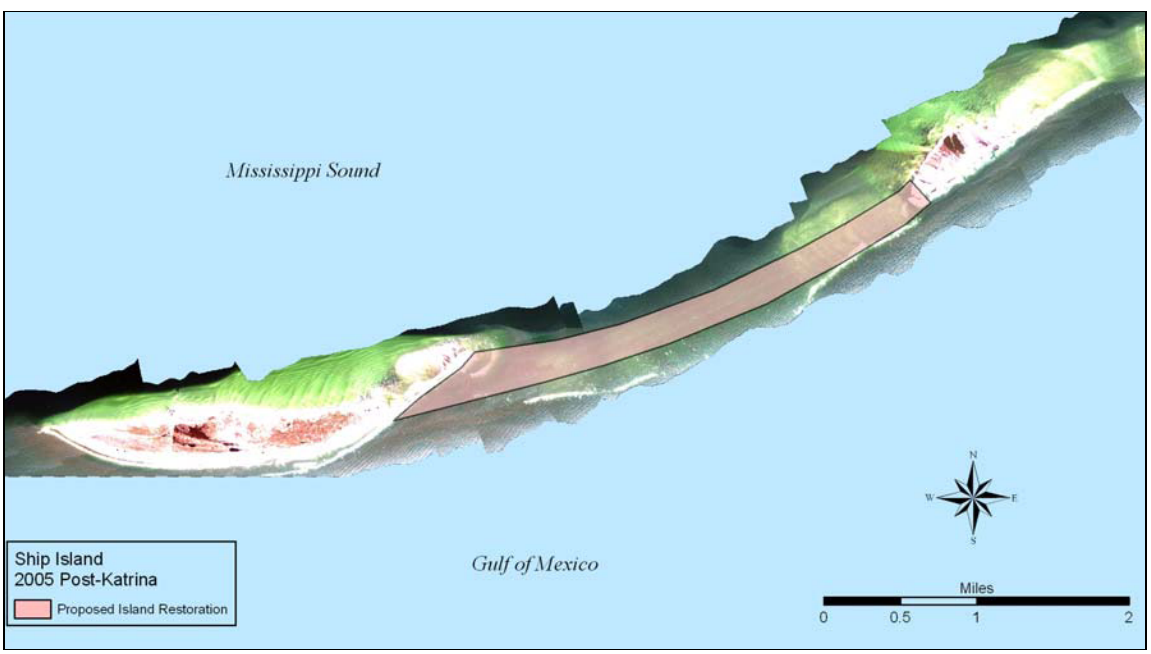

Figure 6.5-3. Approximate conceptual dimensions of the proposed island restoration project connecting East and West Ship Island and filling Camille Cut.

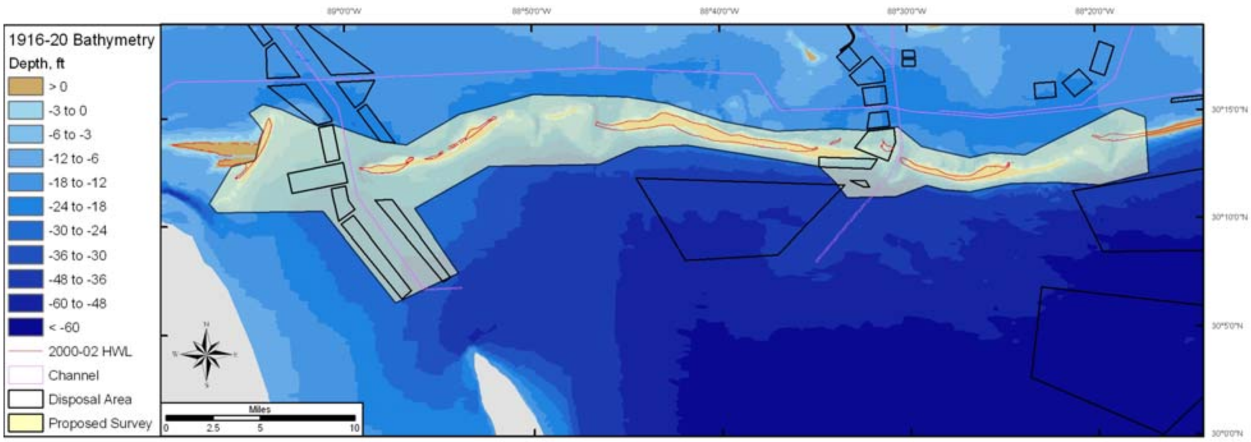

Figure 6.5-4. Proposed location (outlined in the light blue area surrounding the barrier islands) for modern bathymetry survey for identifying potential sand resource targets and updating the existing sediment budget related to island restoration.

CHAPTER 7 THE COMPREHENSIVE BARRIER ISLAND PLAN

7.1 General

The Comprehensive Barrier Island Plan is recommended for construction and will consist of the combination of two engineering options for the barrier islands combined with recommended changes in the local Regional Sediment Management practices. This alternative is recommended to help prevent the accelerated erosion of the barrier islands, especially what is now West and East Ship Island (a single island prior to Hurricane Camille) as well as Petit Bois Island to the east. The National Park Service has endorsed a restoration of islands as described below based on the anthropogenic activities that have compartmentalized the Gulf Islands National Seashore based on national interests including shipping, cultural resources, federally listed species and Essential Fish Habitat components. Stabilizing the outermost barrier islands appears to be the best way to ensure the Mississippi Sound and coastal shoreline ecosystems remain intact. These islands also are the first natural features that protect the coastal counties of the State Mississippi.

To provide needed data on some aspects of completing this plan, additional studies will be conducted during the Engineering and Design (E&D) phase of this project. It is generally understood that the loss of these islands will change the entire ecosystem of the Mississippi Sound as well as having affects on the amount of storm damage incurred along the mainland coast. Since the islands form the Mississippi Sound estuary, continued loss of the islands will allow a different salinity interface as fresh water from the mainland river systems and the salt water from the Gulf of Mexico adjust to new tidal and littoral currents. Under E&D, additional storm surge, wave, water quality, and sediment transport modeling will be conducted to predict the affects of not having West and East Ship Island in place during future hurricanes. Initial modeling indicate that taking Ship Island(s) out of the system will not have a great effect on surge, but will have a major impact on waves that affect the mainland. The additional sediment transport modeling will also be used to optimize the placement of sand in the littoral zone under this plan. Water quality models will also be conducted to predict the changes to salinity levels in the Sound without Ship Island.

Immediately following Hurricane Katrina, the State of Mississippi proposed restoring the barrier islands back to a pre-Hurricane Camille condition with the concept that this would reduce storm surge on the mainland. Analysis of the land loss among the four islands indicated that from 1917 to 2006 (post-Katrina) over 1600 acres of the islands had been lost. To return the islands back to a 1917 footprint (when there was good data available), a supply of beach quality sand would be required that was estimated at 66,000,000 cubic yards. The quality of the sand source would need to be similar in color, grain size, and roundness to the sand that currently comprises the barrier islands. The NPS had concerns over the State's proposal in that it directly contradicted their policy of letting nature take its course unless it was to restore the activities of man or to protect historical sites within Park boundaries. As modeling efforts to evaluate storm surge were being conducted, a sensitivity analysis was performed on different restoration changes to the barrier islands. These results indicated that reductions in surge would not be large, but that the increase in wave heights would be significant if the barrier islands eroded away. Other studies by the USGS and ERDC showed a continuing trend in erosional loss of the islands and that West and East Ship Island would probably be totally lost in the future. Loss of the islands would also be expected to drastically change the ecology of the estuary formed between the islands and the mainland. With all these considerations, the NPS and the Corps formulated a plan (referred to as the NPS Plan) for the barrier islands that would help mitigate some of the loss at the islands and prolong the existence of the islands. This plan includes direct placement of sand to fill a breach in Ship Island, commonly called Camille Cut, that has existed since Hurricane Camille, add sand to the littoral zone in selected areas, and to propose changes in the disposal practices of littoral zone sediment removed from local navigation channels.

7.2 Additional Studies - Littoral Zone Placement and Cat Island Coastal and Ecological Processes and Confirmation of Borrow Areas

Prior to any placement of sand, additional modeling is required to confirm the quantity and quality of sand in borrow areas, better define the optimal locations for the littoral zone placement and obtain additional data needed to understand the ecology and geomorphic fate of Cat Island.

7.2.1 Confirmation of Offshore Sand Borrow Areas

After funding is obtained, an acoustic survey will be conducted in some areas near the barrier islands to identify areas that may contain sufficient sand to use in both direct island and littoral zone placement at Ship Island. These areas will be both disposal areas where disposal from maintenance dredging may have concentrated usable material and sediments that have been pushed out and deposited with the ebb tide currents at the pass west of Ship Island. Any deposits that have useful quantities will be sampled to test for quality requirements. If these surveys fail to located suitable material, the program will then concentrate on the submerged islands that make up St. Bernard Shoals that lie south of the barrier islands. To verify the quantity of sand available for borrow at St. Bernard Shoals and to obtain physical samples for quality characteristics, a geophysical survey and sampling program will be conducted.

7.2.2 Optimal Littoral Zone Placement

The model that was completed and described in Section 3.0 will be used as a basis to further study the optimal locations to place littoral zone additions of sand and the locations for disposal of material from future maintenance dredging.

7.2.3 Cat Island Coastal and Ecological Processes

Cat Island has a different coastal process that has been identified, but not thoroughly investigated. Initial studies have indicated the littoral zone currents that help replenish the other Mississippi barrier islands do not cross the pass between West Ship Island and Cat Island to the west. The formation of the Mississippi River delta cut off the path of the historic littoral current and may have left Cat Island without the natural nourishment of sand moving from the east. Little information is available on Cat Island, but the additional study will include not only coastal processes, but also ecological processes that will provide valuable information on the little known habitat on Cat Island.

7.3 Camille Cut and Barrier Island Restoration

West Ship has migrated westward along the littoral drift zone with the western end of the island now terminating against the deep-water, Gulfport navigation channel that prevents further drift. Studies (Rosati, 2007) have confirmed that West Ship Island is the last active island system in the littoral zone that originates in northwest Florida. The same type of land loss exists for Petit Bois Island where the east end is migrating westward and the western end is now terminated against the Pascagoula navigation channel. Records indicate that over 22 million cubic yards of sediment have been removed for maintenance from the Pascagoula Channel since it was created. This quantity of sand was used as the basis of adding sand back into the littoral system since, theoretically, this sand would have continued its transport along the littoral system. Three measures were adopted to return this sand into the system. The first would be to fill the three mile breach in Ship Island, Camille Cut, to a 1000-foot width and a height that would require approximately 13-million cubic yards of sand including loss during placement and the re-nourishment of some erosion along the northern shore. Based on current studies, the other two measures would be to add sand into the littoral system with about 5-million cubic yards going into the area east of East Ship Island and the rest (4-million cubic yards) going to the area east of Petit Bois Island. Placing more sand at Ship Island is assumed because of the accelerated erosion that has taken place there. Additional studies will be undertaken during advanced engineering and design to determine if other locations such as Cat Island could benefit from some fraction of this sand placement, therefore the quantities of material assumed for the littoral placements would be subject to change after additional sediment transport modeling if this modeling indicates this adjustment.

Loss of these islands from the barrier islands chain will have severe impacts to both cultural and ecological resources in Mississippi. The islands play a major role in maintaining the ecosystem of the Mississippi Sound. The various types of vegetation found on the islands provide habitat to many species including endangered birds such as Least Tern and Piping Plovers. Oysters, shrimp and many species of fish depend on the role the islands play in maintaining lower salinity levels found within the Sound and the presence of these species are tremendously important to the local economy and provide a way of life for the thousands of local residents employed by the seafood industry. The many miles of beaches associated with the islands also provide recreation for tens of thousands of visitors annually.

The pre-Camille footprint of Ship Island was obtained from historical records and this data showed that the island was breached during Hurricane Camille in 1969 forming two separate islands as mentioned above. This breach had been partially filled with a sand spit extending westward from East Ship Island when Hurricane Katrina again opened the breach in 2005. As happened during Hurricane Camille, the new breach was formed leaving two islands with approximately three miles of open water between the remaining portions. West Ship Island has been experiencing severe erosion in some areas because of the loss of sand in the system from the ebb tidal flows through the breach. East Ship Island is also losing land mass as the sand in its system migrates into the breach area. Currents studies (USGS, 2007 and Rosati, 2007) indicate that West and East Ship will probably not recover from their current severely eroded state.

West and East Ship Island also have two major historic sites that are in danger from the continuing erosion of the barrier islands. The presence of these historic sites, in addition to the nationally significant natural resources, led to the inclusion of the barrier islands off the coast of Mississippi as a National Seashore. Current studies by the Corps indicate that restoring the two islands to a single island, pre-Camille condition may prevent the rapid erosion of the beaches that is now occurring at these sites and aid in the reduction of erosion that is endangering Historic Fort Massachusetts on West Ship Island.

The addition of sand into the littoral system on the eastern ends of East Ship and Petit Bois Islands and possibly Cat Island will provide a sediment source for the islands and help mitigate any affects from the maintenance of the navigation channels. Figure 7-3 provides potential locations where littoral zones placements may occur, The additional sediment transport modeling will include modeling to predict the optimal location for the placement of sand into the littoral zone near the islands to provide a source of sand for the natural healing on the breach.

The quantity of sand required for these options are considerably less than the total restoration of the islands, but still substantial. To fill the breach, the sand would have strict requirements on color, grain size, and roundness. In discussions with the USGS, a potential source of sand was identified at St. Bernard Shoals which is a submerged chain of barrier islands approximately 45 miles south of the Mississippi barrier islands. Both quality and quantity are assumed to be available, but further investigations are required to verify the source. Activity from oil and gas production in the local area must also be considered. As described above approximately 13,000,000 cubic yards of the high quality sand are needed to fill the breach. For costing purposes, an additional 5,000,000 cubic yards of sand is being proposed for placement into the littoral zone east of East Ship Island and to add approximately 4,000,000 cubic yards of compatible sand into the littoral zone east of Petit Bois Island. This sand would still have physical compatibility characteristics to the sand in the littoral system that must be considered.

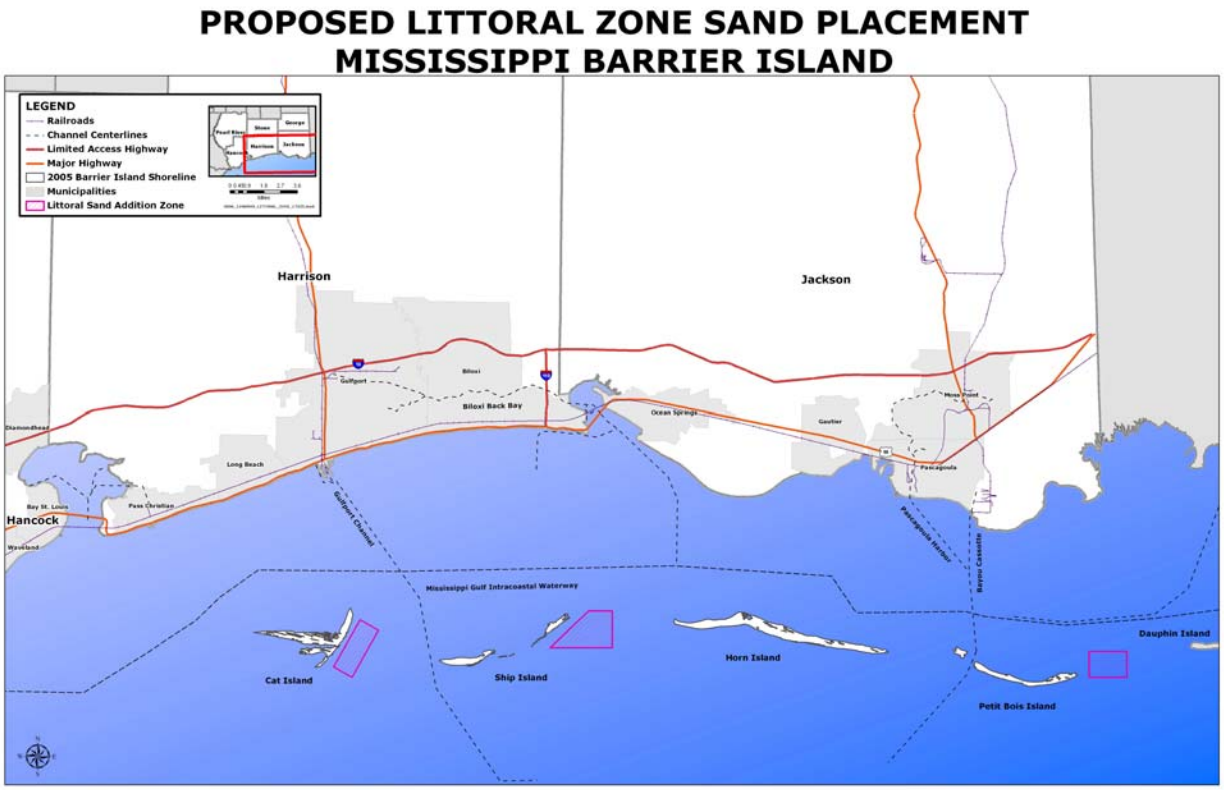

Figure 7.1 Potential Littoral Zone Placements

Also during the E&D phase, another potential source of sand would be investigated that would be much closer to the project site and would also allow the beneficial reuse of dredged material. This further study would look at historical disposal areas for the Gulfport navigation channel that crosses through the littoral zone. The sediments that are removed from the channel during routine maintenance dredging have been placed in approved disposal areas that have been used for an extended period of time. While the material placed in these areas was not segregated by grain size, there may be substantial quantities of beach quality material that has potential use at Ship Island, either for filling Camille Cut, adding to the littoral zone, or both. Reuse of the sediments from the disposal areas would follow Regional Sediment Management practices that promote keeping sediments in the littoral system and/or beneficial use of material that is removed during both new and maintenance dredging.

In this same local area, recent sediment transport studies have shown that westward sediment migration has been affected by the southward extension of the Mississippi River delta. This extension has cut off the littoral current and terminated the westward migration of sediments in the pass in the vicinity between Cat and West Ship Island. The fate of these sediments has not been determined, but there may be a large deposit of sand that could be used at Camille Cut or replaced in the littoral system.

The placement of sand in Camille Cut and the littoral zone are planned as one-time events to restore some of the islands land surface that may have been lost to erosion from past human activities or from mass erosion during storm events. NPS Management Policies (2006) allows restoration of lands disturbed by human activities, and protection of significant cultural resources in NPS units. Addition of sediment into the littoral system will help restore its function , which modeling indicates is necessary for the long-term preservation of the three barrier islands. This will extend the life of the islands and the closure of Camille Cut will help maintain the boundaries of the Mississippi Sound estuary. It is understandably difficult to quantify either of these sand loss causes because the barrier islands themselves are dynamic systems that are undergoing constant change

7.4 Regional Sediment Management Issues

The presence of two deepwater navigation channels that pass through the littoral zone have created artificial boundaries to the westward migration of the islands. The continued maintenance of these channels will require that sand and other sediments be removed, but under the guidelines of the Regional Sediment Management Practices, the sand removed from the channels will be returned to the littoral system. The placement of this sand in the future will be supported and guided by the results of additional focused sediment transport modeling that will be conducted prior to any placement.

This continuing study would evaluate future placement of maintenance material dredged from the Pascagoula Harbor Navigation Channel. It has been recommended that sand from the channel be placed down-drift in a newly designated disposal area located in the littoral zone near Sand Island. Much of the sand dredged in the past was placed down-drift, but was formed into a small island commonly called Sand Island. Sand Island has become a prime environmental resource vegetated with dune grasses that provide habitat to many types of shore birds. With no further sand additions, the sand within this islands will probably return to the littoral system as wind and currents erode the land mass.

Material removed from the Gulfport Channel has historically been placed in disposal areas south of the littoral zone. In keeping with the guidelines of the Regional Sediment Management Practices, revised recommendations will be made to more properly dispose of the material removed from the littoral zone segment of the channel so it will have improved beneficial use. The existing channel alignment is at the western tip of West Ship Island and is a trap for the migrating sand. It has been recommended to study and model placement zones that will maximize the benefits of disposing of this sand. This practice will allow the sand to continue to nourish the barrier islands and slow the erosional processes of the land masses. How to best achieve this will be considered in the continuing study of the islands. Initial ideas include immediate reuse by littoral zone placement or stockpiling high quality sand in selected disposal areas so the material would be readily available in the future for relocating the sand into the littoral zone as needed. The disposal areas that are currently designated may be used or additional areas could be defined.

7.5 Long Term Monitoring Program

Monitoring during and following the implementation of the barrier island restoration actions described in this plan is needed to assess the progress of the restoration and short- and long-term impacts to the barrier island system and cultural resources. Monitoring recommendations include:

- Task 1 - Obtain orthophotography of each barrier island on an annual basis to determine shoreline position change annually for five (5) years and for an additional three (3) events every two (2) years;
- Task 2 - Map bathymetry in the barrier islands area pre- and post-project, 1 year after project completion, 5 yrs after project completion, and immediately following passage of a tropical storm or hurricane to document movement of sand placed in Camille Cut and in the littoral system;
- Task 3 - Use topographic, bathymetric and hyperspectral sensors on the Compact Hydrographic Airborne Rapid Total Survey (CHARTS) system to document land elevation and vegetation density change annually, and process and analyze acquired data in an efficient and timely manner to make adjustments in sand placement strategies if desired results are not being achieved; and
- Task 4 - Obtain daily real-time water quality data adjacent to all beach renourishment, direct placement and littoral zone placement areas in coordination with EPA Gulf of Mexico, MS Department of Marine Resources and MS Department of Environmental Quality. Water quality sampling will be conducted quarterly for 5 years, then quarterly every other year for the remaining 6 years.

7.6 Emergency Sand Placement for Fort Massachusetts and French Warehouse

An emergency project to place sand in two areas is being included in the Comprehensive Barrier Island Restoration Plan. These sand placements are to protect Fort Massachusetts on West Ship Island and the French Warehouse site on East Ship Island from damage or destruction from erosion of the northern beaches at their respective locations. This project has been requested by the National Park Service to mitigate the recent storm damage to these two historic sites. This project was included in the Main Report Section 5.3.14 - Public Input and Review of Planning Options, Round One, but was not selected in the initial group of Interim Projects because of extensive coordination that was required by multiple agencies. This effort made it impossible to meet the short time frames required for the Interim Projects.

CHAPTER 8 COST ESTIMATES

8.1 General

The Comprehensive Barrier Island Restoration Plan has many study components will be included within the "Engineering and Design" cost based on the estimated contract cost. These studies were requested as part of the overall plan, but will be covered under the required studies for design. They include the Optimal Littoral Zone Placement and Cat Island Coastal and Ecological Processes. Studies that will have an additional cost are associated with a recommended monitoring plan to document from the pre-construction conditions at the barrier islands, then for about ten years post-construction. The summary costs for the Comprehensive Barrier Island Restoration Plan is shown in Table 8-1. The local Regional Sediment Management Practice team has been heavily involved in the Mississippi barrier island study and will make revisions to their operating practices at the Mississippi Barrier Islands. These changes will not have a direct cost to the Comprehensive Barrier Island Restoration Plan.

Table 8-1.
Summary of Costs for the Comprehensive Barrier Island Restoration Plan

Project Sub-item	Costs
Sand Placement, Ship Island Breach and Littoral Zones	$516,000,000
Long Term Monitoring	$4,950,000
Cat Island Cat Coastal and Ecological Processes and Optimal Littoral Zone Placement	$1,000,000 (see note)
Regional Sediment Management Practice Revision	(see note)
Emergency Sand Placement, Fort Mass and French Warehouse	$3,000,000

Note 1: As described in Section 8.1 and shown in Table 8-2, this cost are included in the Engineering and Design costs ($17 million) for the "Sand Placement, Ship Island Breach and Littoral Zones"

8.2 Construction (Sand Placement) Costs

The Total Project Costs for the construction associated with the barrier island restoration will include all costs that were described in Options C1, C2 and G under the LOD-1 estimates in the Cost Appendix. These detailed costs were combined into a single estimate and is included in Table 8-2.

8.3 Monitoring Program

The total costs for the long term monitoring program (over a period of 11 years) as described in Section 7.5 are included in Table 8-3. The tasks are fully described in Section 7.5.

8.4 Emergency Sand Placement, Fort Massachusetts and French Warehouse

An emergency project to protect Fort Massachusetts on West Ship Island and the French Warehouse on East Ship Island has been requested by the National Park Service to mitigate storm damage to these two historic sites. This project was included in the Main Report Section 5.3.14 - Public Input and Review of Planning Options, Round One, but was not selected in the initial group of Interim Projects because of extensive coordination that was required by multiple agencies. This effort made it impossible to meet the short time frames required for the Interim Projects. The cost for this project is included in Table 8-4.

Table 8-2.
Sand Placement, Ship Island Breach and Littoral Zones

TOTAL PROJECT | **** TOTAL PROJECT COST SUMMARY **** | PAGE 1 OF 2

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE Feasibility, DATED: Aug 08

PROJECT: Mississippi Coastal Improvemnets Program, Barier Islands | DISTRICT: MOBILE

LOCATION: Mississippi Coastal Barrier Islands | P.O.C.: Joseph H. Ellsworth

	CURRENT MCACES ESTIMATE PREPARED: Aug 08 EFFECTIVE PRICING LEVEL: Aug 08				AUTHORIZ./BUDGET YEAR: FY-09 EFFECTIVE PRICING LEVEL: Aug 08			FULLY FUNDED ESTIMATE		
ACCOUNT NUM FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	COST ($K)	CNTG ($K)	TOTAL ($K)	COST ($K)	CNTG ($K)	FULL ($K)
17--- BEACH REPLENISHMENT (Barrier Islands) *(Barrier Islands)*	326,279,000	107,543,280	33%	433,822,280	326,279,000	107,543,280	433,822,280	353,465,241	116,490,463	469,955,704
30--- PLANNING, ENGINEERING & DESIGN	13,051,160	4,301,731	33%	17,352,891	13,051,160	4,301,731	17,352,891	13,490,461	4,448,199	17,938,660
31--- CONSTRUCTION MANAGEMENT	19,576,740	6,452,597	33%	26,029,337	19,576,740	6,452,597	26,029,337	21,207,914	6,989,428	28,197,342
TOTAL PROJECT COST =======>	**358,906,900**	**118,297,608**		**477,204,508**	**358,906,900**	**118,297,608**	**477,204,508**	**388,163,616**	**127,928,090**	**516,091,706**

rounded

100% TOTAL FEDERAL COSTS ============> $516,000,000

0% TOTAL NON - FEDERAL COSTS ======>

DISTRICT APPROVED:

____________ CHIEF, COST ENGINEERING

____________ CHIEF, REAL ESTATE

____________ CHIEF, PLANNING

____________ CHIEF, ENGINEERING

____________ CHIEF, OPERATIONS

____________ CHIEF, CONSTRUCTION

____________ CHIEF, PROGRAMS MANAGEMENT

____________ PROJECT MANAGER

____________ DDE (PM)

Table 8-2.
Sand Placement, Ship Island Breach and Littoral Zones (continued)

FEDERAL COSTS — **** TOTAL CONTRACT COST SUMMARY **** — PAGE 2 OF 2

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE Feasibility, DATED: Aug 08

PROJECT: Mississippi Coastal Improvemnets Program, Barier Islands — DISTRICT: MOBILE

LOCATION: Mississippi Coastal Barrier Islands — P.O.C.: Joseph H. Ellsworth

ACCOUNT No.	FEATURE DESCRIPTION	CURRENT MCACES ESTIMATE PREPARED: Aug 08 EFFECTIVE PRICING LEVEL: Aug 08 COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	AUTHORIZ./BUDGET YEAR: FY-09 EFFECTIVE PRICING LEVEL: Aug 08 OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FULLY FUNDED ESTIMATE FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
	Contract 1													
17---	DREDGING (Hopper)	183,829,000	58,825,280	32%	242,654,280	0.0%	183,829,000	58,825,280	242,654,280	Apr 12	7.9%	198,351,491	63,472,477	261,823,968
30---	PLANNING, ENGINEERING & DESIGN, 4%	7,353,160	2,353,011	32%	9,706,171	0.0%	7,353,160	2,353,011	9,706,171	Apr 09	1.6%	7,470,811	2,390,659	9,861,470
31---	CONSTRUCTION MANAGEMENT, 6% +-	11,029,740	3,529,517	32%	14,559,257	0.0%	11,029,740	3,529,517	14,559,257	Apr 12	7.9%	11,901,089	3,808,349	15,709,438
	Contract # 1 Subtotal	202,211,900	64,707,808		266,919,708		202,211,900	64,707,808	266,919,708			217,723,391	69,671,485	287,394,876
	Contract 2													
17---	DREDGING (Hopper)	78,350,000	28,206,000	36%	106,556,000	0.0%	78,350,000	28,206,000	106,556,000	Apr 12	7.9%	84,539,650	30,434,274	114,973,924
30---	PLANNING, ENGINEERING & DESIGN, 4%	3,134,000	1,128,240	36%	4,262,240	0.0%	3,134,000	1,128,240	4,262,240	Oct 10	4.7%	3,281,298	1,181,267	4,462,565
31---	CONSTRUCTION MANAGEMENT, 6% +-	4,701,000	1,692,360	36%	6,393,360	0.0%	4,701,000	1,692,360	6,393,360	Apr 12	7.9%	5,072,379	1,826,056	6,898,435
	Contract # 2 Subtotal	86,185,000	31,026,600		117,211,600		86,185,000	31,026,600	117,211,600			92,893,327	33,441,597	126,334,924
	Contract 3													
17---	DREDGING (Hopper)	64,100,000	20,512,000	32%	84,612,000	0.0%	64,100,000	20,512,000	84,612,000	Apr13	10.1%	70,574,100	22,583,712	93,157,812
30---	PLANNING, ENGINEERING & DESIGN, 4%	2,564,000	820,480	32%	3,384,480	0.0%	2,564,000	820,480	3,384,480	Apr 11	6.8%	2,738,352	876,273	3,614,625
31---	CONSTRUCTION MANAGEMENT, 6% +-	3,846,000	1,230,720	32%	5,076,720	0.0%	3,846,000	1,230,720	5,076,720	Apr 13	10.1%	4,234,446	1,355,023	5,589,469
	Contract # 3 Subtotal	70,510,000	22,563,200		93,073,200		70,510,000	22,563,200	93,073,200			77,546,898	24,815,008	102,361,906

Table 8-3.
Long Term Monitoring Program

Task	Program Costs
1 - Orthophotography	Included in Task 3
2 - Bathymetry	$1,400,000
3 - CHARTS	$3,300,000
4 – Water Quality	$250,000

Table 8-4.
Emergency Sand Placement, Fort Massachusetts and French Warehouse

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT:	**Mississippi Coastal Improvements Program "MsCIP"**	ITEM NO.	DATE 7-Jan-09
LOCATION:	**Mississippi**	SHEET NO. 1	OF 1
		PREPARED: Joseph H. Ellsworth	CHECKED: Gary A. Payton
WORK ITEM:	*Line of Defense 1*	BASIS of ESTIMATE:	info furnished per Project Delivery Team
	Beach / Dune Construction	FILE NAME:	

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Ship Island Fort Mass & French Warehouse Emergency Beach Nourishment				
Mobilization, Preparatory Work, Demobilization (Dredge Plant)	1	job	allow	$900,000
Mobilization, Preparatory Work, Demobilization (Land Base Equipment	1	job	allow	45,000
Construct Sand (dune), Dredged from near Shore Borrow Site	125,000	cy	9.00	1,125,000
Misc Site Items	1	ls	allow	2,800
Current Contract Cost, Jan 09				$2,072,800
CONTINGENCY		@	**25.0%**	518,200
				$2,591,000
01 Account, Lands & Damage		PCA	**LS**	25,000
				$2,616,000
30 Account, Plan, Engr.& Design		@	**8.0%**	209,280
				$2,825,280
31 Account, Constr. Management		@	**6.0%**	169,517
				$2,994,797
ESCALATION		@	**1.0%**	29,948
				$3,024,745
				rounded
TOTAL PROJECT COST, Oct 09				$3,000,000