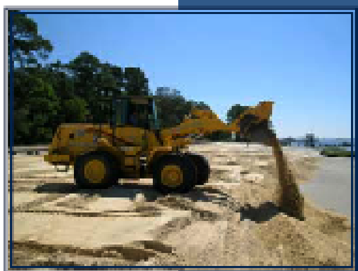

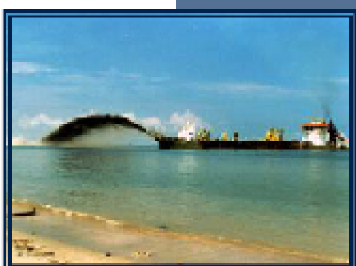

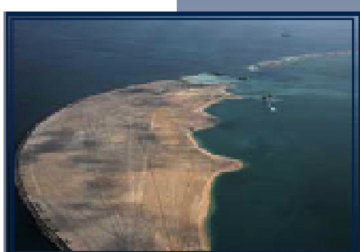

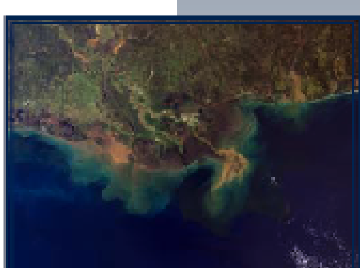

Technical Framework for the Gulf Regional Sediment Management Master Plan (GRSMMP)

GULF OF MEXICO ALLIANCE

A Partnership With a Purpose

Water Quality • Nutrients • Ecosystems • Education • Restoration • Resilience

Developed By The

Habitat Conservation & Restoration Team

September 2009

State Support

Federal Support

NGO Support

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Contributing Authors

Cover

Ryan Fikes, Gulf of Mexico Foundation, Corpus Christi, TX

(ryan@gulfmex.org; 361-882-3939)

1.0 Introduction

Larry Parson, U.S. Army Corps of Engineers, Mobile District

(larry.e.parson@usace.army.mil; 251 690-3139)

2.0 Gulf of Mexico Processes

Jean Ellis, Department of Geography, University of South Carolina

(jtellis@mailbox.sc.edu; 803-777-1593)

S. Jeffress Williams, U.S. Geological Survey, Woods Hole Science Center, MA

(jwilliams@usgs.gov; 508-457-2383)

3.1.1 Gulf of Mexico Regional Sediment Budget

Jeffrey P. Waters, Coastal & Hydraulics Lab, U.S. Army Engineer Research & Development Center, Vicksburg, MS

(Jeffrey.P.Waters@usace.army.mil; 601-634-2020)

Syed Khalil, Louisiana Office of Coastal Protection and Restoration

(Syed.Khalil@la.gov; 225-342-1641)

3.1.2 Offshore Sediment Resource Inventory

S. Jeffress Williams, U.S. Geological Survey, Woods Hole Science Center, MA

(jwilliams@usgs.gov; 508-457-2383)

Matthew A. Arsenault, U.S. Geological Survey, Woods Hole Science Center, MA

(marsenault@usgs.gov; (508)-457-2354)

James Flocks, U.S. Geological Survey, St Petersburg Science Center, FL

(jflocks@usgs.gov; 727-803-8747)

Syed Khalil, Louisiana Office of Coastal Protection and Restoration

(Syed.Khalil@la.gov; 225-342-1641)

Juan Moya, Texas General Land Office

(Juan.Moya@glo.state.tx.us; 512-475-3735)

3.1.3 Dredging Activities

Larry Parson, U.S. Army Corps of Engineers, Mobile District

(larry.e.parson@usace.army.mil; 251 690-3139)

3.2 Ecological Aspects of Coastal Sediment Management in the Gulf of Mexico

Denise J. Reed, Pontchartrain Institute for Environmental Sciences, University of New Orleans

(djreed@uno.edu: 504-280-7395)

Ann M. Commagere, Pontchartrain Institute for Environmental Sciences, University of New Orleans

(acommage@uno.edu: 504-280-6790)

Sarah M. Fearnley, Laredo Community College

(sarah.fearnley@laredo.edu: 956-721-5195)

3.3 Information Management Related to RSM

Clint Padgett, U.S. Army Corps of Engineers, Mobile District, Spatial Data Branch

(Clint.Padgett@usace.army.mil; 251-6943721)

Klay Williams, Bowhead Contractor for the U.S. Army Corps of Engineers, Mobile District, Spatial Data Branch

(Richard.C.Williams@usace.army.mil; 251-694-3747)

Rose Dopsovic, Bowhead Contractor for the U.S. Army Corps of Engineers, Mobile District, Spatial Data Branch

(Rose.Dopsovic@usace.army.mil; 251-680-4047)

3.4 Policies, Authorities, and Funding

Ray Newby, Texas General Land Office

(Ray.Newby@glo.state.tx.us; 512-475-3624)

John Bowie, Environmental Protection Agency, Gulf of Mexico Program

(Bowie.John@epamail.epa.gov; 228-688-3888)

Lynn Martin, U.S. Army Institute for Water Resources, Alexandria, VA

(Lynn.R.Martin@usace.army.mil; 703-428-8065)

4.0 Managing Gulf Sediments in the Future

Lynn Martin, U.S. Army Institute for Water Resources, Alexandria, VA

(Lynn.R.Martin@usace.army.mil; 703-428-8065)

Larry Parson, U.S. Army Corps of Engineers, Mobile District

(larry.e.parson@usace.army.mil; 251 690-3139)

EXECUTIVE SUMMARY

The Gulf of Mexico Alliance (GOMA) has instituted a collaborative partnership among the Gulf States to enhance the ecological and economic health of the Gulf of Mexico. The Habitat Conservation and Restoration Team (HCRT), established under GOMA, has recognized that sediment resources are integral to and a critical resource necessary in accomplishing many of the GOMA conservation and restoration initiatives and objectives. The Gulf Regional Sediment Management Master Plan (GRSMMP) was initiated as a result for managing this valuable resource and verifies the need for a comprehensive understanding of regional sediment systems and processes.

This plan will provide guidelines using the understanding of sediment dynamics (inputs, outputs, movement) to manage sediment resources towards accomplishing environmental restoration, conservation, and preservation while enhancing abilities to make informed, cooperative management decisions.

The first step in the development of such a plan is to identify the technical framework that provides an understanding of the foundation associated with regional sediment management (RSM) processes. These processes are key for establishing management guidelines that balance sediment dynamics and available sediment resources with sediment needs, and provide a basis for assessing competing sediment needs, enhance abilities to make informed cooperative management decisions, and develop regional strategies.

Issues surrounding sediment management, both natural movement and dredged sediments, have significant impact on the ability to restore and sustain coastal habitats. Sediment management must occur on a regional scale unencumbered by agency, state, or national boundaries. Guidelines and recommendations resulting from this effort will aid the Gulf States for more effective management of sediment resources, recognizing they are a part of a regional system involving natural processes and man-made activities. The effort involves a range of state and federal agencies as well as NGO representatives.

As a result of the extensive interagency coordination and planning activities, several essential baseline topics emerged. Along with summarizing the general processes throughout the Gulf, these topics became the main focal points and technical framework of the GRSMMP. The focus areas and work groups providing a mix of Federal, state, or non-governmental representatives were formed to address each of these topics for inclusion in this document. These focus areas address the essential technical framework for the GRSMMP and include:

Sediment Resources. This focus area looks at sediment transport processes and sediment budget issues and evaluates studies that have been done that support the GRSMMP. The focus area also identifies and summarizes existing programs, studies, and databases that can provide information concerning sediment resources throughout the Gulf. Due to the comprehensive nature of this focus area, it is partitioned into three sub-focus areas:

- ***Sediment Budgets***: Deals with sediment transport, sediment budgets, and inventories that may support the GRSMMP. This effort will also compile and summarize programs, studies, and databases that provide information concerning sediment sources and dredging activities. Recommendations from this focus area include the following:
    - The Gulf Alliance should continue to identify, update, and compile sediment budget data into a common GIS-based data management framework in order to address various sediment management issues related to restoration around the Gulf of Mexico.

    - The Gulf Alliance should work to increase awareness of the importance of reliable sediment budgets to inform sediment management decisions.
    - Future work should include the development of sediment budgets for riverine and estuarine systems and the linkage of these budgets with existing coastal sediment budgets.
    - Operational sediment budgets should be developed for coarse and fine grained sediments.
    - Gulf state agencies should continue to work with Federal partners to develop more detailed sediment budgets.
    - Future updates to the GRSMMP should include references and citations to any coastal, estuarine, or riverine sediment budgets that have been developed in intervening years.
    - Regional Sediment Management Principles should be incorporated into all Gulf State CZM plans through enhancement policies and/or enforceable policies.
- ***Sediment Inventories**:* Defined as taking inventory and assessing existing offshore sediment resources throughout the Gulf. The effort presents baseline scientific information on seafloor sediment character and composition that would be needed for managing and protecting natural resources and for providing ecosystem restoration. This focus area resulted in the following recommendations:
    - Much of the data and scientific information have been collected by the energy industry and some state and federal agencies and are not readily available to the public. A concerted effort should be made to get these data, publications, and results on publicly accessible Internet Web sites.
    - While a great deal of existing high resolution data sets could serve specific needs for assessing marine sediments, a program is needed to create repositories in each state agency and appropriate federal agencies to develop databases containing such information to meet immediate and future needs.
    - There is an increasing need for very large quantities (hundreds of millions of cubic meters) of high quality marine sediments for use as fill in coastal protection and wetlands restoration projects throughout the Gulf. Current knowledge of the location, character, and volumes of marine sediments is limited for planning, but current understanding suggests that suitable sediment resources may not be sufficient for sustainable coastal protection with the anticipated rates of sea level rise and storm activity for this century and into the future. Additional systematic surveys and assessments should be done to inventory the location and character of offshore sediments.
    - Many seafloor areas containing potential sand bodies are subject to multiple uses or contain "exclusionary areas." Maps and detailed assessments should be done to identify exclusionary areas and their effects on sediment resource availability.
    - Beneficial use/reuse of materials placed in Ocean Dredged Material Disposal Sites (ODMDSs). It is recommended that USACE policies should be modified to avoid (when possible) the disposal of more sediments in the ODMDSs, which results in the removal of valuable sediment from the active littoral system. An inventory and assessment

of these sites and the character and chemistry of the sediments contained is recommended.

- ***Dredging Activities**:* Dredging activities are a potential source of sediment and should be considered in any conservation and restoration planning process. Currently this type of information is not consistently maintained or easily accessible. This focus area addresses the need and ability to improve data access and management for dredging activities and ways to better manage such information using a database approach that would be accessible to managers and planners. Recommendations of this focus area as follows:
    - Dredged material should be promoted as a valuable resource, <u>not</u> spoil, disposal material, or waste.
    - When dealing with dredging projects, reporting requirements in regulatory process should be levied to track actual dredging activities.
    - Information should be developed on how state CZM programs/COE regulatory track dredging activities. Recommendations should be developed for minimum reporting requirements needed to adequately track dredging activities.
    - Dredging projects should be included in the sediment sources inventory process.
    - Coordinate with local sponsors/stakeholders when utilizing dredged material to acquire needed easements, rights of ways, etc.
    - Include dredged material in restoration planning process as potential borrow alternative.
    - Promote most beneficial disposal practices, even if not being used as a borrow area for a specific project.
    - Consider placement alternatives that would keep dredged sediment within the natural system.
    - Develop emergency use plan towards proactive permitting and environmental coordination.
    - States should cooperate in the CE-Dredge workgroup to expand linkage into other dredging databases.
    - The Port Authorities should be included in the beneficial use of dredged material management and planning.
    - Data should be gathered on the cost of dredging and disposal for consideration when planning restoration activities.
    - Information should be gathered on Corps civil works vs. regulatory project processes, reporting, etc. in the different Gulf States.
    - Ports and Navigation districts may have valuable data on private dredging activities which utilize their disposal areas.
    - ODMDS Site Management and Monitoring Plans (SMMPs) may be a useful source of data.

  - Organize and participate in annual dredging conferences to arrange schedules, identify potential sediment sources, coordinate activities, regulatory processes, etc., for distinct geographical areas.

Ecological Considerations. This focus area examines the relationship between sediment and ecology in the context of RSM by exploring some of the anthropogenic activities that have affected sediment distribution, supply, and delivery; the ecological implications to multiple habitat types; and presents recommendations on how holistic approaches to sediment management can alleviate potential problems. This focus area produced the following recommendations:

- The ecological consequences of existing sediment management actions, not only those planned for the future, should be evaluated and potentially mitigated.
- The ecological consequences of sediment management actions must be considered in the context of future climate change and how they may exacerbate or diminish their effects.
- Changes in habitat resulting from sediment management should not always be considered detrimental – the present situation may not be ideal.
- The potential ecological benefits should be considered in planning any dredging or sediment management activity as it can be an important tool for habitat restoration.
- The effects of sediment management, both positive and negative, on fauna and habitat may not be immediate; monitoring plans to detect ecological effects must be based on the expected response/ recovery time of the habitat.
- Monitoring is essential to capture the beneficial effects of sediment management on coastal habitats. Monitoring plans should consider the natural dynamics of the expected communities, the pace of succession and the potential influence of natural disturbances.

Information Management. This effort is intended to examine ways and opportunities to collaborate and share data throughout all levels of government and the numerous interested stakeholders. Integrating the appropriate type of technology to assist in the efficient retrieval and distribution of RSM related data is a key component to the success of an information management plan. Encourage regionalization of data and information availability at all levels of project management. Recommendations from this focus area include the following:

- Select a universal platform to link and share RSM-related information.
- Promote permissibility of organizations to publish layers of spatial data information into an open source map.
- Encourage use of GIS databases and supporting tools to be part of the planning and management process.
- Continue to identify and promote development of data management and associated planning tools.
- Make recommendations for standardization of future data collection, including metadata.
- Link project managers, GIS staff and data managers to develop more user-friendly databases and GIS systems.

Policies, Authorities, and Funding. This focus area identifies existing authorities, policies, and funding mechanisms relevant to Federal and Gulf of Mexico (GOM) State dredging activities that affect the implementation of RSM actions and restoration projects. This focus area looks at ways to leverage existing state and federal authorities and policies, as well as ways to make them more flexible to facilitate implementing the recommendations that come out of the master plan. The following recommendations were produced from this focus area:

- Language regarding RSM principles should be placed into all Gulf State CZM Plans through enhancement polices and/or enforceable policies. Model policy language could be developed by the GRSMMP work group as a starting point for consistent RSM themes to be adopted by states.
- GOMA should provide leadership for integrating environmental benefits and coastal zone management policies into the Federal Standard decision-making process.
- Regional beneficial use groups should be established across the Gulf Coast.
- Promote the most beneficial sediment placement practices, even if the material is not currently being used as borrow for a specific project.
- Develop more flexible dredged material management alternatives.
- Find innovative ways to utilize fine-grained sediments.
- Develop recommendations to the Principles and Guidelines used by USACE to place more emphasis on environmental restoration benefits.
- Revisit O&M base plans, National Ecosystem Restoration plans, and National Economic Development plans for existing projects. Base plans may contain elements that are no longer considered environmentally acceptable.
- Recommend funding levels to adequately implement BUDM/RSM principles at all projects.
- Fully use the HMTF for its intended purpose of funding Federal channel O&M.
- Make recommendations that environmental considerations be taken into account in benefit-cost analyses.
- The economic value of sediments should be considered. Sediment as a natural resource is a commodity that has a monetary value.
- Non-service values and net intrinsic values should also be considered in benefit-cost analyses.
- Environmental benefits should be considered through cost incremental and cost effective analysis. An example of this is the Florida benefit-cost analysis for living shorelines.
- The quantification of ecological benefits of BUDM should be captured and considered in benefit-cost analysis. More work by environmental economists and planners is needed to better develop standardized processes to quantify environmental benefits.
- The non-Federal project sponsors need to be brought into and engaged early in the RSM and BUDM planning process.
- GOMA could provide leadership to push the monetization of environmental benefits of RSM/BUDM forward. State and Federal Natural Resource Damage Assessment programs could provide the model for this process.

- View loss of wetlands and the loss of dredged sediments as an economic loss such that not using dredged sediments in BUDM is a negative project cost. Justification for not using sediments in a beneficial manner should be required. A unit cost could be placed on sediment not used beneficially.
- A national goal of No Net Loss of Sediments through anthropogenic processes should be developed similar to the No Net Loss of Wetlands goal.

NEXT STEPS. This document presents the technical framework necessary to understand the impact and significance of wise sediment management practices in a regional context but does not yet put forth the desired guidelines on how to implement regional sediment management throughout the Gulf. The intent is for the Alliance partners to use the information presented here concerning the regional sediment processes consisting of sediment inventories, sediment budgets and transport processes, navigation activities, ecological processes, and policy as well as other regional priorities, and evaluate what this means in relation to current management practices within the sub-regions around the Gulf. Outcomes from these evaluations will be the beginning of a process of formulating guidelines and recommendations on how management and planning practices can be improved to make better decisions on a regional scale. This approach will be critical towards improving the design, maintenance, and overall regional management practices throughout the Gulf.

The next phase in the development the GRSMMP will involve establishing guidelines based on future development and refinement of the recommendations presented within this technical framework. The GRSMMP will also reflect the goals and objectives set forth by the Governors' Action Plan II as established for the Habitat Conservation and Restoration Team (HCRT). The activities associated with accomplishing these goals and objectives are actively being formulated by the HCRT.

Index of Key Words and Phrases: regional sediment management, sediment budget, sediment inventory, dredging activities, ecological aspects of regional sediment management, information management, RSM policies, RSM authorities, habitat restoration and conservation, Gulf of Mexico Alliance, Habitat Conservation and Restoration Team.

LIST OF ABBREVIATIONS

ADCNR - Alabama Department of Conservation and Nature Resources

BICM - Barrier Island Comprehensive Monitoring

BSMP - Best Sediment Management Practices

BUDM - Beneficial Use of Dredge Material

BUG - Beneficial Users Group

CAA - Clean Air Act

CAP - Continuing Authorities Program

CCSP - Climate Change Science Program

CEPRA - Coastal Erosion Planning and Response Act

CIAP - Coastal Impact Assistance Program

COE - Corps of Engineers

CSMW - Coastal Sediment Management Workshop

CWA - Clean Water Act

CWPPRA - Coastal Wetland Planning, Protection, and Restoration Act

CZM - Coastal Zone Management

DBMS - Database Management System

DEP - Department of Environmental Protection

DMMP - Dredge Material Management Plan

DSSM - Delta Sand Search Model

EGIS - Enterprise Geographic Information System

EIS - Environmental Impact Assessment

EPA - Environmental Protection Agency

ERDC - Engineering Research and Development Center

HCRT - Habitat Conservation and Restoration Team

HMTF - Harbor Maintenance Trust Fund

IPCC - Intergovernmental Panel on Climate Change

ICT - Interagency Coordination Team

GI - General Investigations

GIS - Geographic Information System

GLO - General Land Office

GOM - Gulf of Mexico

GOMA - Gulf of Mexico Alliance

GRSMMP- Gulf Regional Sediment Management Master Plan

GUI - Graphic User Interface

LASAMP - Louisiana Sand Management Plan

LASARD - Louisiana Sand Resource Database

LCWCRTF - Louisiana Coastal Wetlands Conservation and Restoration Task Force

LDNR - Louisiana Department of Natural Resources

LSU - Louisiana State University

MMS - Minerals Management Service

MPRSA - Marine Protection, Research, and Sanctuaries Act

MsCIP - Mississippi Coastal Improvement Program

NASA - National Aeronautics and Space Administration

NDBC - National Data Buoy Center

NEP - National Estuarine Program

NEPA - National Environmental Protection Act

NGO - Non-Government Organization

NMFS - National Marine Fisheries Service

NOAA - National Oceanographic and Atmospheric Administration

O&M - Operations and Maintenance

OCPR - Office of Coastal Protection and Restoration

ODMDS - Ocean Dredge Material Disposal Site

OMB - Office of Management and Budget

PA - Placement Area

PHINS - Priority Habitat Information System

ROSS - Reconnaissance Offshore Sand Search

RSLR - Relative Sea Level Rise

RSM - Regional Sediment Management

SBAS - Sediment Budget Analysis System

SCOUP - Sediment Compatibility and Opportunistic Use Program

SDSFIE - Spatial Data Standard for Facilities, Infrastructure, and Environment

SLR - Sea Level Rise

SMMP - Site Management Monitoring Plan

TNC - The Nature Conservatory

URL - Uniform Resource Locator

USACE - U.S. Army Corps of Engineers

USFWS - U.S. Fish and Wildlife Service

USGS - U.S. Geological Survey

WRDA - Water Resource Development Act

WIS - Wave Information System

Technical Framework for the

Gulf Regional Sediment Management Master Plan

1.0 INTRODUCTION

The Gulf of Mexico Alliance (GOMA) has been instrumental in establishing a collaborative partnership among the states of Alabama, Florida, Louisiana, Mississippi, and Texas to enhance the ecological and economic health of the Gulf of Mexico. Through this partnership, the Gulf States have acknowledged that sediment resources are critical physical resources necessary in accomplishing many of the GOMA conservation and restoration initiatives and objectives. Furthermore, it is recognized that sediments are an essential element toward accomplishing coastal community protection and resiliency goals. The development of a Gulf Regional Sediment Management Master Plan (GRSMMP) for managing sediment resources substantiates the need for a comprehensive understanding of regional sediment systems and processes. Such a plan will be beneficial to provide guidelines using the understanding of sediment dynamics (inputs, outputs, movement) to manage sediment resources in the context of environmental restoration, conservation, and preservation, while reducing coastal erosion, storm damages, and associated costs of sediment management. The plan will provide an inventory of potential sediment sources, along with sediment needs; assess competing needs for sediment; develop regional strategies that facilitate cooperation among stakeholders; and enhance abilities to make informed, cooperative management decisions.

This document presents the technical framework involved in understanding regional sediment systems and processes necessary in managing sediment in a regional context. Establishing this framework is the first step in the development of the GRSMMP. Understanding the technical underpinnings associated with regional sediment management processes are key towards establishing management guidelines that balance sediment dynamics and available sediment resources with sediment needs and provides a basis for assessing competing needs for sediment, enhancing abilities to make informed cooperative management decisions and develop regional strategies.

1.1 Background

As a result of a shared vision for a healthy and resilient Gulf of Mexico coast, the Gulf States, together with federal partnerships, formalized the Gulf of Mexico Alliance (GOMA). The GOMA is a partnership of the states of Alabama, Florida, Louisiana, Mississippi, and Texas, with the goal of significantly increasing regional collaboration to enhance the ecological and economic health of the Gulf of Mexico. One of the first actions taken under GOMA was the development of the Governors' Action Plan for Healthy and Resilient Coasts. This plan is supported by President George W. Bush's U.S. Ocean Action Plan, December 2004 and challenges the Gulf of Mexico Alliance to make tangible progress on several critical issues. In response, the five Gulf States have identified six initial priority issues that are regionally significant and can be effectively addressed through increased collaboration at local, state, and federal levels. The priority issues include:

- Water quality for healthy beaches and shellfish beds
- Wetland and coastal conservation and restoration
- Environmental education
- Identification and characterization of Gulf habitats

- Reducing nutrient inputs to coastal ecosystems
- Coastal community resiliency

It was envisioned that addressing these critical issues would supplement ongoing recovery efforts across the entire Gulf region.

The Habitat Conservation and Restoration Team (HCRT) was established under the Wetland and Coastal Conservation and Restoration priority issue. The importance of developing a Gulf Regional Sediment Management Master Plan was realized during the formation of this team. More specific details concerning the HCRT are presented below.

The mission of the HCRT is to provide leadership to advance conservation and restoration of coastal habitats and ecosystems throughout the Gulf of Mexico and associated watersheds. Research has demonstrated significant degradation and loss of natural habitats within the Gulf of Mexico and Caribbean Sea ecosystems and the associated loss of ecological services attendant to these changes in habitat character, quality, and quantity. Population growth and anthropogenic impacts, natural geomorphologic processes, and changes in land use patterns in the coastal zones and throughout the watersheds of the Gulf of Mexico have exacerbated and accelerated these trends. To remain healthy and sustainable, the communities of the Gulf of Mexico must achieve economic development within the boundaries of environmental sustainability. Sustainability of natural resources is the foundation on which economic development and quality of life are established.

Habitat conservation and restoration are critical needs throughout the Gulf of Mexico and Caribbean Sea region in all of the territories of the United States, Mexico, and Cuba. Habitat restoration is not keeping pace with the loss and degradation of coastal habitats nor is ongoing restoration and conservation sufficient to sustain critical ecological services such as storm surge reduction and fisheries production. It is critical that restoration efforts are increased and made more effective through the application of the growing body of restoration science and that conservation of habitats be implemented on a more aggressive scale.

To achieve conservation and restoration goals, broad issues of policy, socioeconomics, and science, as well as public awareness, an understanding must be addressed. To undertake the mission of the HCRT, all vested interests must be included in the planning and implementation of conservation and restoration strategies. The HRCT will play an integral role in coordination and information exchange among the Gulf States and local, federal, and tribal governments, international partners, business and non-profit partners. The HRCT will facilitate a greater understanding of issues and commitments to the future in order to speak as one voice to ensure the health, productivity, and sustainability of the Gulf of Mexico and Caribbean Sea ecosystems.

Among numerous actions, the HCRT proposed the development of a Gulf Regional Sediment Management Master Plan (GRSMMP) to enable more effective use of dredged material. During the initial stages of coordination, it became evident that such a plan would go well beyond just dealing with dredged material. The scope of the GRSMMP was expanded under the actions of the HCRT and is presented below.

1.2 Gulf Regional Sediment Management Master Plan (GRSMMP)

As previously discussed, the HCRT under the GOMA has recognized the need and initiated the development of the Gulf Regional Sediment Management Master Plan (GRSMMP) to facilitate and assess the implementation of sediment management to provide for more effective use of dredged material and other sediment resources for habitat conservation and restoration. The intent is for the plan to provide guidelines to the Gulf States for more effective management of sediment resources, recognizing they are a part of a regional system involving natural processes and dredging activities. Issues surrounding sediment management, both natural movement and dredged sediments, have significant impact on the ability to restore and sustain coastal habitats. Sediment management must occur on a regional scale unencumbered by agency, state, or national boundaries. It should be realized that the GRSMMP effort is not a Federal program but a federally-led effort to provide guidance to the Gulf States towards achieving the goals and objectives established by the GOMA. The U.S. Army Corps of Engineers and USGS are the Federal agencies that have been tasked to lead this effort along with a range of state agencies, other federal agencies, and NGO representatives.

1.3.1 Purpose

The purpose of this document is to establish and present the technical framework that will ultimately lead to the development of a regional sediment management plan that uses the understanding of sediment dynamics (inputs, outputs, movement) to manage sediment resources to accomplish environmental restoration, conservation, and preservation, while reducing coastal erosion, coastal storm damages and associated costs of sediment management. It will help link sources of sediment with sediment needs, provide a basis for assessing competing needs for sediment, and provide regional strategies for sediment management that:

- make more effective use of sediment from inlets, navigation channels and other sources in support of environmental and economic objectives;
- coordinate the collection and dissemination of data about the movement of sediment to better integrate the understanding of regional sediment process into planning, management and other decisions; and
- facilitate cooperation among states, federal agencies, and other stakeholders in sediment management.

1.3.2 Goals

Once the technical framework has been established, information gleaned from this phase of the effort can be used towards achieving the goals of the GRSMMP which include:

- Developing an understanding of Gulf sediment system dynamics and provisions for better management of sediment resources in the region (including sources, movement, sinks, related watershed and coastal processes, and influences of structures and actions that affect sediment movement, use, and loss).
- Providing information to projects and activities involving sediment, and assist in prioritizing uses of sediment resources.
- Developing and/or suggesting a streamlined approach for regulatory and policy processes that take biodiversity and environmental considerations in the same light (cost-benefit) as other costs and benefits.
- Leverage resources for inter-related programs and projects.
- Facilitate effective sediment management in sediment systems that cross political boundaries.

- Increase stakeholder participation in development and implementation of sediment management strategies.
- Using best management practices in managing sediment resources and minimizing secondary adverse impacts.
- Promoting information exchange about Gulf region sediment resources and the range of related management needs.
- Taking inventory of available sediment resources and needs.
- Engaging the Port Authorities in the sediment management process.
- Supporting Gulf resiliency goals and objectives.

2.0 GULF OF MEXICO PROCESSES

This chapter is a broad overview of the general setting, geologic history, coastal processes, hydrodynamics, and sediment sources for the Gulf of Mexico (GOM). Aberrations to the generalizations outlined below are expected if conducting a small-scale investigation within the Gulf of Mexico coastal region. Eight geomorphic regions will be introduced and described that will serve as guidance for this report.

The Gulf of Mexico is a 1,500,000 square kilometer semi-enclosed water body bordered by Cuba (south), United States (east, north, and west), and Mexico (west). This report focuses on the portion within the United States, which involves the states of Texas, Louisiana, Mississippi, Alabama, and Florida, and comprises over 75,000 kilometers of coastline (NOS-NOAA, 2008).

2.1 Gulf of Mexico setting

It is believed that the present day Gulf of Mexico formed in the Late Triassic period from rifting within the North American Plate. Rifting continued through the Early and Middle Jurassic periods and during the latter period extensive salt deposits formed. Since the Late Jurassic, the Gulf has been relatively stable with continuous subsidence in the central basin. Today, the Gulf is classified as a passive margin, distinguished by a wide and flat (0.3-0.6 m/km slope) continental shelf (especially off Florida) and extensive barrier island systems (especially off Texas). Approximately 38% of the Gulf is less than 20 m deep, while the abyssal areas and continental slope and shelf each comprise approximately 20%.

The Gulf of Mexico is a shallow basin that averages 1,615 m with its deepest point at 4,383 m. The passive margin continental shelf (<180 km) is most expansive offshore of the Apalachee Bay to the Florida Straits (Figure 2-1). The sediments become more carbonate rich toward the Florida Straits. Between Apalachee Bay and east of the Mississippi Delta, softer sediments are found; there are variable shelf widths and the DeSoto Canyon (shown in dark blue offshore MS-AL continental shelf) dominates. Generally, the shelf width decreases from the TX-LA to TX-Mexico border. The narrowest shelf is offshore AL-FL border and at the Mississippi Delta. Water enters the Gulf (that holds approximately 2.5 million cubic kilometers of water (Nipper et al., 2008)) through the Yucatan Strait and exits through the Florida Strait. While in the Gulf, circulation is dominated by the Loop Current and anticylonic gyres spawned from the Loop Current. Generally, longshore sediment transport (shore parallel sand movement driven by wave-influenced shore parallel currents) is westward, west of the Mississippi River, and eastward, east of the Mississippi River. Sediment transport is driven by energy from waves and tides, and to a lesser extent wind.

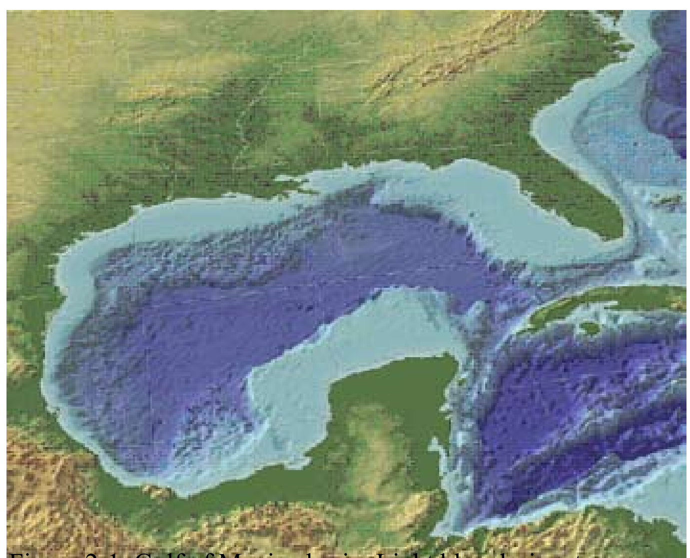

Figure 2-1. Gulf of Mexico basin. Light blue designates continental shelf (http://www.gulfbase.org/facts.php).

General precipitation totals vary considerably along the GOM: south Texas = 50-99 cm/yr, north Texas and Florida = 100-149 cm/yr, and LA, MS, and AL = 150-199 cm/yr. The U.S. GOM climate, strongly dependent on precipitation and temperature averages, is primarily humid, sub-tropical with warm to hot, wet summers and cool and wet winters (Cf, according to Koppen's climate classification). The southern tip of Florida is classified as a tropical savanna (Aw: hot, wet summer and hot, dry winter) and the southern Texas coast is hot all year (BSh).The relatively high precipitation results in abundant salt marshes, maritime forests, and limited aeolian processes from the northern Texas coast to Florida. The south Texas coast has high rates of evapo-transpiration with sand dunes and grasses.

The GOM coast is predominantly microtidal (< 2 m), with most regions having a smaller than 0.5 m tidal amplitude. The coastal processes, morphodynamics, and to a lesser extent, vegetation patterns and distribution, are strongly influenced by storms. Tropical cyclones have impacted every GOM coastal county/parish since 1900, with the most impacts in Monroe County, southwest Florida (Figure 2-2) (see http://www.nhc.noaa.gov/pastall.shtml for details on individual storms). Numerous winter storms accompanied by increased wave heights and wind speed affect the region yearly. Winds are predominately from the southwest throughout most of the Gulf switching to southeast along in the western Gulf along Texas, with large-scale exceptions during tropical cyclones and winter frontal passages. Wind-driven waves, with nearshore significant wave heights averaging less than 1 m (high spatial variability, forecasts available at http://www.wunderground.com/MAR/) and tidally-driven currents are the dominant non-storm geomorphic agents for change. Historical and present meteorological, tide, and offshore wave data for stations within the Gulf can be ascertained from NOAA's National Data Bouy Center (NDBC) (http://www.ndbc.noaa.gov/obs.shtml).

2.1.1 Gulf of Mexico Hydrodynamics

The Gulf of Mexico is strongly influenced by 33 major rivers that drain 31 U.S. states. More than 150 rivers flow into the Gulf; 85% of the fluvial water contribution is from U.S. rivers and 64% is from the Mississippi River. The Mississippi River drains an area of 3,344,560 km^2 with an average flow at the delta apex equaling 15,360 m^3/s (ranging between 57,900 and 2830 m^3/s) and sediment discharge at approximately 2.4 billion kg per annum. The Mississippi River discharge comprises clay, silt, and approximately 70% fine sand. Historically, the Mississippi River delta lobes have migrated through time to its current and most seaward position (details about the multiple lobate features are found in Kolb and Van Lopik, 1966).

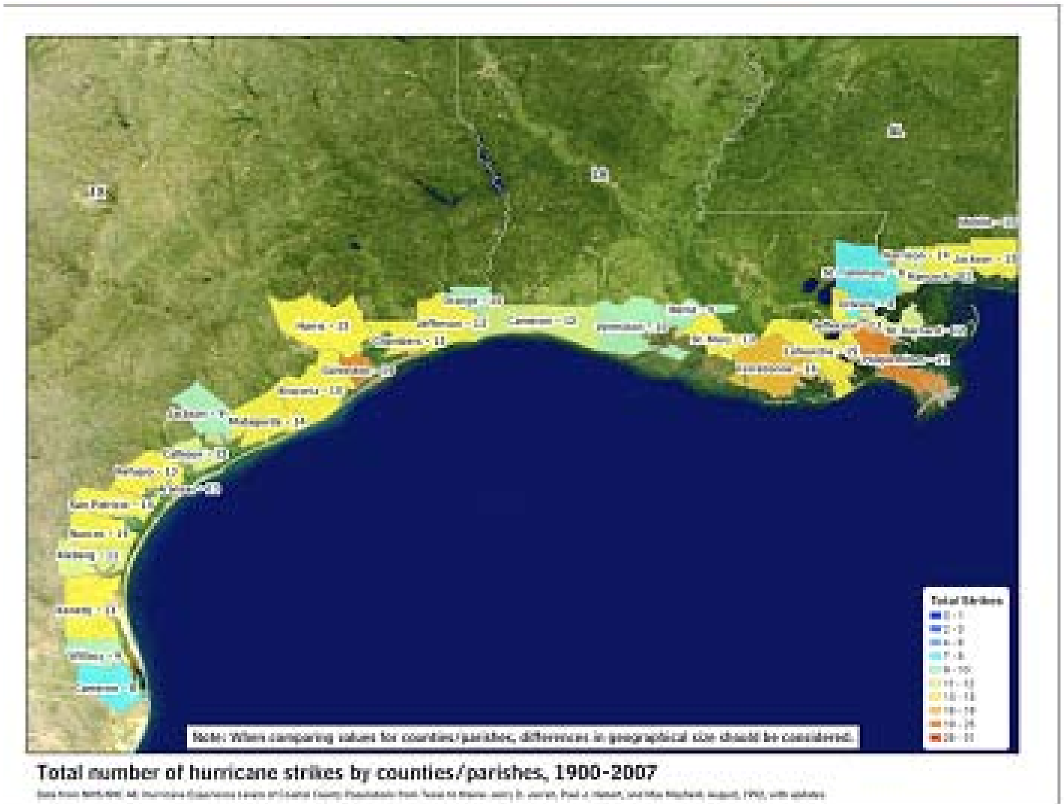

Figure 2-2. Total hurricane strikes between 1900 and 2007, by county/parish in the western (top: http://www.nhc.noaa.gov/gifs/strikes_wgulf.jpg) and eastern Gulf (bottom: http://www.nhc.noaa.gov/gifs/strikes_egulf.jpg).

2.1.2 Gulf of Mexico Sediments

Under natural conditions, the coastal sediment budget is balanced; the supply equals the loss. Sediment supply, or sources, originates from rivers, dunes, and cliffs (the latter not applicable to the Gulf of Mexico). Offshore coastal canyons are the major sediment sink. Humans are altering the sediment supply through beach nourishment and dredging, and are impacting the beach-dune sediment exchange (c.f., Sherman and Bauer, 1993 regarding beach-dune interaction). Sediment is transported by air or water when the force (primarily, fluid velocity) of the transporting agent exceeds a critical threshold value. The critical threshold value is strongly dependent on sediment size, but is also influenced by slope, packing, and moisture, the later pertinent to air-borne sediment (or aeolian) transport. Additional information about nearshore and aeolian sediment transport can be found in Komar (1997) and Pye and Tsoar (2009), respectively.

Sediment sources in the Gulf are predominately fluvial, especially west of the AL-FL border. In general, the Texas coast has a few large coastal rivers (Trinity and Sabine, for example) that are sediment deficient. However, the Colorado and Brazos Rivers, relatively, carry more sediment because of the favorable climatic conditions and topographical features. The northern Gulf Coast sediment is dominated by the Mississippi River. Silt and clay are prevalent and sand is scarce, but concentrated where it is present. Mississippi River sediment is largely confined within its channel banks and flows off the continental shelf, thus removing sediment from the nearshore coastal sediment budget. Mobile Bay also contributes sediment and freshwater to the Northern Gulf, primarily via the Mobile and Tensaw Rivers. The Mobile Delta is prograding and the bay has high relative turbidity flowing offshore between Dauphin Island and Fort Morgan Point. Sediment from Mobile Bay largely remains in the nearshore system. The Eastern U.S. Gulf Coast significantly varies from the rest of the coast, as it comprises primarily reworked carbonate stemming from the carbonate-rich (karst) bedrock dominating the region.

2.1.3 Gulf of Mexico Geomorphology

The U.S. and northern Mexico Gulf Coast is classified according to eight geomorphic regions, following Morang (2007) (Figure 2-3). The eight regions extend from the southernmost tip of the Florida Keys to Veracruz, Mexico and are as follows:

- Dry Tortugas, FL to Soldier Key, FL (G1)
- Cape Romano to Long Key, FL (G2)
- Pinellas-Pasco line, FL to Cape Romero, FL (G3)
- Lighthouse Point, FL to Pinellas-Pasco line, FL (G4)
- Pass Christian, MS to Lighthouse Point, FL (G5)
- Southwest Pass, LA to Pass Christian, MS (G6)
- High Island, TX to Southwest Pass, LA (G7)
- Veracruz State, MX to High Island, TX (G8)

The corresponding regions from Figure 2-3 are indicated in parentheses. Note that geomorphically, the northern coast of Mexico is linked to Texas, as sediments don’t recognize jurisdictions; however, this report will only consider activities within the United States. Within each region, wave energy, geology,

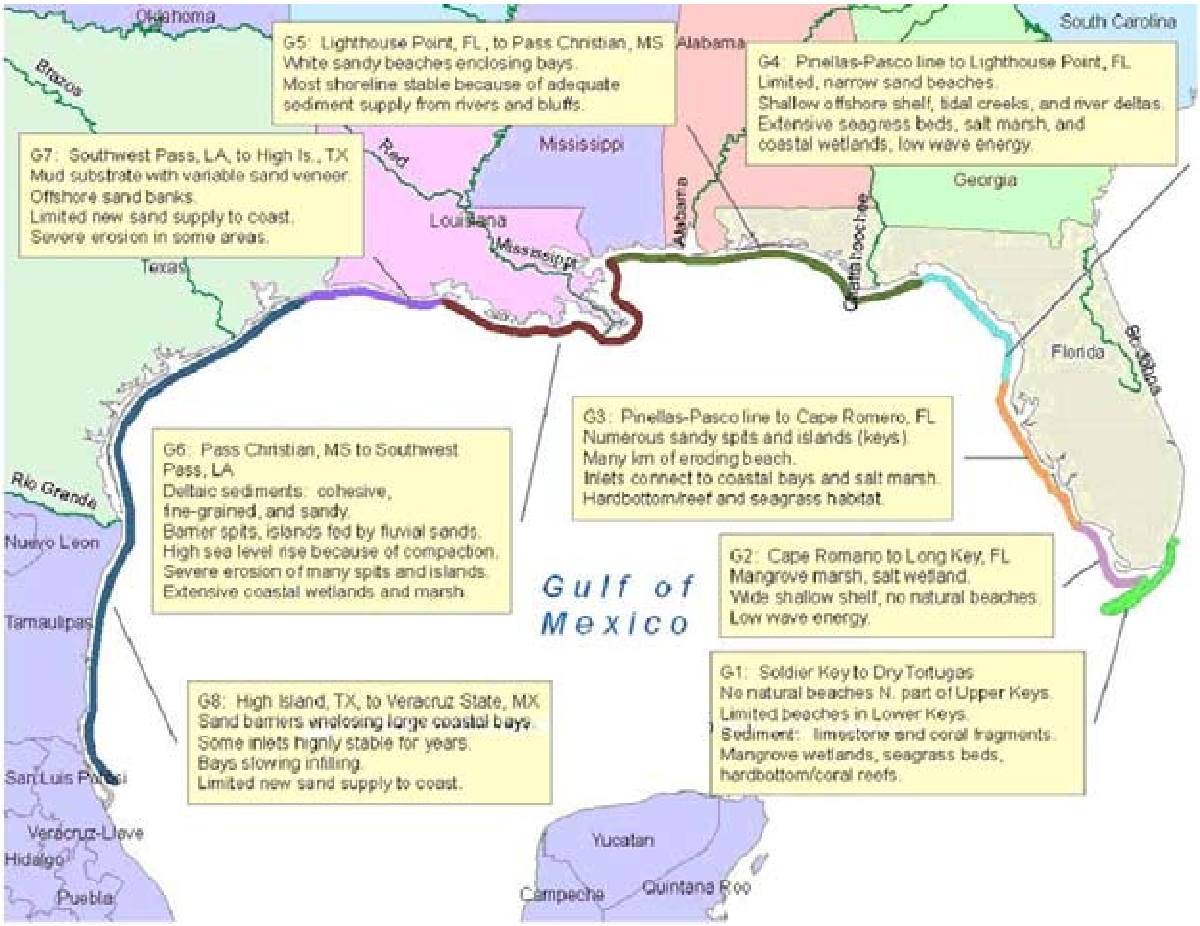

Figure 2-3. The Gulf Coast can be divided into eight morphologic regions of similar littoral characteristics such as unique erosion or accretion occurrences and dredging activities. They are numbered G1 to G8 in a counter-clockwise direction. Reach G1 is the “Florida Keys,” Reach G2 is “Lower Everglades,” Reach G3 the “Lower Gulf Coast,” Reach G4 the “Big Bend,” and the eastern part of Reach G5 is the “Panhandle Gulf Coast.” The westernmost reach, G8, a flat terrain of sand spits, barrier islands, and shallow lagoons, extends from east Texas southward into the Mexican state of Veracruz-Llave (Morang 2007).

and sediment conditions are close to uniform (Morang, 2007). Morang’s (2007) Florida regions coincide with the physiographic reaches from Balsille and Clark (2001): Florida Keys (G1), Lower Everglades (G2), Lower Gulf Coast (G3), Big Bend (G4), and Panhandle Gulf Coast (eastern portions of G5).

Regions G1-4 comprises largely carbonate (karst), with the carbonate content increasing from G4 to G1. These coastal regions are minimally impacted by rivers. Regions G1-G3, in particular, are sand-starved, resulting in the need for extensive beach nourishment. In fact, there are no natural beaches in the northern reaches of G1 and in G2. Salt wetlands, mangrove marshes, seagrass beds, and sand beaches are dominant throughout. Offshore sediment transport is impacted by low wave energy and reduced sand supply, relative to other GOM locations.

A significant amount of sand is found in region G5, primarily from bluffs and rivers. Aeolian transport is prevalent around the Chatachoochee River outflow at Apalachicola Bay and large sand dunes, wide beaches, and aeolian transport is on Cape San Blas, just east of the Bay. Many barrier islands are present and the onshore beaches are generally stable. The region has been significantly impacted by several hurricanes, the three most damaging being Katrina, Ivan, and Camille. The dominant sediment transport is from east to west, therefore a large portion of this region is strongly impacted by the sediment-laden Mobile Bay system.

Region G6 generally comprises the eastern portion of LA. It is most influenced by the cohesive deltaic sediments (clays and muds) delivered by the Mississippi River. Coastal sediment supply has greatly reduced with time (mainly from river channelization), thus strongly contributing to extensive coastal erosion and wetland and marsh erosion. There are large sand banks offshore, but these sediments are not available to the near coastal system. The deltatic sediments are highly susceptible to compaction, contributing to substantial relative sea level rise. This region has expansive wetlands that are severely threatened, this problem exacerbated by an approximately 560 km^2 Louisiana wetland loss from Hurricanes Katrina and Rita (Barras, 2007).

The western LA coast (G7) has mud substrate with variable sand veneers. Sand supply is limited, primarily because of the sediment deficient and anthropogenicaly-impacted Sabine River (forming the LA-TX border). This coastal region with extensive wetlands has relatively low population, yet Cameron and Vermillion counties experienced extensive environmental and human-built structure loss from the 2005 (Katrina and Rita) and 2008 (Gustav and Ike) hurricanes.

The majority of the Texas coast is region G8. It is dominated by extensive barrier islands and sand dunes, highlighted by Padre Island, the longest continuous barrier island in the world. The net sediment transport is to the SW, however a NNE longshore current prevails from Mexico to Big and Little Shell beach along South Padre, thus causing a convergence zone and greatly contributing to the existence and sustainability of the barrier. There is, however, limited new sand supply to the coast and a more significant contribution of new clay and mud-sized sediments. The Texas coast has numerous bay-sand inlets, the former infilling. This coast was strongly impacted by Hurricane Ike (2008). Figure 2-4 shows the increased offshore suspended sediment (tan colored) offshore eastern TX and western LA.

2.2 Climate Change and Social Vulnerability

Scientific observations from across the region and around the world show that the increase in global temperature is unequivocal; there is consensus in the scientific community that the warming and wide-spread environmental changes are primarily the result of the rapid increase in greenhouse gas emissions from fossil fuel burning since the late 19th century. The effects of global warming on the Gulf region will be pervasive and variable, but one of the most significant climate-change impacts of the upward trend in global temperature is sea-level rise (SLR). Direct SLR impacts include increased coastal erosion, more frequent storm-surge flooding, inundation of low-lying areas, saltwater intrusion into aquifers, wetland loss, and threats to human infrastructure in coastal zones.

Recent climate-change assessments, such as the Intergovernmental Panel on Climate Change (IPCC, 2007), the U.S. Climate Change Science Program reports SAP 4.1 and 4.7 (CCSP, 2009; 2008), U.S. Global Change Research Program report “Global Climate Change Impacts in the U.S.” (2009), and the report from the International Alliance of Research Universities Congress (2009), suggest global sea level is likely to rise by 0.5 to 1 m or more by year 2100; and, possibly much more due to climate processes that appear to be more dynamic than previously thought (e.g., Greenland and West Antarctica ice-sheet melting, ocean current disruptions).

The Gulf of Mexico coastline is experiencing a rise in sea level, with regional variations in magnitude. New Orleans has one of highest rates in the U.S., exceeding 10 mm/yr, mainly due to natural compaction of deltaic Holocene deltatic sediments (Penland and Ramsey, 1990) and from man-made factors (i.e., oil and gas, water withdrawal). East of Louisiana, relative SLR approximates 2 mm/yr, which exceeds the eustatic rate of 1.8 mm/yr (the 0.2 mm/yr is attributed to subsidence). From Texas to New Orleans, the rising rate ranges between 3-5 mm/yr. Some climate scientists suggest that highly accelerated melting in Greenland and West Antarctica could lead to SLR of about 5 m over the next several hundred years. Such accelerated SLR, coupled with storms and sediment deficiencies at the coast, further emphasize the need for region-wide sediment management planning and adaptation planning for climate change impacts.

Figure 2-4. Suspended sediment following Hurricane Ike (2009). This image is from NASA's Moderate Resolution Imaging Spectroradiometer (MODIS) on the Terra satellite acquired 26 September 2008 (http://earthobservatory.nasa.gov/IOTD/view.php?id=35521).

Accelerated SLR will have significant impacts on coastal systems, natural resources and habitats, and societies worldwide. Coastal scientists have well-established conceptual and qualitative frameworks based on field studies and modeling regarding the primary factors and processes that drive coastal change. Current techniques used to predict coastal change, however, cannot at present provide reliable long-term quantitative predictions at spatial and temporal scales needed for detailed coastal planning. With substantial acceleration of SLR, "traditional" coastal management and engineering practices (i.e., protecting and maintaining shoreline position with hard structures, beach nourishment) will become more difficult for society and may not be economically or environmentally sustainable for many coastal regions. Predicted accelerated rates of SLR need to be fully considered in coastal management plans and engineering design. Options such as strategic relocation of infrastructure to higher elevation and conversion of low-lying developed areas to open space may be more appropriate in managing for and adapting to future coastal change.

Thieler and Hammer-Klose (2001) quantified coastal vulnerability along the U.S. Gulf Coast by considering geomorphology, coastal slope, relative sea level change, shoreline change, and mean tide range and wave height (Figure 2-5). Forty two percent of the coast (3387 km) was considered to be at a very high risk and 37% was at moderate risk. The most vulnerable areas are along the TX-LA coast, resulting from the low-lying beaches and marshes. Thieler and Hammer-Klose report that geomorphology and tidal range most strongly influence the vulnerability ranking and that in general, the western Gulf is more influenced by relative sea level rise compared to the eastern Gulf.

Figure 2-5. Coastal vulnerability of the U.S. Gulf of Mexico coast (http://pubs.usgs.gov/of/2000/of00-179/pages/figpage/fig4.html).

At the county/parish scale, Cutter et al. has examined vulnerability by considering physical and socioeconomic variables (Cutter et al., 2003). Boruff et al. (2005) conclude that the counties most vulnerable to physical factors are in Louisiana, west Mississippi, and north Texas (CVI in Figure 2-6). The socioeconomic vulnerability is highest in northwest Florida and south Texas, generally because of high populations of elderly people and international immigrants, respectively (CSoVI in Figure 2-6). Integrating socioeconomic and physical vulnerabilities for the Gulf indicate that the south Texas and Louisiana are the most vulnerable. The factors contributing to this vulnerability (in ranked order) are percent of population 65 years and older, birth rate, sea level rise, mean wave height, and median age. Six of the 10 most vulnerable coastal counties in the U.S. are in the Gulf region.

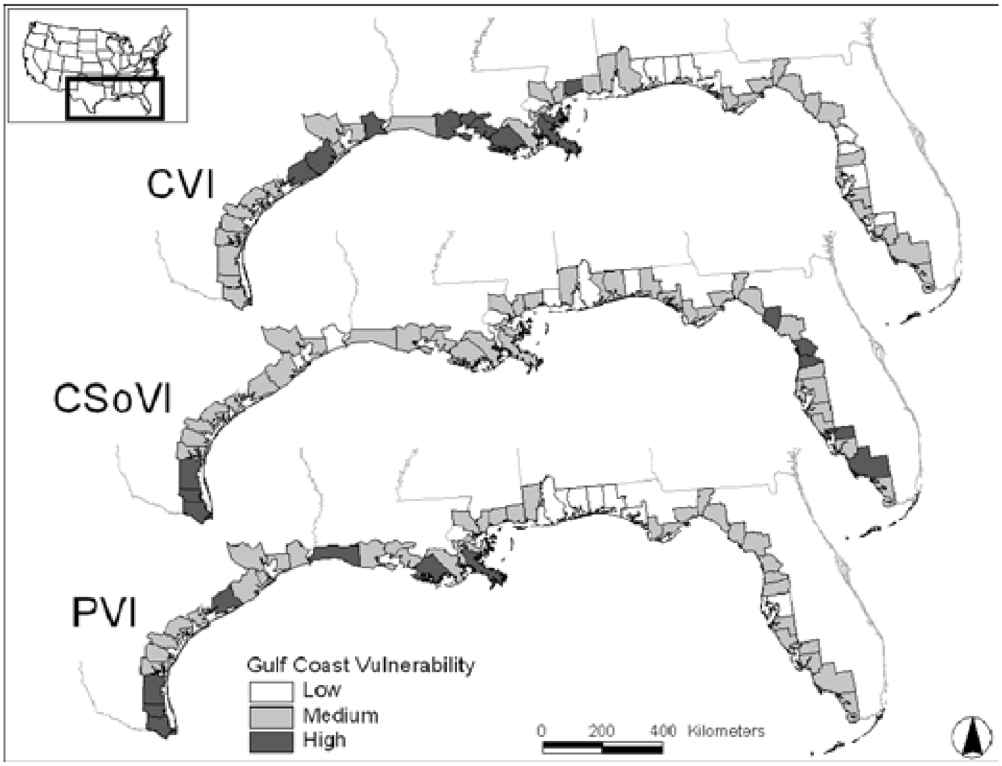

Figure 2-6. Vulnerability of coastal counties. CVI and CSoVI are physical and socioeconomic indicators. PVI shows the integration of CVI and CSoVI into a place-based vulnerability assessment (Boruff et al., 2005; their Figure 2).

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3.0 GULF OF MEXICO RSM FOCUS AREAS

As a result of the extensive interagency coordination and planning activities, several essential themes to regional sediment management emerged. These became the main focal points and technical framework of the initial GRSMMP effort. Focus areas and associated work groups were established to address each of these topics and prepare information for inclusion in the master plan. Co-leads for the work teams were selected to provide a mix of either Federal, state, or non-governmental representatives. These focus areas include:

Sediment Resources. This focus area looks at sediment transport processes, sediment budget issues, and evaluates studies that have been done that support the GRSMMP. The focus area also identifies and summarizes existing programs, studies, and databases that can provide information concerning sediment resources throughout the Gulf. Due to the comprehensive nature of this focus area, it is partitioned into three sub-focus areas:

- *Sediment Budgets:* Deals with sediment transport, sediment budgets, and inventories that may support the GRSMMP. This effort will also compile and summarize programs, studies, and databases that provide information concerning sediment sources and dredging activities. The workgroup co-leads are Jeff Waters with the U.S. Army Engineering Research and Development Center (ERDC) and Syed Khalil with the Coastal Protection & Restoration Authority of Louisiana.
- *Sediment Inventories:* Defined as taking inventory and assessing existing offshore sediment resources throughout the Gulf. The effort presents baseline scientific information on seafloor sediment character and composition that would be needed for managing and protecting natural resources and for providing ecosystem restoration. The co-leads for this workgroup are Jeff Williams of USGS and Juan Moya from the Texas General Land Office (GLO).
- *Dredging Activities:* Dredging activities are a potential source of sediment and should be considered in any conservation and restoration planning process. Currently this type of information is not consistently maintained or easily accessible. This focus area addresses the need and ability to improve data access and management for dredging activities and ways to better manage such information using a database approach that would be accessible to managers and planners. The co-leads for this effort are Larry Parson with the U.S. Army Corps of Engineers, Mobile District (USACE) and Greg Ducote from the Louisiana Department of Natural Resources (LDNR).

Ecological Considerations. This focus area examines the relationship between sediment and ecology in the context of RSM by exploring some of the anthropogenic activities that have affected sediment distribution, supply, and delivery; the ecological implications to multiple habitat types; and presents recommendations on how holistic approaches to sediment management can alleviate potential problems. The co-leads for this workgroup are Rafael Calderon with the Nature Conservancy (TNC) and Carl Ferraro with the Alabama Department of Conservation and Natural Resources (ADCNR). This section was authored by Dr. Denise Reed of the University of New Orleans.

Information Management. This effort is intended to examine ways and opportunities to collaborate and share data throughout all levels of government and the numerous interested stakeholders. Integrating the appropriate type of technology to assist in the efficient retrieval and distribution of RSM-related data is a key component to the success of an information management plan. The co-leads for this effort are

Clint Padgett, Mobile District USACE, and Rose Dopsovic and Klay Williams, Bowhead contractors for Mobile District USACE.

Policies, Authorities, and Funding. This focus area identifies existing authorities, policies, and funding mechanisms relevant to Federal and Gulf of Mexico (GOM) State dredging activities that affect the implementation of RSM actions and restoration projects. This focus area looks at ways to leverage existing state and federal authorities and policies, as well as ways to make them more flexible to facilitate implementing the recommendations that come out of the master plan. The co-leads for this effort are John Bowie with the EPA, Gulf of Mexico Program and Ray Newby of the Texas GLO.

These focus areas are discussed in greater detail below.

3.1 Sediment Resources

This focus area looks at sediment transport processes, sediment budget issues, and evaluates studies that have been done that support the GRSMMP. This effort will also compile and summarize programs, studies, and databases that have been developed that provide information concerning sediment sources and dredging activities.

3.1.1 Gulf of Mexico Regional Sediment Budget

3.1.1.1 Introduction

The purpose of this chapter in the Gulf Regional Sediment Management Master Plan is to provide a broad overview of the current knowledge about the systems of sand movement around the shorelines of the Gulf of Mexico. This discussion is aimed at coastal managers and policymakers and provides a general technical foundation on the basics of sediment movement to aid in future coastal restoration and management policy discussions. It is intended to provide background information for developing recommendations regarding the use of a systems approach to sediment management. In particular, it will address the fact that sediments (especially sand) in the nearshore and coastal zone are valuable and increasingly scarce resources that can have costly impacts if not carefully managed and conserved and hence the concept of regional sediment management (RSM).

Broadly speaking, RSM refers to the optimum utilization of various sediment resources (littoral, estuarine, and riverine) in an environmentally effective and economically feasible manner. RSM changes the complexion of engineering activities within the systems from the local or project-specific scale to a broader regional scale which is defined by the natural sediment processes (Khalil & Finkl, 2009). By managing the sediment on a regional scale, RSM aids in making the best local project decisions within the context of a regional plan that maximizes overall benefits and/or reduces total cost. Basically, RSM in a geological regime comprises sediment deposits and its inventory on regional scales, encompasses understanding of regional sediment budgets of the system along with records of dredging activities in the region (Khalil & Finkl, 2009).

Dynamic regional sediment management plans are needed for future planning, construction, and monitoring of wetland and barrier island restoration. Coordination of the supply and demand sides of sand resources in a comprehensive manner will be required as program planning moves forward. All this is possible only when the data on sediment sources along with sediment budgets and dredging activities are available to the planner. GIS will provide the interface to all the three components of RSM for better managing the sediment resources. However all these tools may not be very helpful as long as the very approach of planning projects without regional overview of sediment availability is not taken into account (Khalil & Finkl, 2009).

Sediment/sand resources are the part of a regional system which not only involves natural processes but dredging activities also. Both these have significant impact on ability to restore and sustain coastal habitats, which is the ultimate goal. Natural processes on a regional scale include existing sediment/sand deposit as well as the dynamic sand which moves along the shoreline. A sediment budget is normally developed for sand. Sediment budgets have both spatial and temporal dimensions and although the sediment budget is inherently related to sediment/sand inventories, budgets differ from sediment resource inventories due to their dynamic nature.

The sediment budget is a planning tool that provides an accounting of sediment sources, sinks, and pathways as well as engineering activities (Dolan et al. 1987, Kana and Stevens 1992). Sediment budgets have generally been characterized as conceptual, interim, or operational depending upon the quality of the data, the level of analysis and the uncertainty associated with the volume fluxes in the sediment budget.

The objective of this chapter is to summarize available sediment budget data for the GOM in a manner to allow this information to be compiled into a common GIS-based data management framework in order to address various sediment management issues related to restoration around GOM. The data management framework selected for the Gulf regional sediment budget is the Sediment Budget Analysis System (SBAS), a PC-based application for calculating and displaying local and regional sediment budgets including single and multiple inlets, estuaries, bays, and adjacent beaches (Dopsovic et al. 2002).

Sediment transport magnitude and direction data came from a variety of sources. These included published journal papers, reports from state agencies and the U.S. Army Corps of Engineers, and, to a minor degree, personal communications with faculty members and representatives from state agencies. To date, the sediment volumes in the Gulf regional sediment budget do not include newly-calculated volumes, only values calculated by other researchers. It should be noted that this is an initial attempt and will serve as a status report to help identify gaps in information. In order to be an effective tool for coastal restoration design, a regional sediment budget should be developed from its initial conceptual scale to an operational scale as recommended in the later portion of this chapter.

3.1.1.2 Gulf Regional Sediment Budget

For the purpose of the regional sediment budget, as discussed in Chapter 2, the Gulf Coast can be divided into eight morphologic regions of similar littoral characteristics, such as unique erosion or accretion occurrences and dredging activities as illustrated in Figure 2-1 in Chapter 2.

They are numbered G1 to G8 in a counter-clockwise direction. Reach G1 is the “Florida Keys,” Reach G2 is “Lower Everglades,” Reach G3 the “Lower Gulf Coast,” Reach G4 is the “Big Bend,” and the eastern part of Reach G5 is the “Panhandle Gulf Coast.” The westernmost reach, G8, a flat terrain of sand spits, barrier islands, and shallow lagoons, extends from east Texas southward into the Mexican state of Veracruz-Llave. Reaches G1, G2, and G4 are plant-dominated, sediment-starved, low-energy coasts and are not included in the Gulf regional sediment budget.

Reach G3, Florida Central Gulf Sandy Coast

Reach G3 covers the Florida Central Gulf Sandy Coast and extends from the Pinellas-Pasco County line to Cape Romano, Florida along the west coast of Florida, which is characterized by a series of long barrier spits and islands (keys) that enclose bays or sounds. Numerous inlets connect to coastal bays and salt marshes. It exists between two plant-dominated, sediment-starved, low-energy coasts: to the north is the pen-marine, salt-marsh Big Bend coast, and to the south is the open-marine, mangrove-dominated Ten Thousand Island coast (Hine et al. 2001).

Along this reach, the streams carry dissolved limestone from the peninsula, but little sand, silt, or mud. The deposited sediment consists mostly of seashell fragments. The resulting beaches are light but not nearly as reflective as the quartz beaches in the Gulf Islands National Seashore. The lower wave climate along Florida's west coast results in a significantly lower sediment transport rate than experienced along the Atlantic coast. The net littoral drift direction along the central Gulf coast of Florida is north to south. The presence of the numerous keys and inlets along this reach were used to define these cells. It should be noted that all sediment quantities presented represent coarse-grained (sand) movement, with the exception of that within Tampa Bay. Sediment dredged from Tampa Bay within the lower bay (silt and sand) is placed at an offshore disposal site, while the middle and upper bay dredged material is primarily silt and is placed into two artificial islands in Hillsborough Bay.

The west-central coast of Florida is characterized by a series of long barrier spits and islands (keys) that enclose bays or sounds. Numerous inlets connect to coastal bays and salt marshes. A large percentage of coastal residents within this reach (except for Immokalee, Lehigh Acres, and eastern Sarasota County) live on land only a few feet above sea level. Beach and Inlet Management plans produced for and by the Florida Department of Environmental Protection are based upon sufficiently refined local sediment budgets, many of which can be considered "operational" sediment budgets.

The lower wave climate along Florida's west coast results in a significantly lower sediment transport rate than experienced along the Atlantic coast. The net littoral drift direction along the central Gulf Coast of Florida is north to south (Figures 3.1-1 thru 3.1-4). Taylor Engineering (2002) developed the sediment budget for the 290 km (180 mile) reach from Honeymoon Island just south of the Pinellas County line to Cape Romano through investigations of multiple literature sources, inlet management plans, dredging records and nourishment placements from 1970-2000.

A sediment budget partitions the area of interest into regions of similar littoral characteristics, such as unique erosion or accretion occurrences and dredging activities. The presence of the numerous keys and inlets along this reach were used to define these cells. The sediment pathways and directions are represented by arrows and the amount of movement (in average m^3/yr) is annotated. Arrows indicating the average annual littoral transport rate in and out of the cell are also presented. Figures 3.1-1 through 3.1-4 present the sediment pathways and average annual quantities. It should be noted that all sediment quantities presented represent coarse-grained (sand) movement, with the exception of that within Tampa Bay. As mentioned earlier, sediment dredged from Tampa Bay within the lower bay (silt and sand) is placed at an offshore disposal site, while the middle and upper bay dredged material is primarily silt and is placed into two artificial islands in Hillsborough Bay.

It should be noted that since the budget was based upon 1970-2000, it does not capture a significant change occurring at Boca Grade Pass (Figure 3.1-1). Previously, material removed from this Charlotte Harbor inlet was placed offshore. In fall 2006, an $11.2 million beach restoration project was awarded to backpass 734,000 m^3 of sand from the pass and place it on the beach from the southern end of Gasparilla Island northward to 19th Street for a total length of about 5.1 km [1]. The current project does not include two T-groins and a segmented breakwater proposed to be constructed at the southern tip of the island to reduce sand losses.

1 Boca Beacon. 2006. County Awards Island Beach Restoration Contract, 13 October 2006, http://www.thebocabeacon.com/?p=1285 , 18 Jan 2007

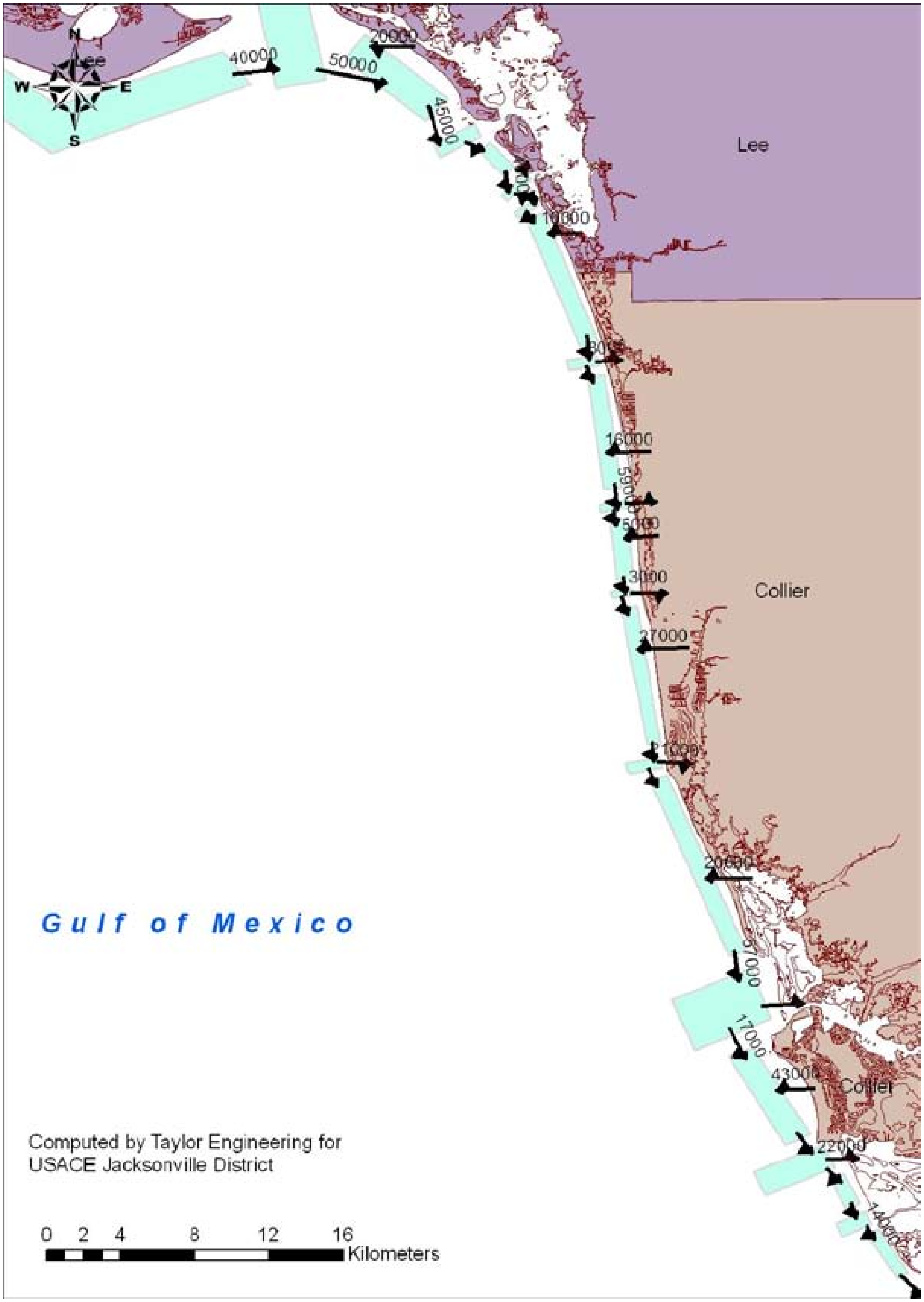

Figure 3.1-1. Florida Gulf Coast sediment budget from Sanibel to Marco Island.

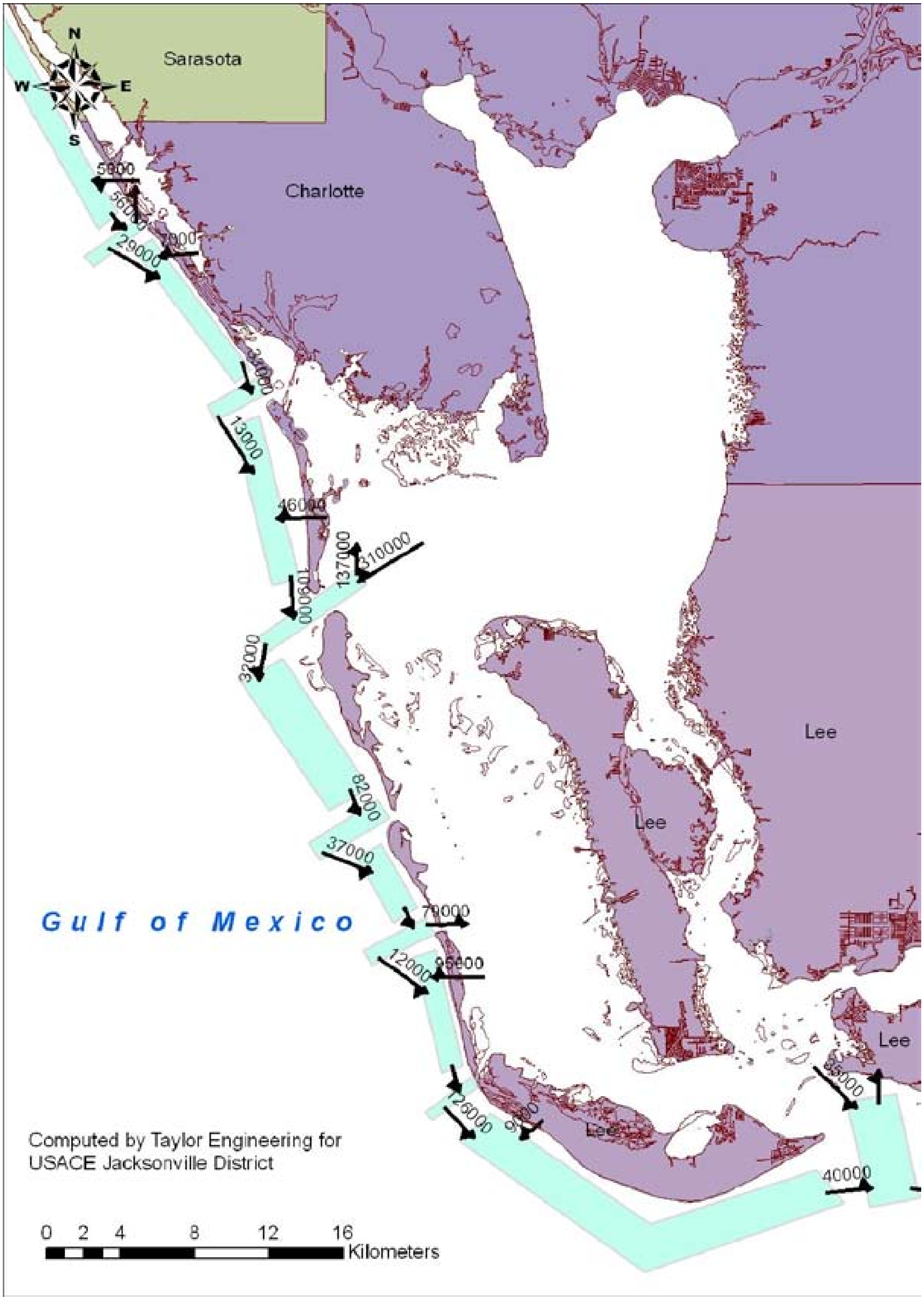

Figure 3.1-2. Florida Gulf Coast sediment budget from Stump Pass to San Carlos Bay.

Figure 3.1-3. Sediment budget from Anna Marie Island to Venice Inlet, Florida.

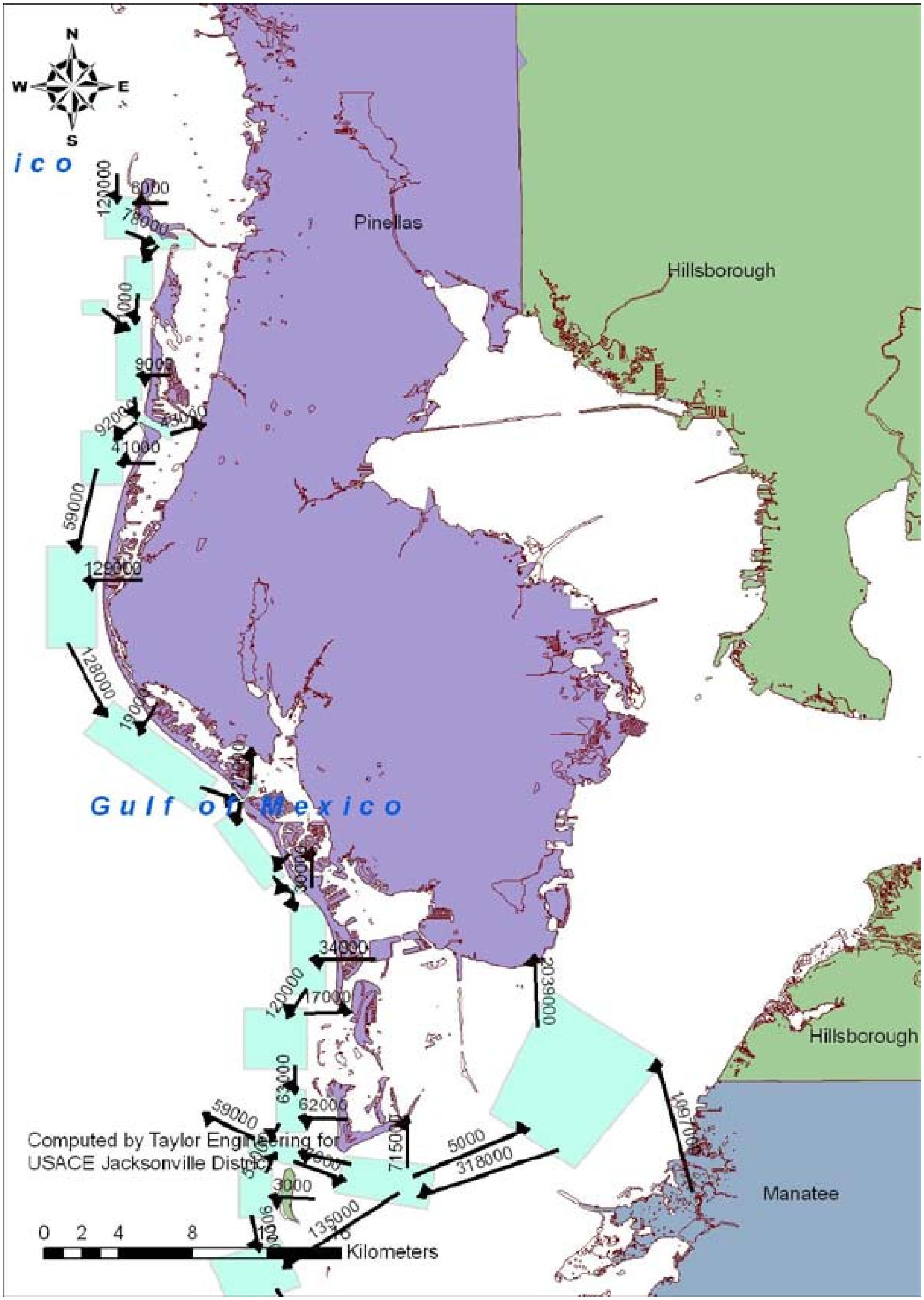

Figure 3.1-4. Florida Gulf Coast sediment budget from Egmont Key to Honeymoon Island.

Reach G5, Northeast Gulf sand coast: Florida Panhandle, Alabama, Mississippi

Drainage into the Gulf covers almost 60% of the continental United States and includes the outlets of 33 river systems and 207 estuaries. The sizes and locations of the drainage areas have heavily influenced sediment deposition along the northern Gulf Coast.

For example, the sediment that reaches the beaches of the north central Gulf, east of the Mississippi Delta, comes from the southernmost portion of the Appalachian Mountains. Streams carry mostly clear white quartz grains a short distance across the coastal plain to the Gulf. Quartz is hard and durable and survives transport by fast-moving streams, while softer minerals disintegrate and dissolve, or remain suspended. Therefore, the sedimentary particles available for beach formation along the northeastern Gulf Coast are largely white quartz (Lillie 1999). Longshore currents that flow predominantly westward redistribute it along the coast and barrier islands, resulting in the Panhandle's famous white sandy beaches.

Reach G5 which includes the northeast Gulf sandy coast covering part of Florida Panhandle, Alabama, and Mississippi (Figure 3.1-5), extends from Peninsula Point, the southeast point of Franklin County, Florida to the sandy beaches near Bay St. Louis. This reach is characterized by a series of long barrier spits and islands that enclose bays or sounds along with a section of topographically high sandy upland that extends from St. Joseph Peninsula to Destin. Here, a beach of variable width fronts low sandy bluffs. Another section of mainland shore is found north of St. Joseph Bay near Mexico Beach.

The following descriptions are based on morphological evidence, such as beach erosion, dredging data, and sand accumulations on spits and shoals. This is a rich data area with respect to sediment budgets thanks to studies conducted by Louisiana State University researchers, the U.S. Army Corps of Engineers, and the State of Florida. Figures 3.1-5, 3.1-6, 3.1-7, and 3.1-8 show net drift directions and transport in m^3/year × 1000.

Apalachicola region

The barrier islands, capes, and spits of the Apalachicola region contain a minimum of seven littoral transport cells, which have no significant sediment exchange from cell to cell (Stone and Stapor 1996). Dog Island, for example, has bulges on both ends indicating that sediment from the center of the island moves to either side. But it is unlikely that Dog Island sand moves across East Pass to St. Joseph Island.

Based on morphological evidence, Stone and Stapor (1996) calculated transport to range from 12,000 m^3/year at the east end of Dog Island to 214,000 m^3/year on the southern tip of the St. Joseph Spit (Figure 3.1-6). Along most of the St. Joseph Spit, sediment transport is to the north. The spit once consisted of two islands, with the former channel located at Eagle Harbor (Stapor 1975). Annually, about 79,000 m^3 of sand is deposited on the northern tip of the spit, about 14,000 m^3 ends up in the channel that leads into the bay, and none reaches the mainland beaches.

On the mainland shore in the Beacon Ridge area, the pattern of the beach ridges and the coastal plain's asymmetry indicates eastward longshore transport to this prograding stretch of coast (Stapor 1975).

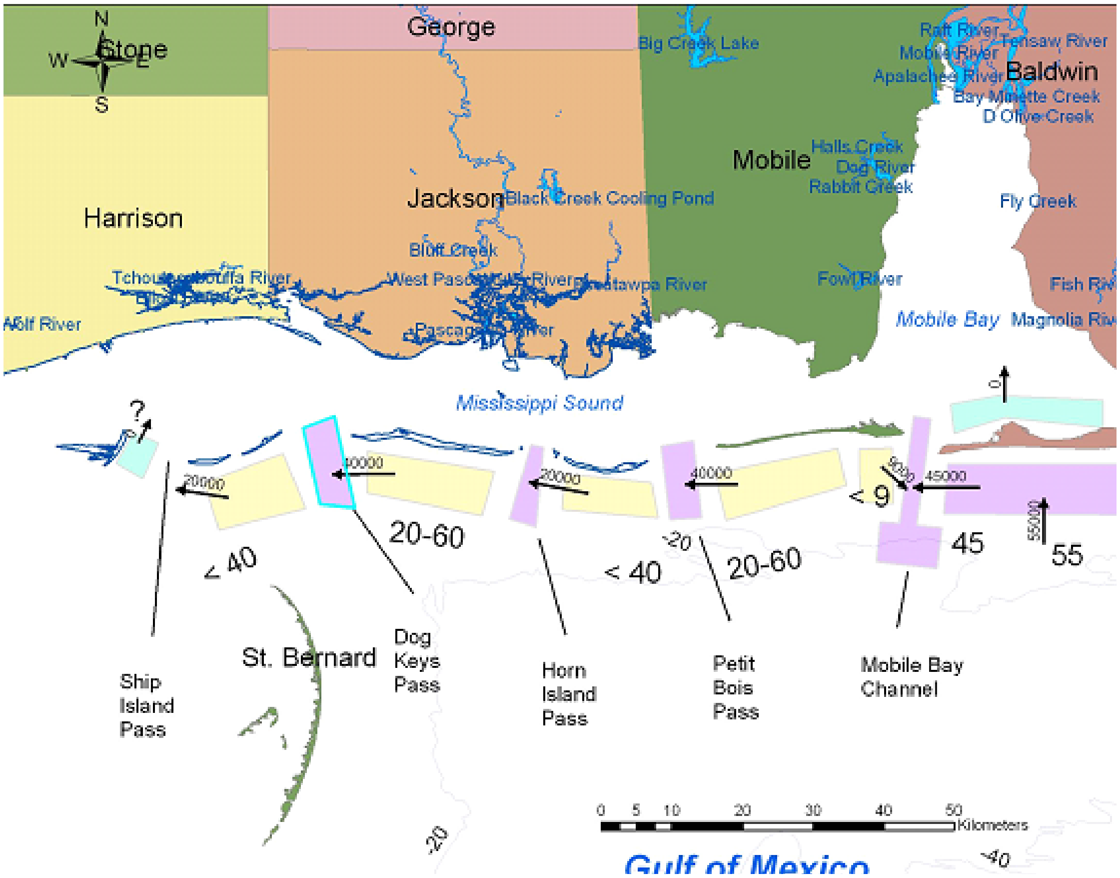

Figure 3.1-5. Reach G5 - Longshore sediment movement, Alabama and Mississippi (m3/year × 1000).

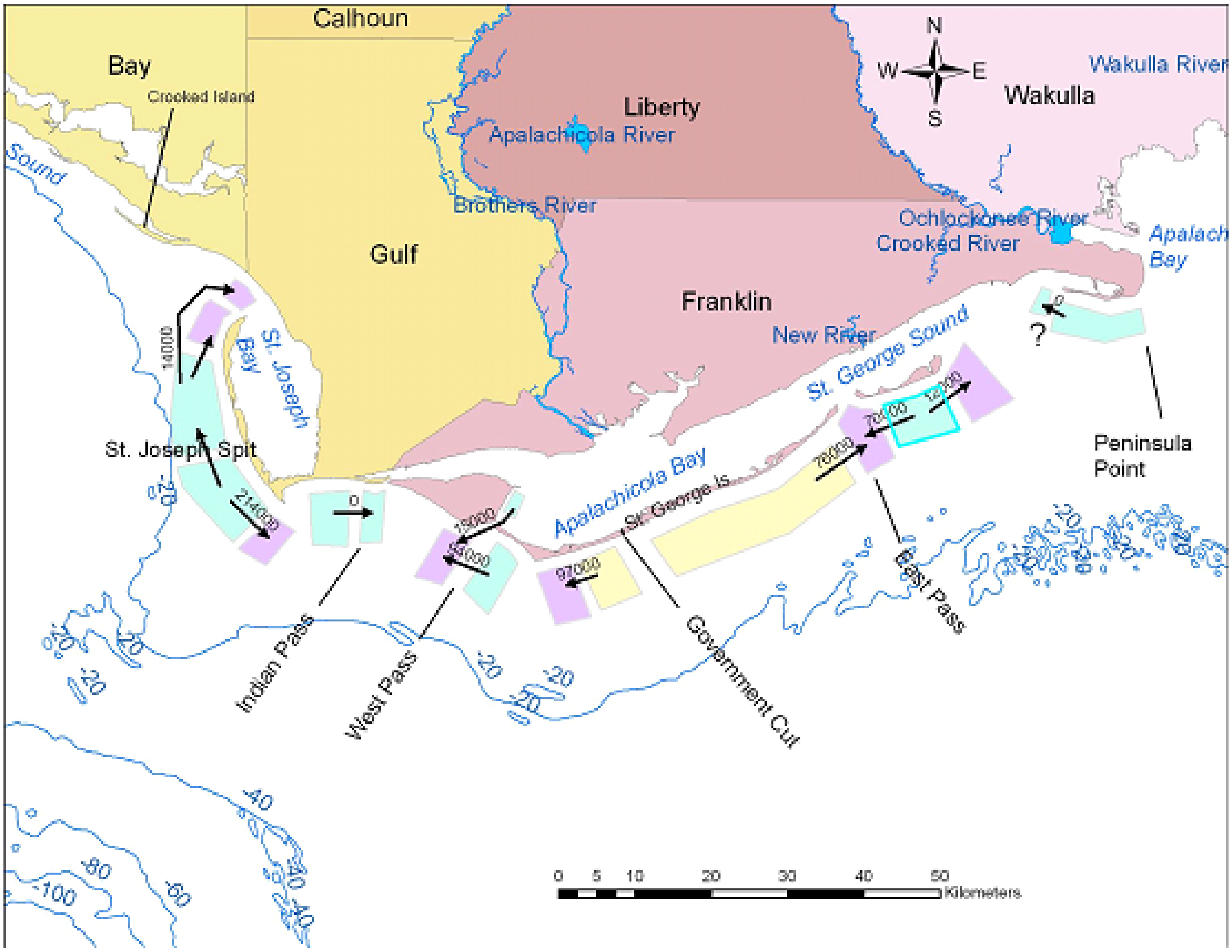

Figure 3.1-6. Net longshore sediment movement in west Florida from Peninsula Point to St. Joseph Spit (m3/year × 1000).

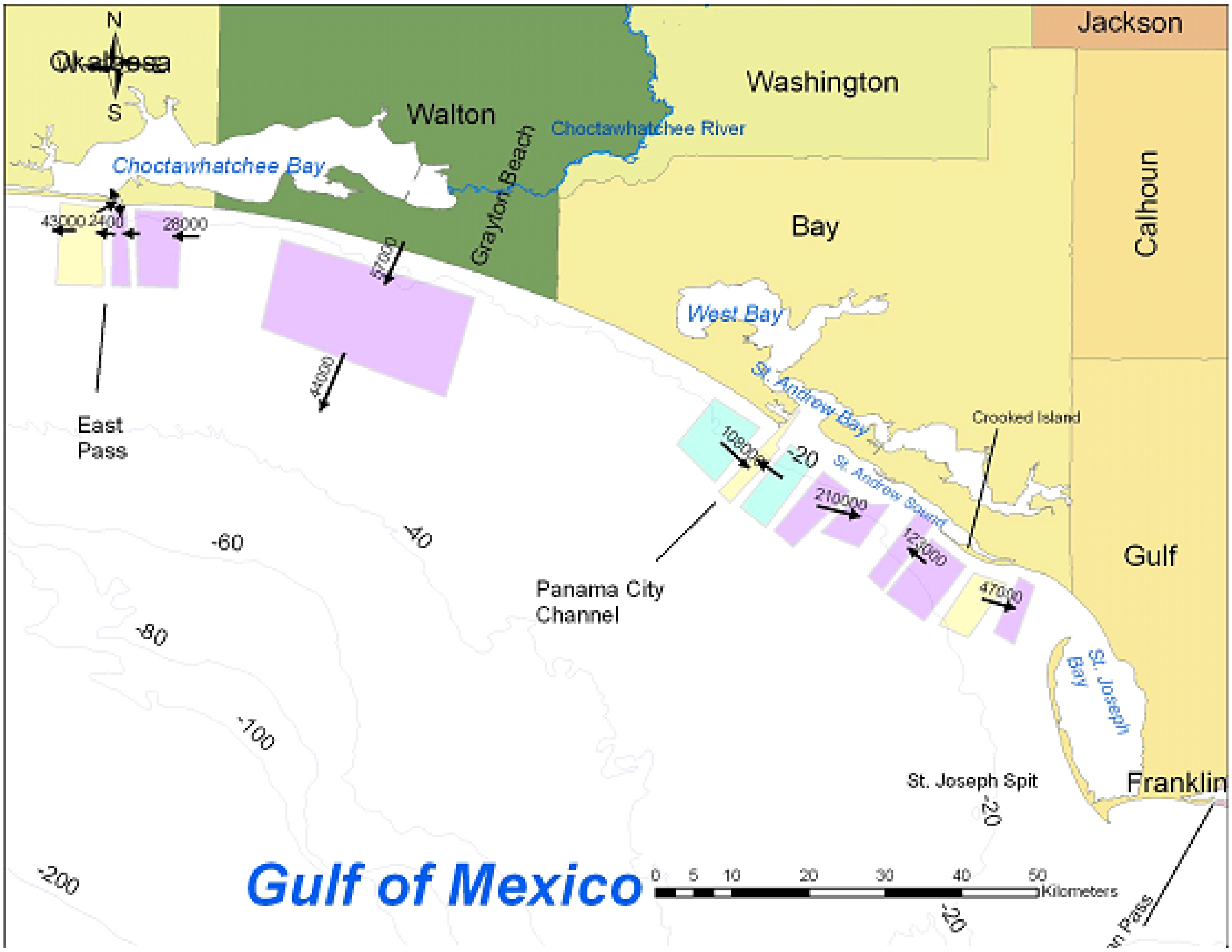

Figure 3.1-7. Net longshore transport, west Florida from St. Joseph Bay to East Pass (m3/year × 1000)

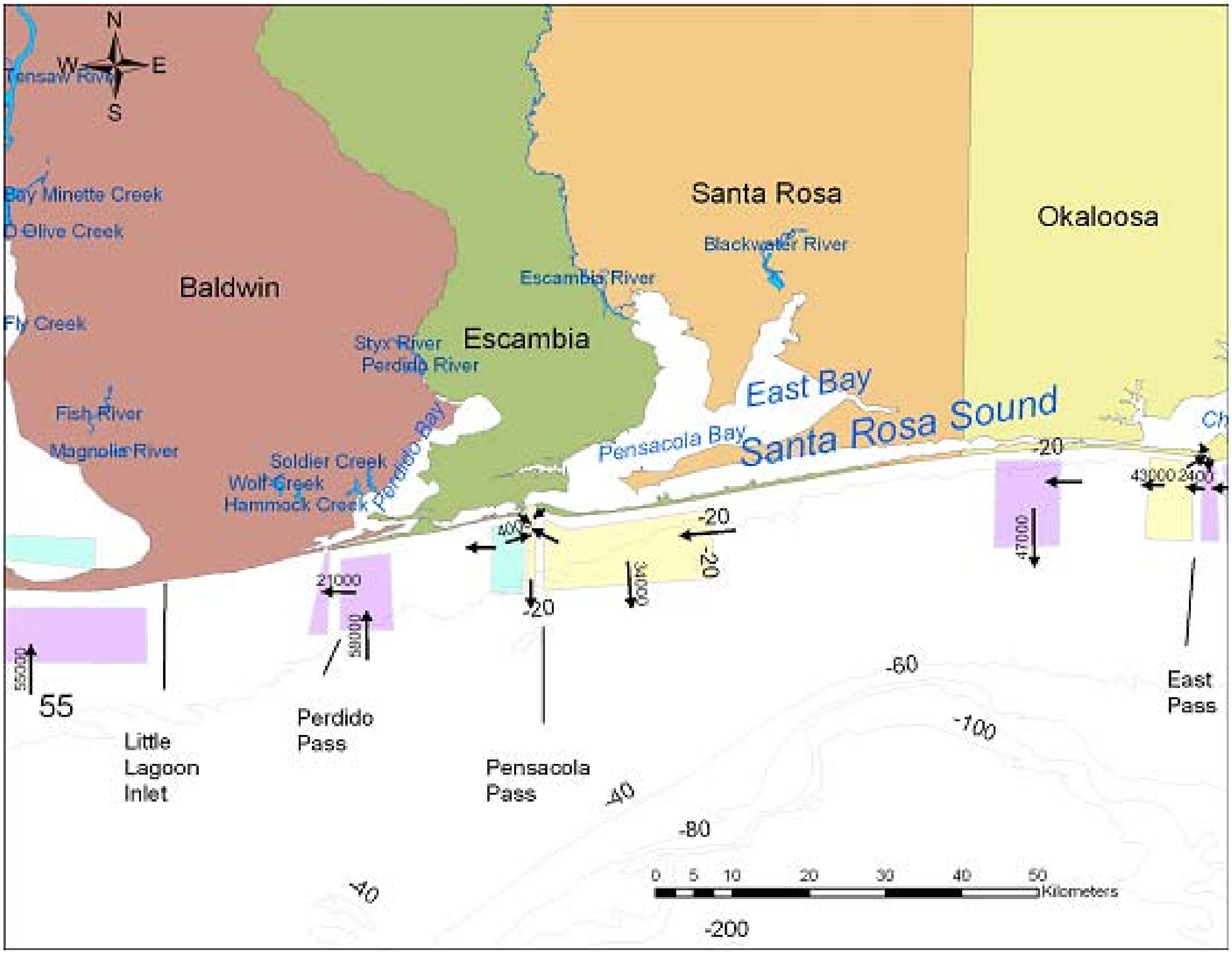

Figure 3.1-8. Net longshore transport, west Florida and Alabama (m3/year × 1000).

Panama City region

The Panama City Harbor Channel was dredged across Land's End Spit in 1933. Since then, sediment has accumulated on both sides of the jetties approximately equally, indicating that a transport direction divide occurs in this area. The gross transport in either direction is about 110,000 – 120,000 m^3/year, while the net is about 10,000 m^3/year to the west (Figure 3.1-7). A few kilometers to the east, Crooked Island also has a transport divide. About 47,000 m^3/year moves east from the east end of the island, while at the west end, about 123,000 m^3/year moves west. The pathways are complicated, and the reader should consult Figure 4 of Stone and Stapor (1996) for details.

Grayton Beach to Santa Rosa Island/Pensacola Pass

Off Grayton beach, about 57,000 m^3 of sand is transported annually to the west (Stone and Stapor 1996). Bathymetry data suggests that more than 40,000 m^3 of this may move offshore onto the shelf (Figure 3.1-6). The well-developed bar across the entrance to East Pass is an efficient bypasser, allowing sand to proceed west to Santa Rosa Island. Because the water is so clear at East Pass Inlet, submerged bedforms demonstrate the process of bypassing (Figure 3.1-6).

The net longshore transport at Destin is from east to west, but reversals may last for days or weeks. Waves approach the coast almost exactly 90 degrees from the shoreline orientation, so minor shifts in meteorological conditions can account for longshore transport being in one direction for days or weeks followed by periods in the other direction (Morang 1992). The inlet management plan at East Pass shows net annual westward transport of 28,100 m^3 on the east side of the inlet and 43,300 m^3 on the west side (Taylor Engineering 1999).

Towards Navarre Beach, annual westward transport is about 50,000 m^3, of which about 47,000 m^3 moves offshore (Figure 3.1-8). Further west, between Pensacola Beach and Pensacola Pass, transport is westward at about 58,000 m^3/year (Stone and Stapor 1996).

Near Pensacola Pass, published estimates of net westward longshore transport range from 25,000 to 280,000 m^3/year. This range underscores the uncertainty in the methods used to compute the values and the uncertainty in the quality of the underlying data (e.g., shoreline change data, wave statistics, shipboard wave observations, etc.). Using morphological evidence from historical and recent maps, Stone and Stapor (1996) estimated that about 24,000 m^3/year is deposited in Pensacola Pass from the east, while on the opposite shore (the east end of Perdido Key), a local reversal carries about 2,000 m^3/year into the Pass.

Browder and Dean (1999a), using WIS hindcast wave data and a sediment budget analysis, estimated westward transport to range from 30,000 to 55,000 m^3/year. They concluded that under typical conditions (predating the period following the Pensacola Pass U.S. Navy deepening), 25,000 m^3/year was deposited in the ebb shoal while 13,000 m^3/year accumulated on the beach. West of the Pass, 38,000 m^3/year was lost from the beaches. Pensacola is one of the deepest natural passes in the Gulf, and with part of the throat more than 20 m deep, it is an effective sediment sink that prevents material from moving back and forth to opposite shores Browder and Dean (1999a).

Pensacola Pass to the mouth of Mobile Bay

The eastern part of Perdido Key is low and frequently overwashed during storms. Stone and Stapor (1996) estimated that up to 130,000 m^3/year of material was eroded and transported across the barrier, with a minor portion pushed east toward Pensacola Pass. Further west, about 21,000 m^3/year is transported west toward Perdido Pass. At the pass, sand crosses a weir into a deposition basin. The basin is periodically dredged and the sand placed on the downdrift (west) side of the inlet. The shore west of the pass has historically suffered erosion.

From Perdido Pass to Morgan Point (at the east side of the mouth of Mobile Bay), onshore sediment transport supplies about 55,000 m^3 of sand annually, of which about 45,000 m^3 moves west toward the mouth of the bay (Stone and Stapor 1996). The shore west of Little Inlet has historically benefited from a sediment surplus and has advanced, in contrast to much of the coast between Pensacola Pass and Perdido Pass. The north shore of the Morgan Peninsula, facing Mobile Bay, has been vulnerable to erosion (Figure 3.1-7). Sand eroded from the north shore is probably deposited in the shallows of Mobile Bay, where it is lost from the coastal littoral system.

Southwest Alabama and Mississippi

The net longshore transport direction along the Dauphin, Petit Bois, Horn, and Ship Islands is to the west with the exception of a reversal along eastern Dauphin Island, caused by wave refraction over the Mobile Pass ebb tidal delta. The eastern end of Dauphin Island has high dunes and a pine forest, indicating that it has been stable for hundreds of years, possibly as a result of the transport reversal. However, it has been necessary to protect the shoreline near Fort Gaines with groins to prevent erosion. The west end of Dauphin Island is a low barrier that is frequently overwashed. Private property is especially vulnerable to storms, and almost all the houses on the west half were damaged or destroyed by Hurricane Katrina. Otvos (2006) states that historically, the west end of Dauphin Island has always recovered from storm destruction with sediment supplied from the Mobile Bay ebb delta.

Cipriana and Stone (2001) calculated that annual net westward transport ranges from 20,000 to 60,000 m^3 on Dauphin, and Horn Islands and from zero to 40,000 m^3 on Petit Bois and Ship Islands (Figure 3.1-5). Sediment tends to coarsen downdrift (to the west), for reasons unknown. In contrast to Dauphin Island's long-term resilience, the combination of storms and fair-weather erosion on Ship Island been profound, long-lasting, and possibly irreversible (Otvos 2006).

Reach G6, Mississippi River Delta and south-central Louisiana

In the western portion of the Gulf of Mexico the sediment supply is fundamentally different. The Mississippi River system drains much of the North American continent. Slow-moving tributaries which drain the Great Plains bring in large quantities of mud and silt in addition to sand. The beaches of Louisiana and east Texas are therefore a brown-gray color and have a higher proportion of fine material than the Florida Panhandle beaches.

It is well documented that the Mississippi Delta is a complex of marshes, channels, bays, and sounds. Because of the low and wet terrain, it is very difficult to define a "shoreline" in the case of most of Louisiana's coast. West of the Mississippi river, the Plaquemines barrier shoreline has a complicated geological framework because it was influenced by different phases of deltaic evolution during the Holocene. Many barrier islands along this coast have been reduced to fragmented relics of the formerly robust islands. This geomorphologic complexity is compounded by deltaic sedimentology with prevalence of clay, silt, and mixed sediment. Sand which is scarce normally hugs around the southern Gulf side shore of degrading barrier islands. The morphologic complexity of the Louisiana coast zone and the apparent inconsistencies in transport rates reported in the literature underscore how little is known about longshore transport patterns and rates along Louisiana's shore.

Coastal erosion is a chronic problem along much of the southwest Louisiana shore (much less in magnitude than southeast Louisiana) except for few segments in southwest Louisiana where some accretion is taking place. The causes are complex and have been the subject of many studies attempting to develop solutions to preserve threatened marshes and wetlands (Committee for the Restoration 2006). The overall cause is a deficit of sediment in the littoral transport system due to numerous natural and man-made processes. Overwash may be one of the major causes of sediment loss from the littoral zone along much of this reach. The quantities that are pushed by storm waves over the low beaches and into the marshes are still unknown, but clearly this is an important mechanism during events such as hurricanes.

Reach G6 (Mississippi River Delta and south-central Louisiana) covers the delta of the Mississippi River and extends from the sandy beaches near Bay St. Louis, MS to the mouth of Vermilion Bay in Vermilion Parish, LA. The shallow geologic structure of the region is primarily the result of deposition by fluvial and deltaic systems. Marine processes reworked the deposits to create the present coastal systems, which include tidal inlets, barrier islands, beach-ridge plains, and chenier plains. The main source of sediment now is the Mississippi River, which carries suspended fine-grained material and some sand as bedload. Several studies have concluded that suspended sediment load and the percentage of sand in the total load of the Mississippi River have decreased significantly (Keown, Dardeau, and Causey 1986; Kesel 1988; Committee on the Restoration (2006)).

River diversion is another condition that has fundamentally affected sediment supply to the coast around the Mississippi Delta. In contrast to the Mississippi and most other rivers in this area, the Atchafalaya, which has served as a distributary of the Mississippi River since the 1500s and carried large volumes of water and sediment throughout this period (Fisk 1952) and flows into Atchafalaya Bay, is gradually supplying more sediment to the coastal zone. Despite high suspended transport by the Atchafalaya, the two newly-formed deltas at Wax Lake outlet and Atchafalaya outlet are sand-rich, containing about 70% sand (Roberts *et al*. 2005).

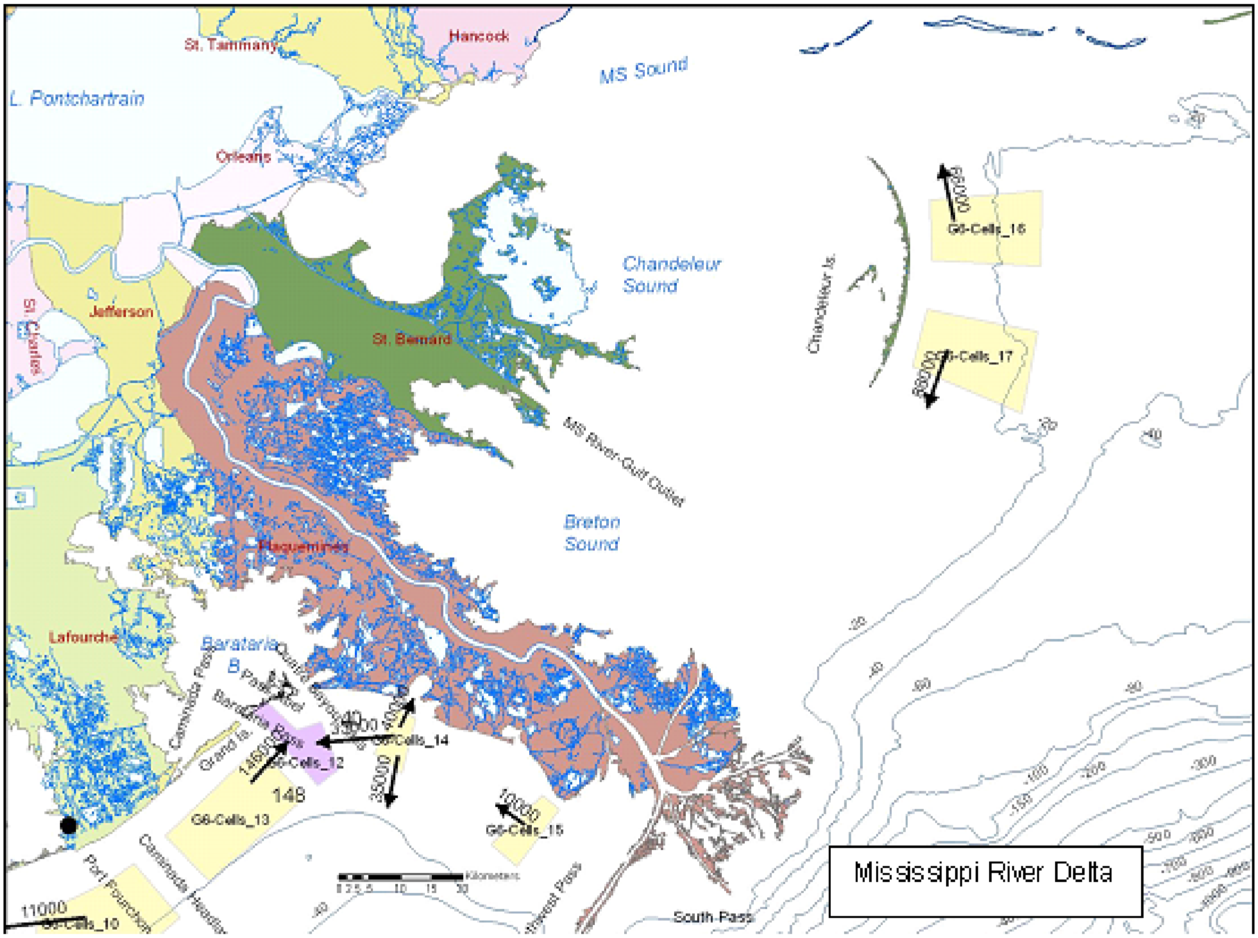

Figure 3.1-9. Mississippi River Delta and southern Louisiana.

A sediment transport nodal point occurs on the south-central part of the Chandeleur Island chain (Figure 3.1-9). North of the node, net transport was about 66,000 m^3/year is to the north, while south of the node, transport was 88,000 m^3/year in a southerly direction (Georgiou et al. 2005). These results were determined primarily from wave modeling studies. The large-scale destruction of the Chandeleurs by Hurricane Katrina has probably fundamentally reduced these transport rates. The storm caused the islands to lose almost 85% of their above-water area and the remnants to retreat an average of 270 m (Sallinger, Wright, and Lillycrop 2007).

The authors noted that after landfall, what remained of the Chandeleur Islands no longer satisfied the definition of sandy barrier islands. Twelve months later, 58% of the remaining islands continued to retreat, while 42% advanced. These are perched on a marsh-deltaic platform, which means very little sand is available for rebuilding. A major research question is to identify the disposition of the lost sand. Did it move westward into the back bay or offshore into the Gulf?

West of the Mississippi River's present route, the Plaquemines barrier shoreline has a complicated geological framework because it was influenced by different phases of deltaic evolution during the Holocene. Many barrier islands along this coast have been reduced to fragmented relics of the formerly robust islands. Georgiou et al. (2005) estimated a longshore transport to the northwest of only 10,000 m3/year. But at Shell Island, situated just northwest of the Bayou Fontenalle entrance to the Empire waterway, Campbell 2 computed transport of up to 33,000 to the northwest, 35,000 offshore, and 40,000 onshore.

For the Barataria Bay area, Georgiou et al. (2005) calculated longshore transport from shoreline morphological trends. About 146,000 m3/year moves east along Grand Isle, which in recent years has been protected with a series of detached breakwaters. Studies conducted in the 1930s by the Beach Erosion Board (1937) suggested that the drift divide occurred midway along Grand Isle. They reported that beach consisted of very fine sand interspersed with finely divided shall fragments and clay. Suspended sediment samples showed that most of the sand in motion was close to shore and that beyond about 80 m offshore, the water was muddy but contained little sediment volume.

The Caminada-Moreau Headland is an abandoned deltaic front that has eroded landward more than 3 km since the 1880s. The beach along the headland consists of fine to medium quartz sand. Georgiou et al. (2005) calculated that along the headland, the net transport is about 11,000 m3/year to the west. But this value may be unrealistically low; also some material may move east towards Grand Isle.

The Timbalier islands have retreated throughout the 20th century. An 1863 map shows how Bayous LaFourche and TerraBonne once served as sediment sources for barrier islands (Figure 3.1-10). The morphology of the Timbalier islands indicated that they spread westward in front of Timbalier Bay, fed by a sediment source (Bayou LaFourche) at the Caminada headland (Kulp et al. 2007). Then, Timbalier and Terra Bonne bays were separate entities, but they have now merged into one water body (compare with Figure 3.1-10). As the bay enlarged because of sediment compaction and land loss (wetland destruction), the tidal prism increased, resulting in a larger throat and growth of the ebb tidal shoal. List et al. (1994) documented that in the century from 1880 to the 1980s, the shoal volume increased from 8×106 to 53×106 m3, which averages to about 450,000 m3 per year.

Much of this growth was probably from sediment removed from the barrier islands (Miner, FitzGerald, and Kulp 2007), but it is likely that a major contribution also came from the eroding Caminada headland. If this is the case, the westward transport might be in the range of 225,000 m3/yr (assuming one half of the shoal annual grow), a value 20 times greater than that reported by Georgiou et al. 2005. The question underscores the fact that there is still not a great understanding of sediment movement along the Louisiana shore.

Along the Isles Derniers, overall sediment transport is to the west at a net rate about 33,000 m3/year (Georgiou et al. 2005). Transport patterns are complicated because of the fragmented nature of the islands. As an example of this complexity, Thomson et al. (2005) calculated that at the east end of Raccoon Island, the longshore transport was about zero or slightly to the east, but it switched to about 30,000 m3/year to the west along the west portion of the island (Figure 3.1-10). These values were for the period 1989-1996, pre-dating construction of detached breakwaters.

2 T. Campbell, Coastal Planning & Engineering, Inc., personal communication, 23 Jan 2007.

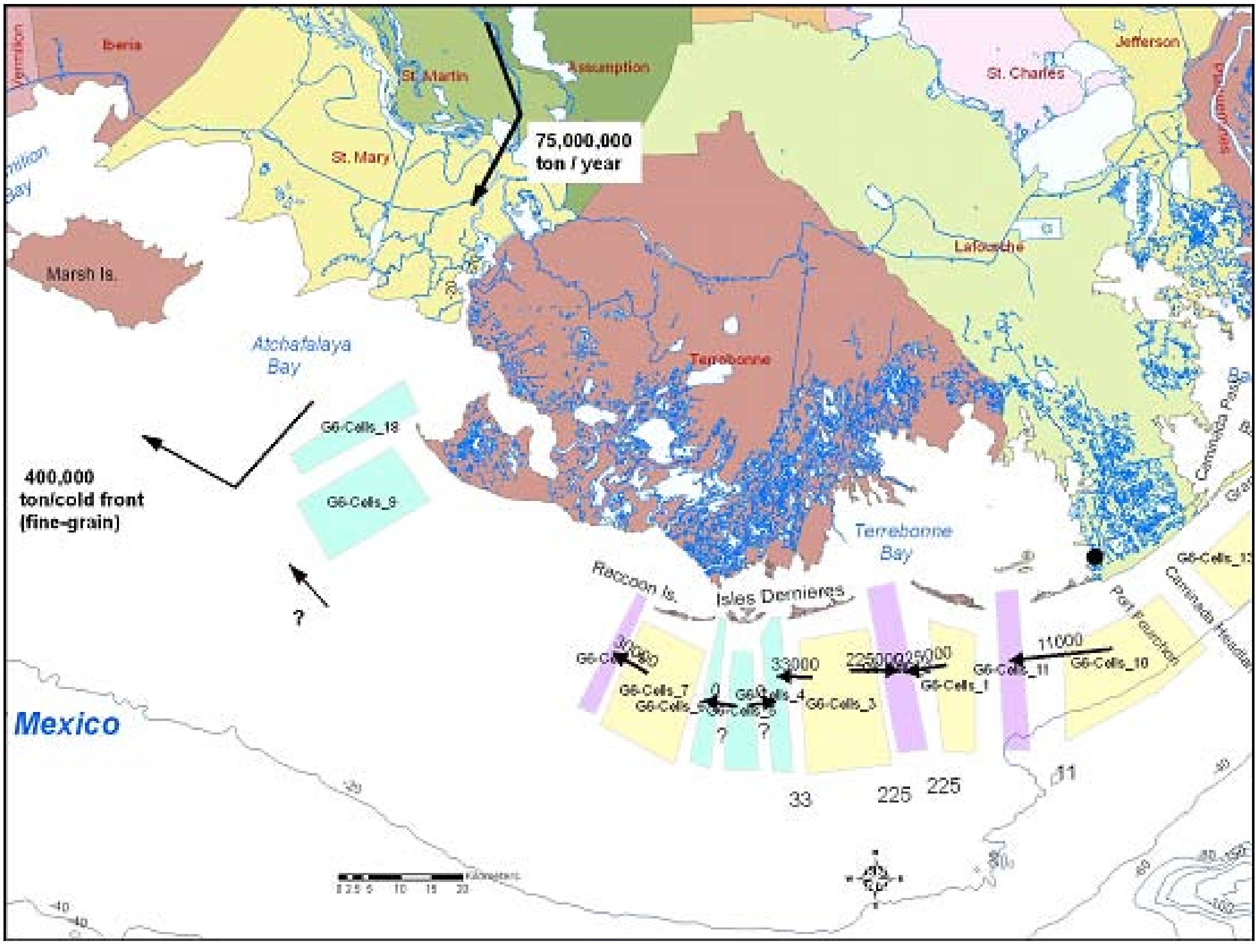

Figure 3.1-10. South central Louisiana.

Reach G7, West Louisiana and East Texas (to High Island)

Along southwest Louisiana and northeast Texas the longshore sediment movement is generally to the west, but there are reversals near Sabine and Calcasieu Passes caused by wave refraction around their offshore shoals (Georgiou, FitzGerald, and Stone 2005). Texas values are based on a sediment budget prepared by the Engineer Research and Development Center for the U.S. Army Corps of Engineers Galveston District (Morang 2006). For southwest Louisiana, little sediment budget data is available.

Reach G7 (West Louisiana to High Island, East Texas) extends from Southwest Pass at the mouth of Vermilion Bay, LA to High Island, TX (Figures 3.1-11 and 3.1-12). This is a flat terrain characterized by muddy sediments and extensive marshes. The generally narrow beaches consist of ribbons of mud, sand, and shell fragments, sometimes covered with veneers of fine sand. They are generally subject to low wave energy except during hurricanes and storms generated during cold-front passages. Sand supply from inland sources or offshore deposits is limited. In southwest Louisiana, there is essentially no beach, but mud banks. Louisiana State Highway 82 runs atop a series of ridges or cheniers between Pecan Island and Sabine Lake. The chenier plain is a unique sequence of alternating shore-parallel ridges composed of sand, shell, and shell fragments deposited on top of and separated from each other by swales of emergent marsh perched on alluvial deposits.

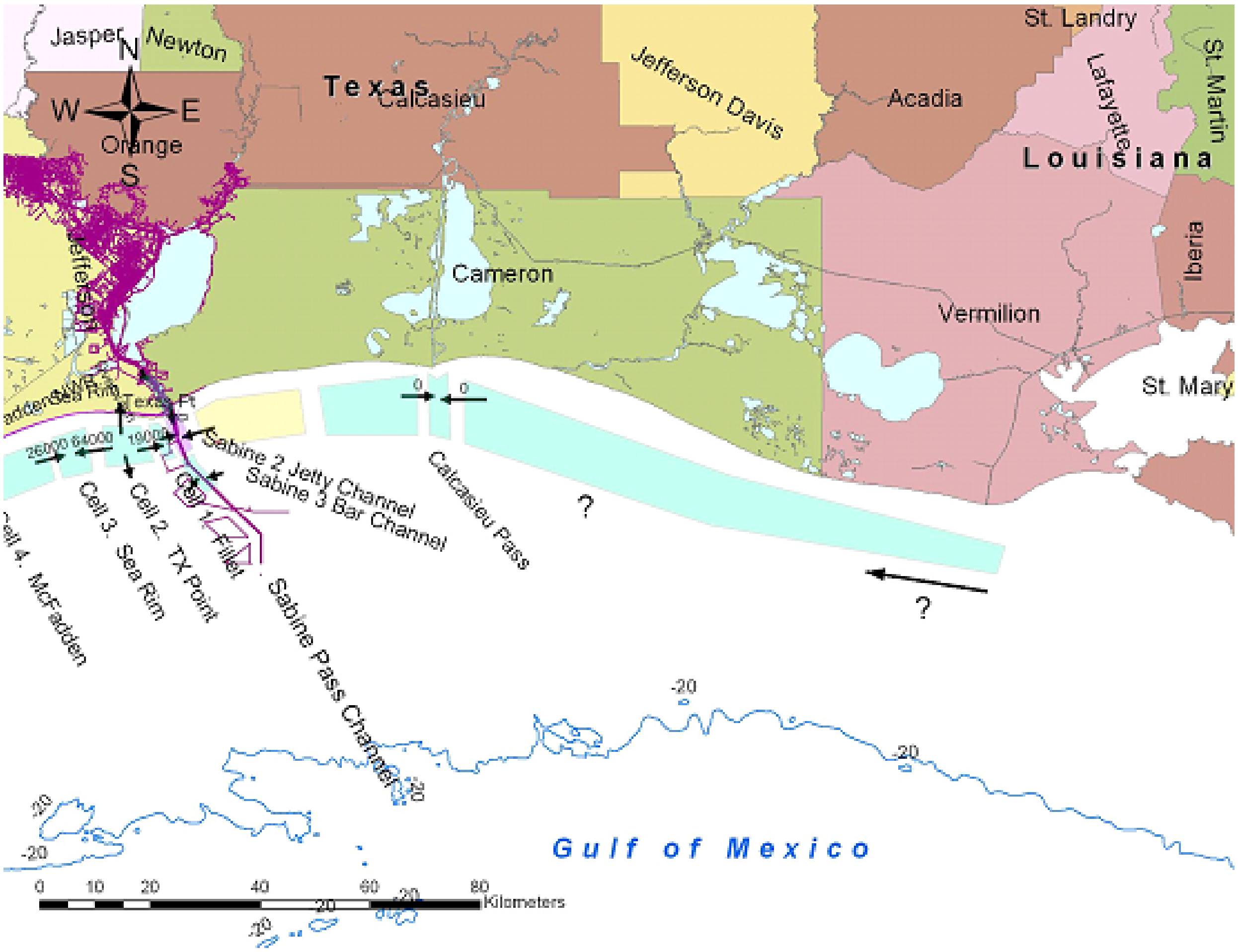

Figure 3.1-11. Western Louisiana Chenier Plain to McFaddin National Wildlife Refuge, Texas.

In the eastern portion of the reach, main sediment sources include sediment input from Sabine and Atchafalaya rivers (mostly fine-grained), sand and clay eroded from beaches and sand probably supplied from offshore deposits. Whereas sediment losses include overwash, littoral transport to the southwest, sediment trapped in fill west of the Sabine west jetty, dredged sediment from Sabine entrance channel is placed on land in confined disposal facilities.

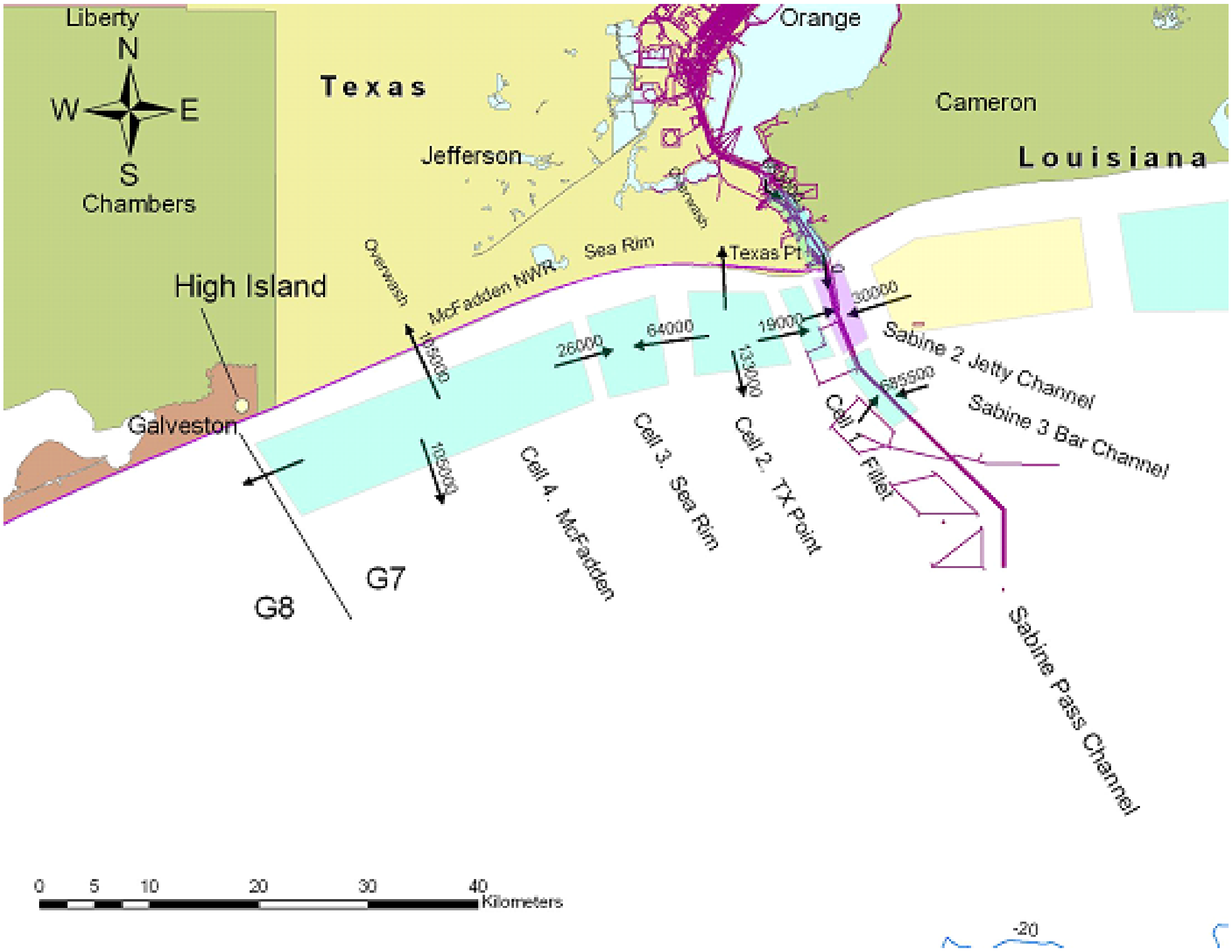

Figure 3.1-12. East Texas from Sabine Pass to High Island.

Reach G8, East Texas (High Island) to Veracruz-Llave State, Mexico

Reach G8 (East Texas, High Island to Veracruz-Llave State, Mexico) covers much of the western margin of the Gulf of Mexico, extending from High Island, TX southward to Veracruz-Llave State, Mexico. This section will only describe the Texas coast, but physical processes and sediment characteristics are generally similar within the entire 1,000-km reach.

The reach is characterized by a low gradient coastal plain generally with sand barriers that enclose extensive shallow coastal bays which are slowly infilling with muddy sediment. Active aeolian transport results in sand dunes and sediment blown into the bays and navigation channels.

The Texas barrier islands feature long stretches of almost straight beach facing the Gulf of Mexico. In contrast, the west margins facing the bays are highly irregular, with washover fans merging with soft lagoonal sediments and wetlands. A series of river mouths and inlets, which are referred to locally as passes, interrupts the Texas coastline. Most of the passes are north of Corpus Christi, and five are stabilized with jetties for deep-draft navigation projects. Both the jettied and naturally open passes are elements of the coastal sediment budget because they have trapped large amounts of sand in their flood and ebb shoals. The passes with navigation projects require periodic and in some cases, annual dredging to keep the channels at the specified depth and width. Although the tide range is low, the bays have a large surface area and therefore have a large tidal prism. As of January 2007, 16 inlets along the Texas coast were open to the Gulf of Mexico (Kraus 2007).

In east Texas, longshore transport is generally to the southwest, although a reversal occurs at Galveston Island near the south jetty (Figure 3.1-13). Further south, longshore transport is bi-directional with a net component to the south or north depending on the specific location (5 and 16). Sediment budgets are largely unavailable for the central and south Texas coast. The Texas coast is underdeveloped compared to many other states and, as a result, little information is available on sediment pathways, beach volume changes, and sediment budgets.

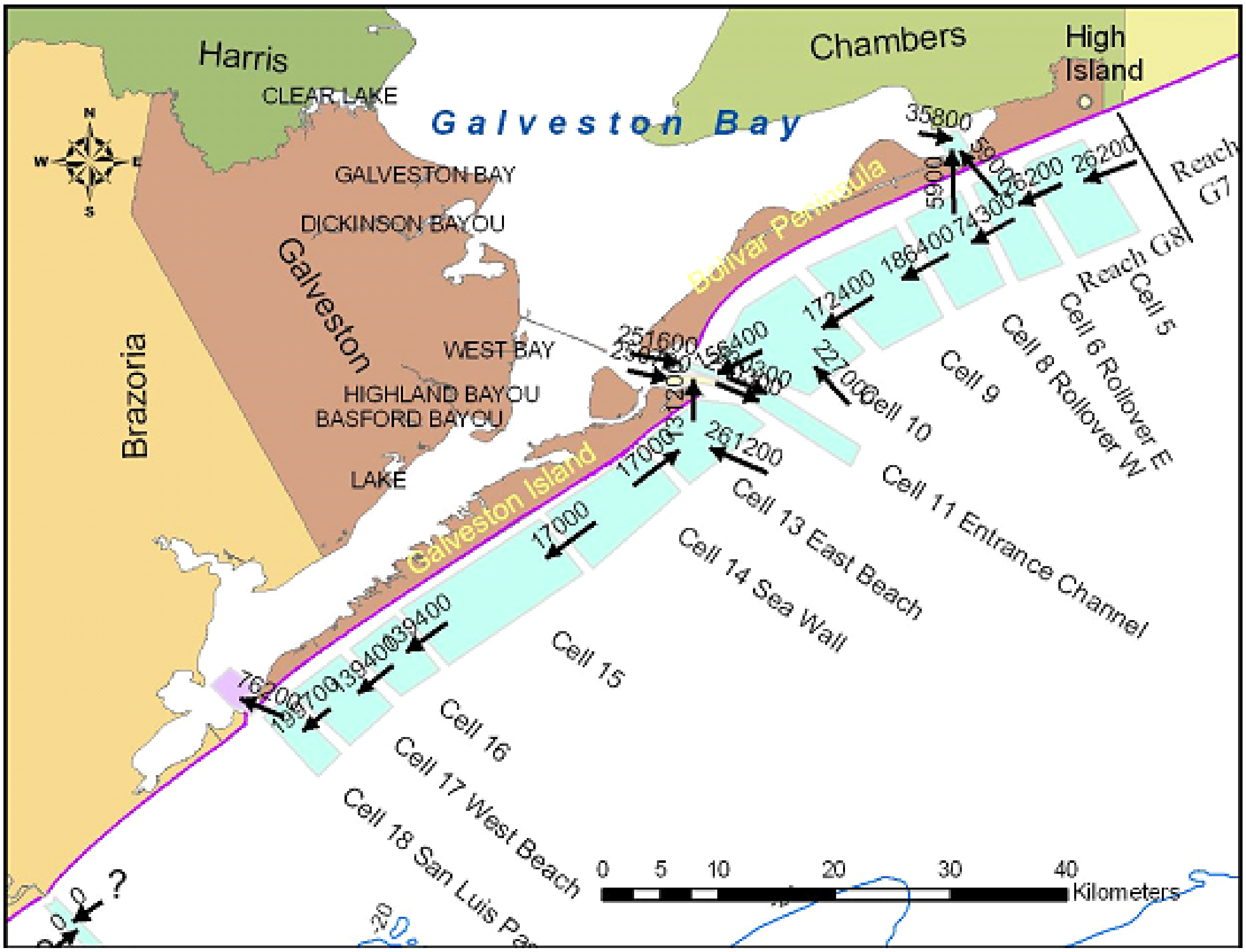

Figure 3.1-13. Sediment movement off the Bolivar Peninsula and Galveston Island, TX.

3.1.1.3 Relevance of Sediment Budgets and Future RSM Needs

The purpose of this work has been to compile available sediment budget data into a common GIS-based data management framework in order to address various sediment management issues related to restoration around the Gulf of Mexico. The regional sediment budget is comprehensive and current through year end 2008. Within the coastal management community, there is an increasing awareness of the importance of reliable sediment budgets to inform sediment management decisions. However more work is needed to provide the sediment budget its appropriate place in management decisions.

The authors are aware of several ongoing efforts that will enhance the knowledge of sediment transport dynamics in the Gulf. Rosati, Byrnes, Gravens and Girffee (2007) have developed a detailed sediment budget for the Mississippi mainland and barrier island coasts as part of the Mississippi Coastal Improvement Project Study (MsCIP). This sediment budget is a fundamental component of proposed sediment management actions in the MsCIP and should be available in final form in 2009.

The New Orleans District of USACE and the Coastal & Hydraulics Lab of ERDC have developed a conceptual regional sediment budget throughout the coastal zone and within the riverine systems of Louisiana. The ultimate goal (funding dependant) is to develop an Operational Sediment Budget for coarse- and fine-grained components in coastal Louisiana. The USGS is completing a study of the Chandeleur Islands that contains most of the components necessary to complete a detailed sediment budget (shoreline and volume change analyses, sediment transport rates derived from numerical modeling, geomorphic evolution models, etc.).

Presently, the Mobile District USACE is in the process of gathering spatial data for the development of a Regional Sediment Management (RSM) pilot project for the Mobile Bay watershed. It is not the intent of the authors to update the current Gulf of Mexico Regional Sediment Budget with these more detailed sediment budgets in the future. Rather, future editions of the GRSMMP should provide references and citations to these (and subsequent) detailed sediment budgets to inform coastal planners/managers of their availability.

It should be realized that developing and compiling the Gulf of Mexico Regional Sediment Budget is an ongoing effort on both regional scale and project level with increasing refinement to ultimately develop an operational sediment budget for the entire northern Gulf of Mexico. As various coastal areas comprise of both sand and clayey sediment our endeavor should be to develop an operational sediment budget for both coarse- and fine-grained components for the entire Northern Gulf of Mexico similar to the efforts which are being made to develop a sediment budget for Louisiana. This will entail continued effort to identify, update, and compile sediment budget data into a common GIS-based data management framework (SBAS) so as to address various sediment management issues related to restoration around the Gulf of Mexico.

It is not sufficient to only develop a Regional Sediment Budget for the coastal areas. It is also necessary to link existing and future coastal sediment budgets with riverine and estuarine sediment budgets throughout the Gulf, realizing these are all interrelated to the coastal systems and would not be complete without one another. Once developed, these sediment budgets would be very helpful in understanding effects of changes in water flow regimes on sediment budgets in riverine, estuaries and nearshore coastal sediment systems.

As stated earlier, the importance of sediment in engineering and design of a coastal restoration projects cannot be overemphasized. Unfortunately the relevance of a regional sediment budget has not been realized or totally comprehended by coastal planners and designers. The increasing awareness of the importance of reliable sediment budgets to inform sediment management decisions will build if it is recommended that states work with federal agencies to develop more detailed sediment budgets via national programs such as RSM. To achieve this goal it is recommended that RSM principles be placed into all Gulf state CZM plans through enhancement polices and/or enforceable policies. It will also be necessary to develop model policy language to be adopted by all five states for consistency.

3.1.1.4 Recommendations

- The Gulf Alliance should continue to identify, update, and compile sediment budget data into a common GIS-based data management framework in order to address various sediment management issues related to restoration around the Gulf of Mexico.
- The Gulf Alliance should work to increase awareness of the importance of reliable sediment budgets to inform sediment management decisions.
- Future work should include the development of sediment budgets for riverine and estuarine systems and the linking of these budgets with existing coastal sediment budgets.
- Operational sediment budgets should be developed for coarse- and fine-grained sediments.
- Gulf state agencies should continue to work with Federal partners to develop more detailed sediment budgets.
- Future updates to the GRSMMP should include references and citations to any coastal, estuarine, or riverine sediment budgets that have been developed in intervening years.
- Regional Sediment Management Principles should be incorporated into all Gulf state CZM plans through enhancement policies and/or enforceable policies.

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3.1.2 Offshore Sediment Resource Inventory

3.1.2.1 Introduction

The Gulf of Mexico continental shelf, extending from the Florida peninsula west to the U.S.-Mexico border, as shown in Figure 3.1-14, is a large area which has been the focus of numerous studies and surveys, especially related to oil and gas exploration. However, little attention has been focused on taking inventory and assessing offshore sediment resources. Details of the Gulf of Mexico offshore sedimentary environments are not well known because seafloor mapping and sampling by remote sensing is expensive and challenging. It is increasingly recognized, however, that base-line scientific information on seafloor sediment character and composition is needed for managing and protecting natural resources and for providing ecosystem restoration.

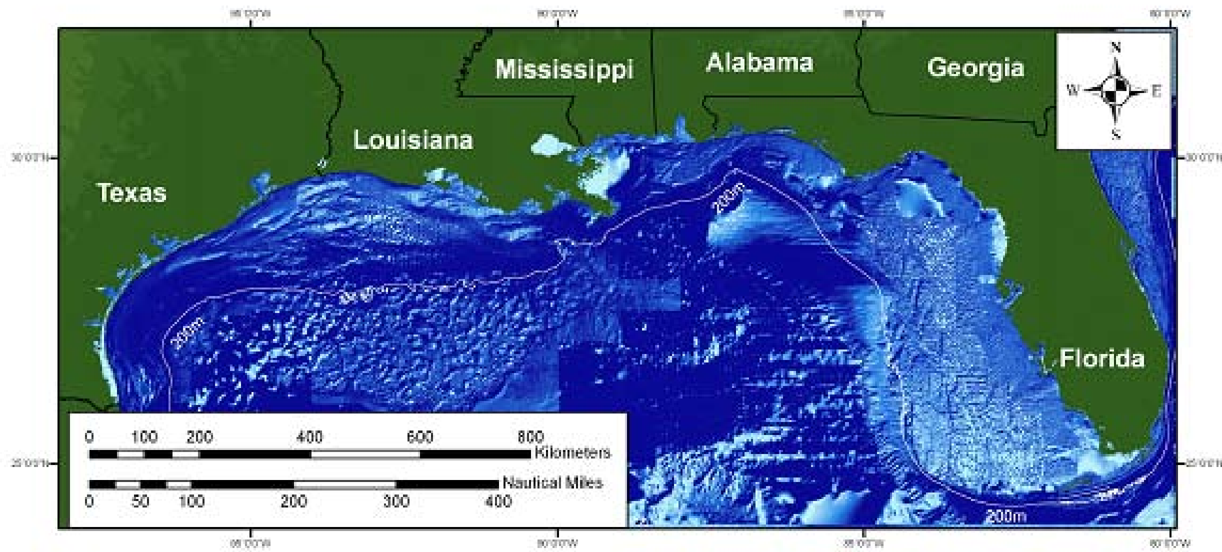

Figure 3.1-14. Location map showing the complex seafloor bathymetry of the northern Gulf of Mexico. The 200 meter contour line defines the approximate seaward limit of the continental shelf.

The largest offshore sand and gravel deposits in the U.S. are found on the Atlantic continental margin due to a geologic history that involved repeated glacial processes and sea-level fluctuations of up to 120 meters over the past several million years. These processes resulted in deposition and preservation of a variety of sand bodies, both on the surface of the seafloor and in buried paleo-stream channels. The geologic history of the Gulf of Mexico is very different. Sand of highly varying grain size, sorting, color, and composition is present throughout parts of the Gulf of Mexico offshore margin, but in limited quantities and often overlain with fine sediment overburden. The sand bodies are often located in nearshore regions and tend to be fine-grained and often mixed with muddy or organic detritus as well as carbonate shell material.

The Gulf of Mexico shelf owes its geomorphologic character and shallow sedimentary stratigraphy mostly to Quaternary sea-level fluctuations and the resulting transgressions and regressions of the coast (Williams et al., in press). The GOM is mantled mostly with sand offshore Florida, with sediments becoming progressively finer and muddier westward across the Alabama, Mississippi, Louisiana and Texas shelf regions (Figure 3.1-15). Off the coast of Alabama, North and South Perdido shoals are dominant features and may represent drowned paleo-shoreline features. In the central Gulf of Mexico, the

Mississippi River has been a dominant influence on the composition and distribution of clastic sediments. Ancestral channels of the Mississippi River have shifted position over at least the past 7,000 years since sea level rise slowed, each channel building large deltaic complexes that are fronted by sandy barrier islands. When the channels change position, the coastal barriers and abandoned deltas subside, erode and migrate landward, leaving blanket-type sand deposits and linear shoals having relief of 5 to10 meters (Williams et al., 1991; Brooks, et al., 1995).

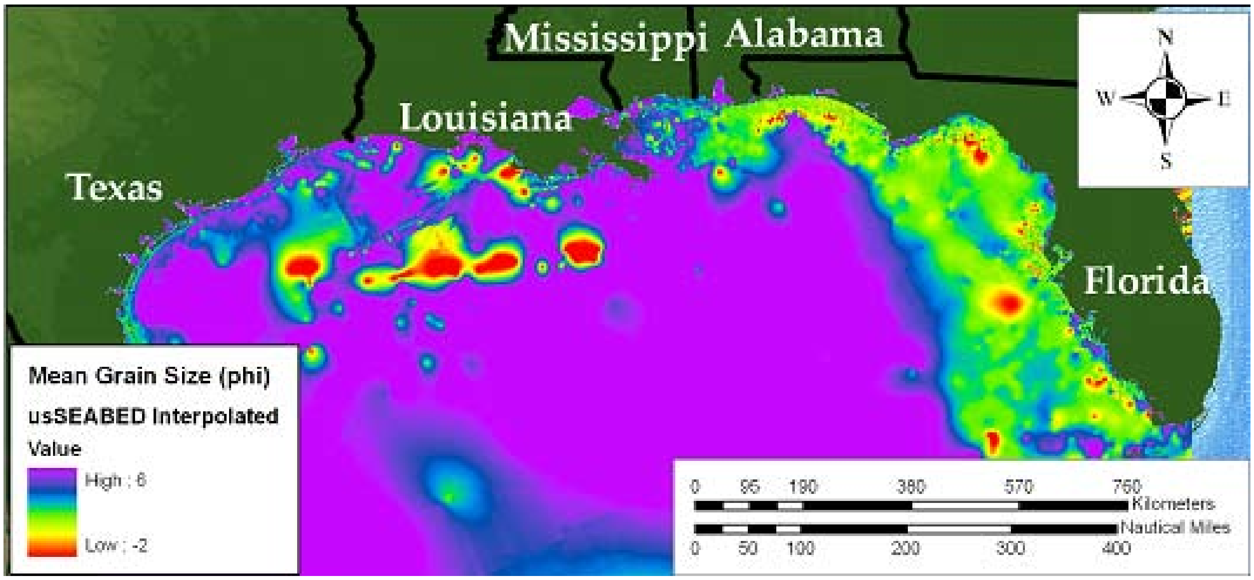

Figure 3.1-15. Map of surficial sediment mean grain size in phi units of the Gulf of Mexico based on kriging interpolation of a subset of 21,273 sediment samples contained in the usSEABED system (Buczkowski et al., 2006; Arsenault et al., in press) Note: many of the coarse-grained areas are due to high carbonate shell content.

Among those off Louisiana are the St. Bernard shoals and the associated sand sheets seaward of the Chandeleur Islands, Sandy Point shoal, Barataria shoal west of the modern delta, Ship Shoal, Outer Shoal and Trinity and Tiger shoals off the central Louisiana coast (Figure 3.1-16). Off western Louisiana and eastern Texas, Sabine Bank and Heald Bank are prominent sand bodies. In addition, three small sand bodies offshore Galveston, Texas were located during geophysical and coring surveys and described by Williams et al. (1979) as relict buried river channels and deltas containing mostly muddy fine sand. Potentially important offshore submerged paleo-deltas are observed in the old Brazos and Colorado River channels off the central Texas coast.

Mapping, characterizing, taking inventory, and assessing offshore sediment resources for the Gulf of Mexico region has not been a high priority and thus has received little attention. However, pervasive coastal erosion and wetland losses and damages from Hurricanes Katrina and Rita in 2005 and other storms over the past decade are emphasizing the need for a variety of sediments to meet many needs including beach nourishment, coastal protection, and ecosystem restoration in all of the states from Florida to Texas. In addition, needs have been expressed for large volumes of sediment for levee construction and rebuilding in New Orleans and other parts of south Louisiana. The U.S. Geological Survey (USGS), in collaboration with other federal and state natural resource agencies and academic groups, has a long history of conducting geologic and geophysical research and seafloor mapping studies in continental margin areas of the United States. These studies have included the Gulf of Mexico with a focus on the Louisiana coast and inner shelf regions for more than the past two decades (Kulp et al., 2005; Flocks et al., 2006, 2008; Kindinger et al., 2001; Penland et al., 1990; Williams, 1986; Williams, et al., 1991, 1992, 2006).

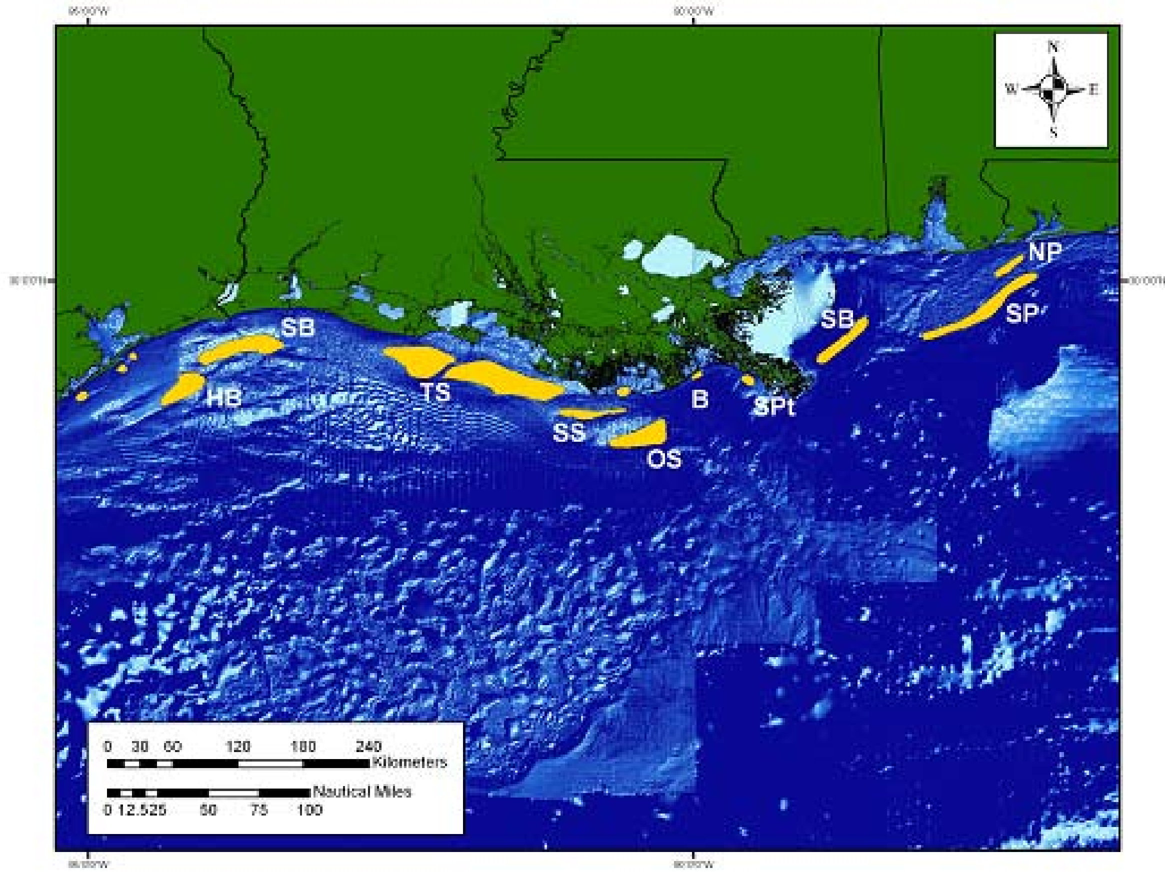

Figure 3.1-16. Map of primary sand bodies on the inner shelf from Florida to eastern Texas identified in various studies to date. Offshore Alabama, NP= North Perdido shoal, SP= South Perdido shoal. Offshore Louisiana, SB= St Bernard shoal, SPt= Sandy Point shoal, B= Barataria shoal, OS= Outer shoal, SS= Ship shoal, TS= Tiger and Trinity shoals. Offshore Texas, SB= Sabine Bank shoal, HB= Heald Bank shoal.

An ongoing USGS research study is particularly germane to the mapping and inventorying of offshore sediment. The Marine Aggregates Resources and Processes project (http://woodshole.er.usgs.gov/project-pages/aggregates/index.htm) is national in scope and focused on characterizing and assessing marine sand and gravel resources, producing geologic maps of the offshore, as well as interpreting the geologic origins of the deposits and the physical processes that maintain them. One of the main tasks of this project is the development of the usSEABED system, a national marine sediment database (http://walrus.wr.usgs.gov/usseabed/).

The USGS Data Series 146 publication by Buczkowski et al. (2006) is the first version release of the Gulf of Mexico and Caribbean (Puerto Rico and U.S. Virgin Islands) coastal and offshore sediment data from the USGS's usSEABED database. The data series contains a compilation of published and previously unpublished sediment-texture and other geologic data about the seafloor from diverse sources. The usSEABED system is an innovative database system developed to bring assorted data together in one unified searchable database that can be linked to various GIS systems for making maps. The extent of the system is illustrated by Figure 3.1-17. The dbSEABED computer program is used to process the data. The database contains information that is a scientific foundation for the USGS Marine Aggregate Resources and Processes Assessment project, but has the application to be useful to the marine science community for other studies of the Gulf of Mexico and Caribbean continental margins. Reports by Buczkowski, et al. (2006) and Williams et al. (2006) are based on the usSEABED data and are specific to the Gulf of Mexico. Version 2 of USGS Data Series 146 is in press (Arsenault et al. in press).

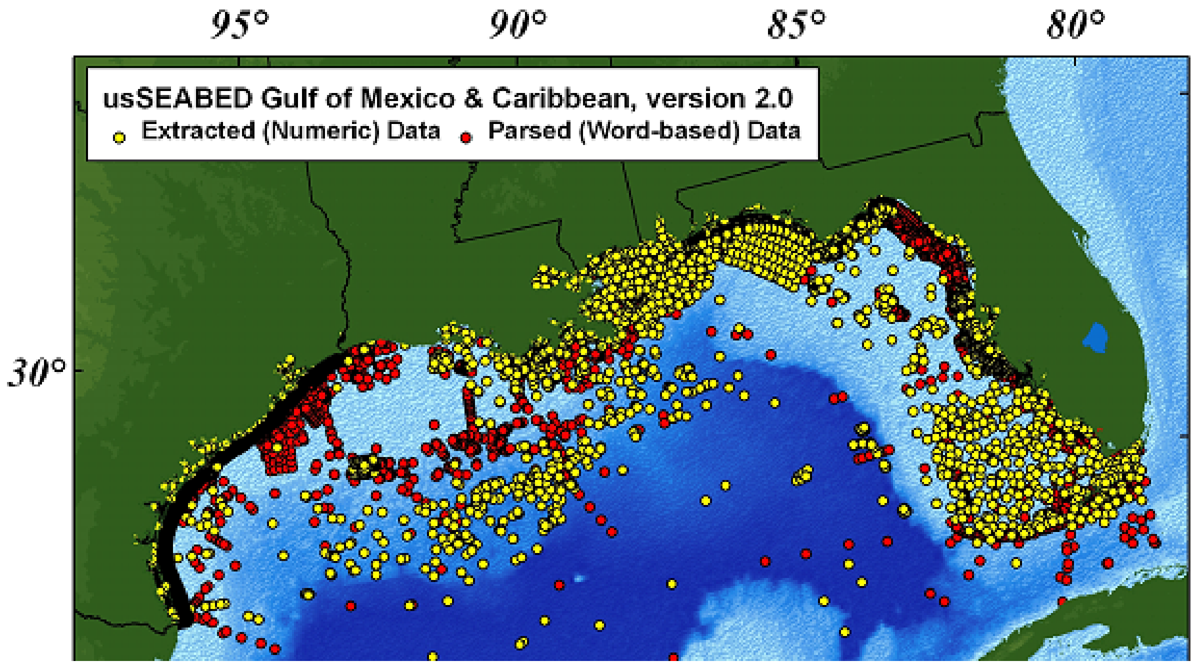

Figure 3.1-17. Map showing the extent of usSEABED sediment data available for the Gulf of Mexico region. From Arsenault et al. (in press).

Several other federal agencies have undertaken studies and work in the compilation of offshore sediment data. The U.S. Minerals Management Service (MMS) has funded sand studies in several coastal states to support sand leasing programs and assess the potential environmental effects of dredging, most recently in Mississippi, Alabama, Louisiana, and Texas (Byrnes et al., 1992a; 1992b; 1999; Morton et al., 1995). Additionally, the U.S. Army Corps of Engineers, New Orleans District, has recently undertaken the Louisiana Interagency Regional Sediment Management GIS project to link sediment inventory activities.

All of the Gulf Coast states have undertaken studies of offshore sediments to meet needs for beach nourishment sand to varying degrees. The Florida Department of Environmental Protection has a program to inventory offshore sand resources using the Reconnaissance Offshore Sand Search sediment database (Balsillie and Clark, 2001). Recent USGS studies by Flocks et al. (2008) have assessed sand offshore Mississippi and Alabama. Louisiana is in the process of identifying potential borrow areas in the lower Mississippi River, within state waters, and in Outer Continental Shelf (OCS) regions to meet project-specific needs for sand. Texas is taking the first steps to build a coastal sediment geodatabase using the data available from state and federal agencies working on a variety of navigation and coastal restoration projects. The sediment geodatabase will serve in the future as a repository site for geotechnical data collected in the bays and estuaries off the Texas coast and will provide an inventory of potential sediment resources. The studies and data compilation efforts by these states will be further described in later sections of this report.

In general, sandy sediments are most abundant offshore Florida and decrease in abundance to the west where fine-grained fluvial sediments from the Mississippi River and other river systems dominate the seafloor sediment character. Many sand shoals and sandy seafloor areas, particularly in Louisiana, are subject to multiple uses due to oil and gas platforms and pipelines, or deemed to be important benthic habitat areas for a variety of marine life and, therefore, are unavailable for use. These could be deemed "exclusionary areas."

An example is Ship Shoal offshore Louisiana, which early geologic surveys showed contains 1.75 billion cubic meters of high quality sand (Penland et al., 1990). However, much of the shoal is off limits for dredging because of oil and gas platforms and pipelines lying across the shoal or buried at shallow depths. Many such potential borrow areas might contain significant sand resources that are currently not available for dredging and removal. Further limitations on dredging sand throughout the Gulf are imposed by the inshore water "depth of closure" related to cross shore sediment transport exchange between the beach and shelf and the offshore depth limits of conventional dredging practice. These depth values are approximately -10 to 12 meters inshore and -40 meters offshore, respectively, which limits potential sand recovery to a relatively narrow coast-parallel band of the inner shelf. Dredging in waters shallower than the depth of closure is likely to disrupt littoral processes and increase beach erosion. For these reasons dredging in nearshore regions should be avoided.

3.1.2.2 Offshore marine sand bodies and sediment resource management

Inner continental shelf regions with a variety of sand bodies are often the most attractive sand sources for coastal restoration. These can be exposed at the seafloor or covered by overburden sediments of variable thickness. Schematic examples of marine sand bodies present in the Gulf of Mexico continental shelf are shown in Figure 3.5 from Williams et al. (2003). Many of these sand bodies are represented as potential borrow areas as shown in Figure 3.1-18.

An important new concept of sediment management aimed at a more holistic, long-term, sustainable form of coastal management is the Regional Sediment Management (RSM) approach, which is applicable to both wetland and shore protection in the Gulf Coast. Using the water quality Best Management Practices concept, a list of Best Sediment Management Practices (BSMP) that conserve, protect and enhance the coastal sedimentary supply should be developed. The BSMP concept should be integrated into the RSM Master Plan that can serve as a tool by anyone making decisions for watershed management planning. BSMP require a detailed understanding of sediment dynamics within a region and ways to maintain natural processes or protect and/or restore the natural dynamics. The essence of a BSMP approach (similar to RSM) is recognition that sediment is a valuable resource and that sea-level rise and storms threaten to either inundate or erode coastal sediment from beaches and wetlands or move it into sediment sinks at faster rates. Sediments in the coastal zone need to be conserved for the possibility of improved sustainability of coastal systems in adapting to climate change.

Responses needed to address future sea-level rise and storms may be obtained by understanding sediment sources, sediment movement, and sediment sinks; the ways in which we have altered the natural flow or stability of sediment; and the ways in which we can mitigate our sediment system interruptions or work with natural dynamics to sustain coastal systems. Again, governmental entities should understand that coastal sediments are a limited and valuable commodity and need to be managed as a natural resource.

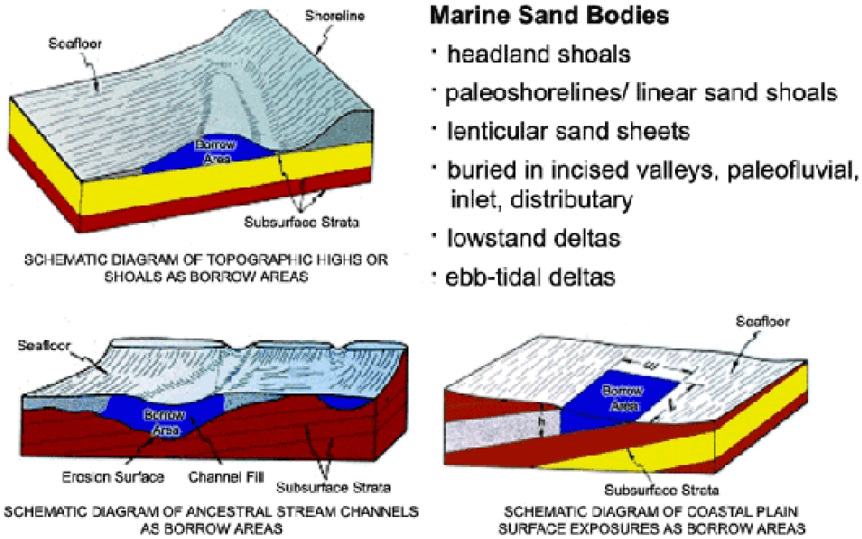

Figure 3.1-18. Marine sand bodies, having diverse geologic origins, are buried and exposed on continental shelves and often have been greatly modified by marine processes associated with sea-level rise and marine transgression over the past 20,000 years. Nearshore marine sand bodies of the types shown offer the best potential sources for high quality sand (From Williams et al., 2003).Arsenault et al. (in press).

3.1.2.3 Environmental issues of offshore dredging

Environmental concerns have been a major deterrent to implementation of marine mining in the United States, even when suitable deposits are present and where the economic factors are favorable. A number of the environmental studies carried out show that the impact of dredging depends largely on the local geologic and biologic conditions. Dredging effects can be most detrimental where proportions of fine-grained sediment are high and where the dredging is close to nonmobile benthic communities because mud can reduce light transmission and smother organisms.

Dredging can also affect the environment by exposing a different substrate or by causing substantial changes in the seabed topography from removal of large volumes of sand. Dredging in areas with mobile fauna produces no apparent long-term ill effects, and in cases where sediment elutriation releases organics into the water column, the effects may actually be beneficial. Most long-term environmental damages can be avoided by careful planning prior to dredging, by the use of proper dredging equipment, and by close monitoring of the dredge site and adjacent areas during the operation.

Dredging too close to the shoreline, inshore of the depth of closure, is likely to cause sand to be removed from the active littoral system and alter wave and current patterns. These changes can eventually increase beach erosion and threaten the stability of the dune-beach system. The volume of sand along the coast and the morphology of nearshore areas are influenced by wave and current conditions. If sand is dredged too close to shore, the shore profile will shift as sand moves seaward from the shore to fill the dredge holes. These problems can be avoided if dredging is limited to relict sand bodies that are no longer active and connected to nearshore transport processes, or to areas where natural sediment input is great enough to compensate for losses due to dredging. Adhering to these safeguards may require dredging farther offshore and moving sediments greater distances, which are likely to increase project costs. However, the alternative of dredging close to the coast is likely to accelerate coastal erosion, flooding and property damage and may ultimately be far more costly. Regardless of the location, the sand borrow sites should be monitored to determine their fate over time following dredging.

3.1.2.4 Florida offshore sediment resources

Florida's beach and dune system acts as the first line of defense against storms. Beach restoration and nourishment can prepare the coastline to better withstand the forces of hurricanes while providing recreational and economic benefits, at least for the immediate future. The Florida Department of Environmental Protection (DEP) recently completed its statewide, comprehensive online tool for identifying suitable sand sources from Florida's coastal waters, making this database the first of its kind for any state (http://www.dep.state.fl.us/secretary/news/2008/02/0211_01.htm). The database includes comprehensive information about offshore sediment and geological features and supports the design and construction of beach restoration and nourishment projects (Figure 3.1-19).

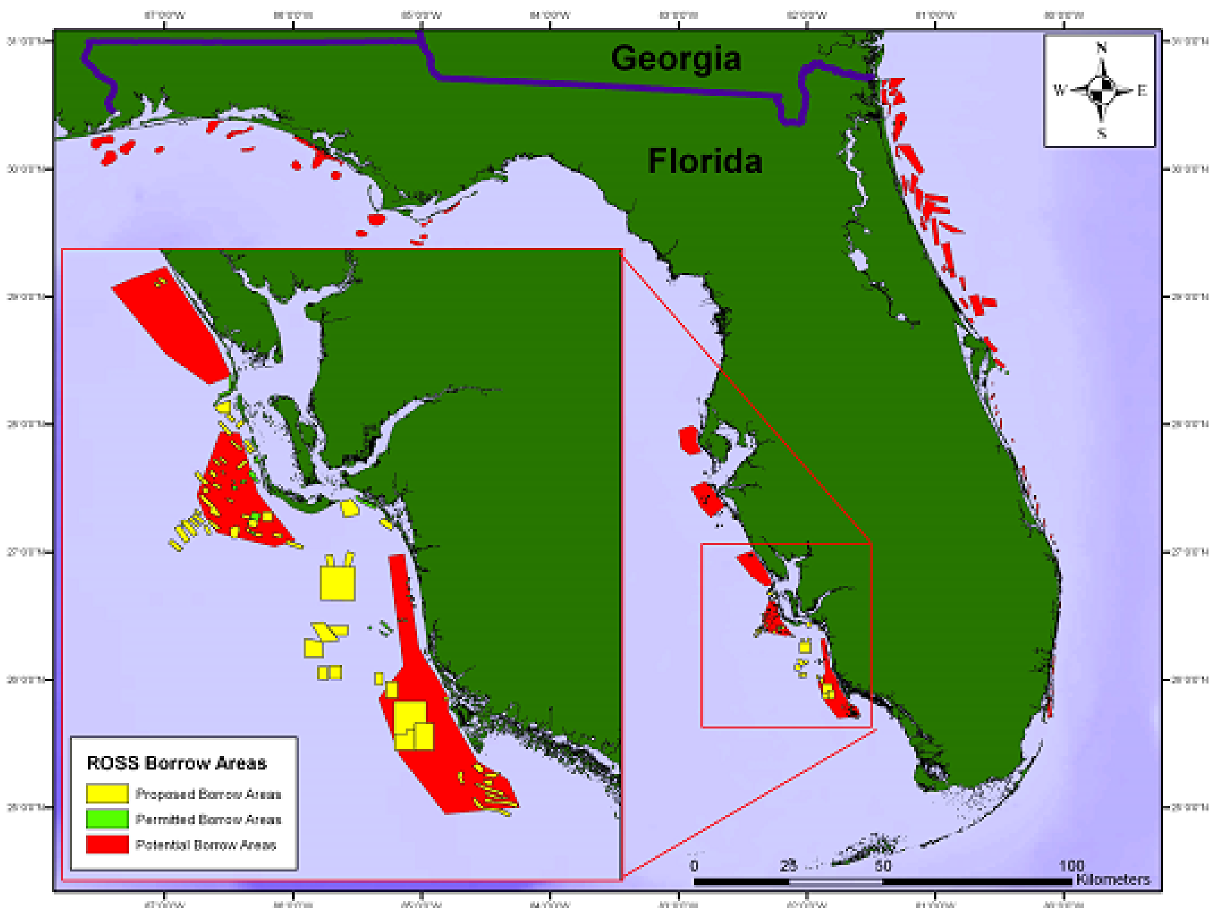

Figure 3.1-19. Map of three classes of sand borrow areas offshore Florida based on the ROSS sediment database system, developed by the Florida Department of Environmental Protection.

As stated earlier, the Reconnaissance Offshore Sand Search (ROSS) database is publicly available on the Internet and a major feature. ROSS facilitates better sand management practices and is a comprehensive tool for coastal engineers, project managers, and regulators as they design and construct beach restoration and nourishment projects. The database is intended to reduce the costs of locating sufficient quantities of quality sand, and assist DEP in regional sand management for the protection of Florida's coastal communities and habitats. To date, more than 300 kilometers of beaches have been restored and maintained through the Florida DEP program.

3.1.2.5 Alabama and Mississippi offshore sediment resources

The Mississippi-Alabama shelf is bounded to the west by the Mississippi River delta, to the north by the barrier-island systems of the Mississippi-Alabama shoreline, and to the east by the Desoto Submarine Canyon (Flocks et al., in press). This portion of the northern Gulf of Mexico has been described as a slowly subsiding, passive continental margin (Sydow and Roberts, 1994). Presently, sediment processes on the shelf are a function of storms and sediment transport processes; however, in the geologic past, the shelf has been the focus of numerous delta cycles. Major episodes of deposition and erosion on the shelf have occurred in response to oscillations in sea level.

The USGS Field Center in St. Petersburg, FL, houses data from five major geophysical surveys and a collection of sediment-core description sheets collected from federal waters off Mississippi and Alabama. Within federal waters off Mississippi, there is a conservative estimate of 2,500 line-kilometers of geophysical data and 70 vibracore description sheets. The geophysical data collected between 1981 and 1992 were acquired using single-channel boomer and sparker systems, and data quality is generally very good. Subsurface geology 40 meters below the seafloor is visible, and surface features such as shoals, sand sheets, and scarps can be identified. Surface shoals, such as the St. Bernard Shoals, may contain sand resources suitable for large-scale shoreline-renourishment efforts along the Louisiana and Mississippi barrier-island shoreline.

Numerous features associated with the last sea-level cycle on the shelf can be identified in seismic profiles. Features such as buried distributary channels and shoals may contain material suitable for sand resources. Seismic profiling is a remote-sensing technique that cannot be used to determine sediment texture without subsequent validation using invasive sampling. Typically, seismic surveys are used to determine acoustic characteristics of the substrate that have been identified in previous surveys to correspond with known geologic structures. Using this prior knowledge, interpretations of the profiles are used to develop a sediment-coring strategy to correlate the substrate physically with the seismic profiles. Once this validation feedback has been acquired, the seismic profiles can then be used to develop a spatial distribution of the physical features identified in the sediment cores.

Through the interpretation of the seismic data available in this report, several areas of interest have been identified across the shelf that likely contain material suitable for shoreline-restoration projects. Although sediment coring is required to ground truth the interpretations, these areas are likely targets because they combine sandy surface expressions such as shoals with buried sand deposits such as distributary channels.

Fluvial systems have been mapped in Mississippi Sound, trending north-south from the mainland to Dauphin and Petit Bois islands (Greene et al., 2004). Captured by the Pascagoula fluvial system, Pleistocene/Holocene extensions of these systems incised channels onto the Mississippi-Alabama shelf at the end of the last sea-level lowstand (Kindinger, 1988; Kindinger et al., 1994). West- to east-trending seismic profiles off Petit Bois Island image the offshore extension of this fluvial system. High-angle reflectors incise adjacent parallel reflectors, indicative of channel fill. These deposits are expected to contain fine to medium silty sand, and are most likely similar to material found on the shoreface of the Mississippi barrier islands. Sediment cores collected within the Sound identified bayhead-delta deposits within the fluvial system (Greene et al., 2004), indicating a laterally fining-shoreward sequence.

The channel patterns are overlain by parallel reflectors with positive surface expression from the otherwise flat seafloor. The relief and laterally thinning reflectors are indicative of sandy shoals, seen throughout the mid-shelf and coastline. Reworking of the fluvial deposits during a marine transgression, longshore transport of coarse-grained material from the Mobile Bay ebb-tidal delta, and inlet dynamics at Petit Bois Pass contribute to the accumulation of shelly sands into shoals. These shoals likely contain the same material as is found on the barrier island shorelines, perhaps with somewhat higher shell content.

Mobile Bay is the drowned remnant of a large fluvial valley that extended from the modern bayhead delta to more than 100 km south across the Mississippi–Alabama shelf, where it formed shelf-edge deltas at the end of the last glacial maximum. Subsequent sea-level rise flooded the fluvial deposits that filled the valley and produced an estuarine/bayhead-delta system that retreated upstream to its present position (Kindinger et al., 1994). The buried valley contains a sequence of fluvial sands overlain by estuarine and bayhead sandy muds.

Throughout the Holocene, barrier islands similar to those found along the modern coastline formed at the bay mouth and were subsequently reworked or drowned as rapid sea-level rise across the flat shelf overran the developing system. Eroded material was reworked by currents to produce the extensive sand sheet and shoals found across the shelf. Valley deposits extend 5 to10 meters below the seafloor and are mapped to 20 meters elsewhere in the study area where thicker bay sequences are reported (Greene et al., 2004). Because of the facies architecture within the flooded valley system, sediments can range from stiff clay to coarse sands. These deposits are overlain by massive fine sand and shells within the shoal deposits (McBride et al., 1996).

Formation of the St. Bernard Delta ceased approximately 2,000 years ago (Kindinger, 1988). Distributary channels extend across most of the western shelf. Following abandonment, subsidence and sea-level rise resulted in the destruction of the delta front, reworking and winnowing sands into sand ridges that produced the St. Bernard Shoals. The shoals lie 30 kilometers off the Chandeleur Islands in 20 meters of water and are composed of a series of northward-oriented ridges each about 5 to 6 kilometers long by 1 kilometer wide (Penland et al., 1989). Samples and cores collected from the shoals consist of 90 to 100% fine-grained sands up to 4 meters thick. The shoals trend oblique to the dominant wave direction and are believed to be migrating northward (Penland et al., 1989). Buried distributary channels associated with the delta front trend west to east in a dendritic pattern extending to the shoals from the southern Chandeleur Islands. Recent studies around the Chandeleur Islands indicate these channels contain up to 75% fine-grained sand (Flocks et al., in press).

A high-resolution grid of seismic profiles was obtained along the western side of the Chandeleur Islands in 1981. The profiles show the thick prodelta sequence of the St. Bernard Delta overlain by shoal deposits. Incised within the prodelta muds are discrete channel packages that contain higher sand content. In sediment cores, the channel deposits contain coarsening-upward, massive to cross-bedded sands with high organics. Coarsening continues into the shoal deposits of massive fine sands with shell fragments and shell-hash layers. A major new USGS report based on a study of the Chandeleur Island region is in review, titled “Sand Resources, Regional Geology, and Coastal Processes of the Chandeleur Island Coastal System – an Evaluation of the Resilience of the Breton National Wildlife Refuge” and authored by USGS and University of New Orleans scientists.

3.1.2.6 Louisiana offshore sediment resources

As discussed in Williams et al. (in press) and above, it is well documented that the sedimentary geology and geomorphology of the Mississippi River delta plain are associated with numerous river diversion and delta switching events over the last 7,000 years. The delta-switching process, where the main distributary location of the river is gradually abandoned and switches to a more hydraulically efficient course, is responsible for the fluvial geomorphology of Louisiana's coastal zone. Aspects of these processes related to offshore sand are briefly summarized by Penland et al. (1988), and Roberts et al. (1994). Subaerial exposure of the continental shelf during the late Pleistocene sea-level low stand facilitated deep fluvial entrenchment when valleys cut 100 meters below the plain surface (Fisk, 1944). Valley landscapes across the present day shelf were common in the Pleistocene and their sediments are now found underwater. Eighteen delta lobes within six major delta complexes comprise the Holocene deltaic plain (Coleman et al., 1998). The most recently abandoned lobes are the Late Lafourche and Plaquemines, both of which exhibit erosional headlands with flanking spits and barrier islands. In this geological setting, large volumes of sand (for beaches and dunes) and mixed sediments (for marshes) required for barrier island restoration can mainly be obtained from offshore sources.

The success of Louisiana restoration effort depends on locating sufficient volumes of sand that are suitable for placement on beaches, building dunes, and creating marshes. Thus location of potential borrow areas with suitable sand that is extractable at acceptable costs is crucial to the success of the overall projects (Finkl and Khalil, 2005). Exploring the geometries of sediment bodies and delta facies architecture in the Louisiana Coastal Plain, Fisk et al. (1954) identified two main types of deltaic systems: 1) those developed on the inner shelf in shallow water (inner shelf and bay-head deltas) and 2) those developed in deeper water on the middle to outer shelf.

Louisiana has a long history of exploration for offshore sand resources. During 1980s, the Louisiana Geological Survey, in collaboration with the U.S. Geological Survey, began investigating the distribution and character of sand-rich sediment within the shallow stratigraphy (approximately top 15 meters) of the region. A regional offshore geological /geophysical investigation between Marsh Island and Sandy Point was undertaken by Suter et al. (1991). Across this area, a total of 55 nearshore, sand-rich deposits were identified within the modern and abandoned deltaic plain. This was followed by another USGS study by Kindinger et al. (2001). Both of these investigations (Suter et al., 1991; Kindinger et al., 2001) were reconnaissance in nature. Large areas were covered during these investigations; thousands of kilometers of high-resolution seismic reflection data and hundreds of vibracores were collected. They discovered potential sand sources in a range of depositional systems that include spit platforms, delta sheet sands, ebb and flood-tidal deltas, distributary mouth bars, distributary channel fills, and inner shelf shoals. The initial reserve estimates on the basis of these regional geophysical surveys indicated hundreds of millions of cubic meters of sand. These estimates were substantially reduced when detailed surveys were undertaken (CP&E, 2003). These nearshore sand deposits (Figure 3.1-20) generally contain varying amounts of sand (up to a maximum of 3 to 4 million cubic meters) and are suitable for individual projects (Khalil and Finkl, in press).

Inner-shelf shoal deposits, such as Sabine Banks (eastern portion), Tiger and Trinity Shoals, Ship Shoal, and St. Bernard Shoals contain large volumes of sand without muddy overburden. The initial reconnaissance investigation of these shoals provided reserve estimates in billions of cubic meters. However, more detailed studies of these large bodies of sand indicate the "dredge-able" quantity of sand is limited by subsea infrastructures placed by the oil and gas industries, environmental/cultural concerns about dredging, and variability of deposits in the shoals.

Another limiting factor in dredging sand is the issue of depth of closure. A review of recent Louisiana projects was conducted to identify the published depth of closure values in similar geologic settings experiencing similar coastal processes. It was observed that the depth of closure values in Louisiana ranges from 4 feet /1.2 m NAVD 88 in Holly Beach (Mann & Thompson, 2003) to 11-12 feet/3.6 m

NAVD 88 in Barataria Basin Barrier Islands (SJB and CEC, 2005; CEC and SJB, 2006; and SJB and CEC, 2009). USACE (2004) computed the depth of closure equal to -12 feet NAVD88 on Grand Isle. However, to be safe, borrow areas are generally not dredged within 12-15 feet NAVD 88 isobaths.

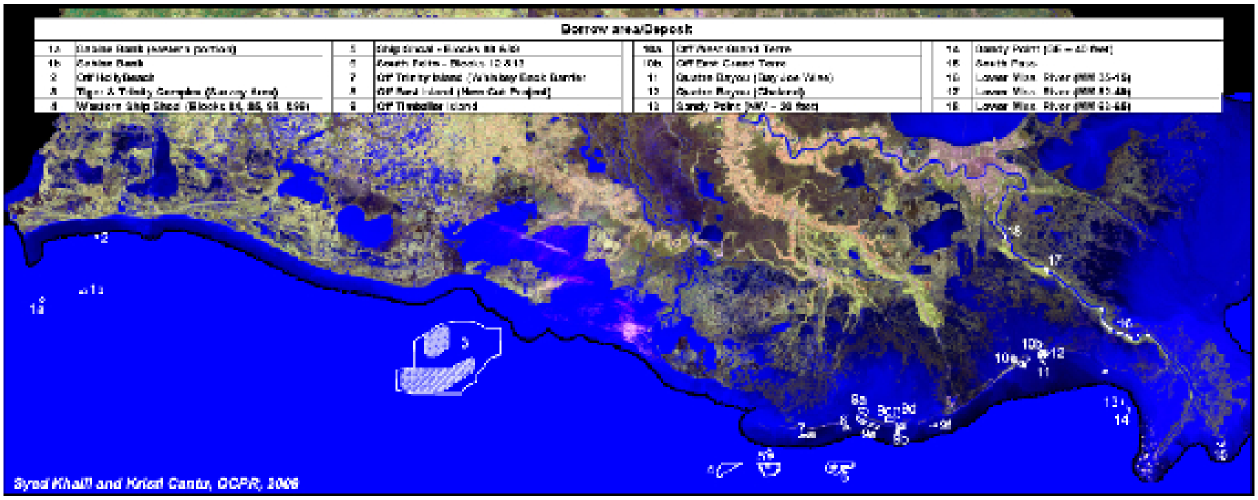

Figure 3.1-20. Map compiled by Louisiana Department of Nature Resources of various sand deposits off coastal Louisiana.

On the basis of a recent study (Nairn et. al., 2004), the MMS established a range of buffer zones (depending upon the sediment characteristics) around oil infrastructures and other magnetic anomalies within the Ship Shoal and other sand resource areas in the Offshore Continental Shelf to ensure quality of borrow sediments and safety of dredging operations. These buffer zones, often up to 300 meters wide can automatically deselect potential sand sources from the dredging arena (Finkl and Khalil, 2005). Cultural resource assessments further reduce the size of potential borrow areas if artifacts or hazards are located from magnetometer and seismic reflection profiling studies (Finkl and Khalil, 2005). Though these deposits are at a distance from various barrier islands or other project areas, they can cater to needs of large scale restoration efforts undertaken in the post-Hurricane Katrina/Rita/Ike/Gustav era.

In the western part of Louisiana only a small eastern portion of Sabine Bank falls (Figure 3-20) in Louisiana. The Office of Coastal Protection and Restoration (OCPR) (formerly Louisiana Department of Natural Resources) analyzed the data collected by Morton and Gibeaut (1995). On the basis of this reconnaissance level investigation it is estimated that this portion contains about 148 million cubic meters of sand (Morton and Gibeaut, 1995; CPE, 2001).

Trinity Shoal is a late Holocene shoal located about 40 kilometers offshore of Chenier Au Tigre and Marsh Island and is a lunate sand body 30 kilometers long and 5 to 10 kilometers wide (Suter et al., 1985). Recently this complex was revisited for a current evaluation of sand available for dredging ("sand-dredgeable"). During this investigation by MMS-OCPR-LSU, about 1100 line kilometers of geophysical data including high resolution bathymetric, seismic, side scan sonar, and magnetic data were collected followed by 46 vibracores of the Tiger and Trinity shoal complex. Presently, these data are being analyzed to provide an estimated reserve of sand available for dredging, and initial results of the ongoing offshore sand exploration indicate the "sand-dredgeable" volumes may be much less than the potential sand. The area shown in the Figure 3.7 (no. 3) is the plan view of the area covered during the survey. The hatched portion within the boundary represents the potential sand deposit.

Penland et al. (1989) estimated that the total sand volume comprising Ship Shoal is approximately 1.75 billion cubic meters. Recent surveys indicate that total dredgeable sand from this large body of sand is restricted to only three areas, Ship Shoal Blocks 88 and 89, South Pelto Blocks 12 and 13, and western Ship Shoal Blocks 84, 85, 98, & 99 (see Figure 3-20, deposits 4, 5, & 6). During 2003, detailed geotechnical investigations were conducted to more accurately evaluate sand volumes that are potentially available for coastal restoration in Ship Shoal Blocks 88 and 89 and South Pelto Blocks 12 and 13 (CEI, 2003a and 2003b). In both areas of Ship Shoal Blocks 88 and 89 and in South Pelto Blocks 12 and 13, analyses of over 650 line kilometers of geophysical data (on 50 meter spacing) and geotechnical exploration identified primarily clean sand (D50 grain size 0.15 to 0.2 mm) with less than 5% silt in upper stratigraphic units that ranged in thickness from approximately 3 to 6 meters over an area of about 26 sq. kilometers.

In the South Pelto Blocks the combined volumes of sand from three closely spaced potential borrows amounted to approximately 21.6 million cubic meters (Khalil et al., 2007 and Finkl et al., 2005). In Ship Shoal Blocks 88 and 89, a reserve of 13.2 million cubic meters was estimated on the basis of 35 vibracores within an area of approximate 3.3 sq. kilometers in the middle to southern half of Block 88. Most recently, during 2006-2007, OCPR and the LSU Coastal Studies Institute for the first time conducted a reconnaissance geophysical survey in the western portion of Ship Shoal (Blocks 85, 86, 98, and 99). Based on this reconnaissance geophysical survey, it was estimated that approximately 94.8 million cubic meters is available to a depth of approximately 3 meters. A report on these recent surveys is in preparation. Therefore it is estimated that the total “sand-dredgeable” from the entire Ship Shoal Complex may be less than 10% of 1.75 billion cubic meters which had been previously estimated (Khalil and Finkl, in press).

The St. Bernard Shoal complex on the eastern side of Louisiana, south of the Chandeleur Islands, is being surveyed by the USGS and the University of New Orleans using geophysics and cores. Reports on results are in review and will be published by the USGS.

In order to fulfill sand requirements for Louisiana, potential sand sources/borrow areas were and are being identified in mainly nearshore/offshore state waters and in the Lower Mississippi River in addition to the aforementioned deposits in the Outer Continental Shelf. The thrust is to find sand deposits nearer to projects and avoid these shoal deposits as much as possible because of the longer distance involved (hence higher cost) and also the time-intensive process to obtain leases for dredging sand from the Outer Continental Shelf. Various sand deposits were explored in state waters for specific projects especially barrier islands during 2003-2008. These are mostly buried paleo-channel deposits (2, 7, 9, 10 b, 11, 12, 13, and 14 in Figure 3.1-20) where sand could only be accessed after the removal of overburden of generally mud-sand admixed sediment. There are some ebb-tidal deltas (8 and 10a in Figure3.1-20) or fluvial deposits in the Lower Mississippi River (16, 17, and 18 in Figure 3.1-20).

While conducting exploration for sand in the deltaic setting it was observed that there are no universal or comprehensive guidelines for a systematic and cost-effective way to conduct an offshore sand search. Finkl and Khalil (2005) suggested that uncontrolled or free-ranging offshore sand searches that more or less indiscriminately cover broad areas of seafloor are costly enterprises that often produce few useful results. Experience has shown that best results are obtained from the judicious deployment of survey resources and careful selection of instrumentation within a procedural strategy that defines protocols for preliminary site selection, field survey, and data reduction. A Delta Sand Search Model (DSSM) was developed (Khalil, 2004, 2008; Finkl and Khalil, 2005) to meet the needs for sand search protocols in coastal Louisiana, where sand deposits are associated with the development of delta lobes of the Mississippi River.

To organize and access enormous amount of geological, geophysical, and geotechnical data that are available and are being collected for the sand searches in the offshore/nearshore Gulf of Mexico and

Mississippi River, the LouisianA SAnd Resource Database (LASARD) program was established. The LASARD program aims to develop a spatial database of coastal and offshore geological, environmental, and associated data relevant to sand resources that is easily accessible by state researchers and decision-makers as well as the general public (Khalil et. al., 2005). This database is on an engineering scale and is designed to be stored in GIS format. It is accessible through the Internet for internal use in the OCPR/LDNR. It may be made available for the general public in the future.

In the post-Hurricane Katrina-Rita-Gustav-Ike era, the entire approach of coastal restoration in Louisiana has changed. A coastal protection component has been added and integrated with restoration and has acquired a kind of urgency. Obviously, the need for all types of sediment (sand, mixed-sediment, clay) has exponentially increased. Sand plays a significant role because it dictates both longevity and the cost of the project. Recognizing the importance of sand in restoration and protection, a Louisiana Sand Management Plan (LASAMP) has been proposed (Khalil and Finkl, in press) which would form an integral part of RSM.

It is expected that a better and effective RSM plan has the potential to significantly reduce the cost. Under the aegis of RSM, a LASAMP would aid in a systematic approach to restoration in Louisiana by viewing the projects regionally as opposed to individually and taking advantage of previously unidentified synergistic effects (Khalil and Finkl, in press). It would also set up priorities to ensure proper and justified (scientifically and economically) distribution of sedimentary resources to different projects. An essential component of this proposed protocol is the implementation of a plan for sharing sand resources, part of a rational management scheme for utilizing sand resources to avoid conflicts of interest and a procedure to arbitrate conflicts (e.g., Finkl and Kreumpel, 2005). Both LASARD and LASAMP would form an important component of the Sediment Inventory and Allocation Program of Louisiana's Comprehensive Master Plan for a Sustainable Coast which has been developed to meet the challenge of restoring and protecting Louisiana's fast deteriorating coastal plain.

3.1.2.7 Texas Offshore Sediment Resources

Texas has developed a new approach in the search for sediments available for coastal restoration projects. The Texas coast is a mud-dominated environment. Limited sand is available onshore and offshore, however sandy sediments are needed for coastal projects, mainly dune-beach and marsh-wetland restoration projects. The search for sediments includes examining stockpiled dredged material in Corps of Engineers placement areas along the Gulf Intercoastal Waterway. The state is also looking for sediments trapped in coastal engineering structures, such as jetties and breakwaters to recover the sediments trapped and return them to the natural system. Implementing new sediment management practices is changing the way Texas considers the use of coastal sediments.

Special interest has been focused on paleo-channels associated with the Sabine, Trinity, Brazos Colorado, and Grande Rivers. The paleo-fluvial incised channels and paleo deltas located offshore the Texas coast represent a promising potential source of sediments for restoration projects. These channels and deltas may be covered by overburden deposits, and may have the limitation of the depth of closure and dredging issues mentioned above. For the paleo-Sabine and Trinity Rivers, important sources of sand have been identified in the Deweyville Pleistocene Terrace. Unknown amounts of sand may be present in the incised valleys, but there is minimum data on the general content of these valleys. For the Brazos and Colorado Rivers, data on the offshore-submerged deltas developed over the last million years show promising deposits of sand.

In general, the large banks including the Sabine, Heald, Shepard, and Thomas submerged banks, which were associated with ancient barrier islands and shorelines, may contain sizable volumes of sand, with the restrictions that many areas along these banks are considered habitat for important marine species. Early indications from USGS coring surveys of Heald Bank in June 2009 however are that shell lag mantles the seafloor and sand is limited (James Flocks, pers.com.). These banks are thought to be associated with the late Quaternary evolution of the Sabine and Trinity river systems. Wellner and Anderson (2003) have reported on assessment results for the central Texas coast. Recently, small banks have been identified by Texas about 15 kilometers north of the town of South Padre Island, with significant amounts of sand. These banks represent examples of other shallow banks located along the shorelines of the Gulf of Mexico away from fluvial sources, which may also be considered for coastal restoration projects.

The general trend in fluvial-deltaic wetlands along the Texas coast is one in which vegetated wetlands are being replaced by water and barren flats. Sediment is needed to help these subsiding/eroding marsh systems keep pace with relative sea level rise. However, this is not occurring because of a number of factors, including: 1) those processes that result in a rise in water level relative to the land's surface, including man-induced subsidence, natural regional compactional subsidence, and global sea-level rise; and 2) those processes that tend to reduce sediment input into marshes, including a) reservoir development in river drainage basins, which reduces river sediment loads, and b) channelization and disposal of spoil on natural levees, which can alter water circulation patterns and prevent overbank flooding.

Many questions remain with regard to fluvial-deltaic sedimentation and the processes that affect it, such as river sediment load and subsidence. Establishment and operation of stream-discharge and sediment-load (including bed load) measuring stations on many streams at locations closer to the coast would allow a better estimation of the quantities of fluvial sediments delivered to the bay-estuary-lagoon systems.

3.1.2.8 Relevance of Sediment Inventories to the GRSMMP

Knowledge of sediment resources through the Gulf of Mexico provides a comprehensive tool for engineers, project managers, planners, and regulators for planning and designing restoration and conservation efforts that encourage better sand management practices. Compiling sediment resource databases will help reduce the costs of locating sufficient quantities of quality sand when implementing regional sand management for the protection of valuable ecological resources through the Gulf. Having an up-to-date tracking system of available offshore and coastal sediment sources will enable projects to move forward in an expeditious manner. With the availability of this valuable information, state and local resource managers will be better equipped to make improved management decisions regarding the ecological restoration and conservation activities.

3.1.2.9 Recommendations

Although much scientific attention and study has been devoted to the Gulf of Mexico over the past 50 years and the state of scientific understanding of the geologic character, oceanography, and biologic systems is generally fair, much of the data and scientific information, potentially useful to geologic mapping of the seafloor and assessing and characterizing marine sediments, have been collected by the energy industry and some state and federal agencies and are not readily available via the Internet to the public. A concerted effort needs to be made to get these data, publications, and results on publicly accessible Internet Web sites.

While a great deal of high resolution geophysical data, side-scan sonar, multibeam bathymetric data and sediment cores, borings and grab sediment samples have been collected for various purposes, these same data sets could serve greater purpose in a federal-state program to serve the specific needs for assessing marine sediments. Such a program is needed but to date has not been under taken due to limited resources and lack of coordination and commitment between federal and state agencies. Repositories should be established in each state agencies and appropriate federal agencies (i.e. USGS) in order to develop such databases to meet immediate and future needs.

There is an increasing need for very large quantities (hundreds of millions of cubic meters) of high quality marine sediments for use as fill in coastal protection and wetlands restoration projects throughout the Gulf. This need became more urgent following the effects of a series of recent Hurricanes: Katrina, Rita (2005) and Ike (2008) on the Mississippi, Louisiana, and Texas coastal regions. High-quality sand is required for beach nourishment and shoreline restoration, muddy sediments (mixtures of silt and clay) for wetlands restoration, and clay for levee construction.

Observations show that warming of the climate is unequivocal and that the warming and wide-spread environmental changes are primarily the result of the rapid increase in greenhouse gas emissions from fossil fuel burning, with additional contributions from forest clearing and agricultural activities since the late 19^{th} century. One significant climate-change impact for the entire Gulf of Mexico region is increased sea-level rise leading to increased coastal erosion and wetland loss. The need for sediments is substantial now and is likely to increase significantly in future decades as sea-level rise accelerates 1 meter or more over current rates by the year 2100 and storms increase as a result of global climate change. While muddy sediments are most abundant throughout the Gulf of Mexico, sand is mostly limited to shoal features and buried relict paleo-stream channels. Clay sediments are uncommon. Current knowledge of the location, character, and volumes of marine sediments is limited for planning, but current understanding suggests that suitable sediment resources may not be sufficient for sustainable coastal protection with the anticipated rates of sea-level rise and storm activity for this century and into the future. Additional systematic surveys and assessments should be done to inventory the location and character of offshore sediments.

Many seafloor areas containing potential sand bodies are subject to multiple uses or contain “exclusionary areas,” particularly with oil and gas platforms, cables, and pipelines, or areas deemed to be important benthic habitat areas for a variety of marine life. Many areas are also being considered for siting wind energy production facilities. Therefore, areas containing significant sand resources (e.g., much of Ship Shoal), are currently not available for dredging and sand removal.

In addition, dredging should be limited to seafloor areas seaward of an approximate “depth of closure” seaward of the base of the shoreface, which approximates the medium-term (decadal and longer) seaward depth limit for significant nearshore sediment transport, and further limits available sand source areas. This depth is generally determined by local wave and current conditions and sediment character. The depth of closure varies considerably around the GOM, but an average depth value is approximately 10 to 12 meters. Dredging is also depth-limited by the current approximately 40 meter limit for U.S. dredging equipment. The full extent of seafloor areas and potential volumes of sediment resources off limits to recovery or excluded due to these and other factors is unknown but worthy of study around the Gulf of Mexico. Maps and detailed assessments should be done to identify exclusionary areas and their effects on sediment resource availability.

Ocean Dredged Material Disposal Sites (ODMDSs) should be reused. All the deep draft navigation channels in the Gulf of Mexico with offshore dredged material disposal sites, also called offshore placement areas (PAs) should be reviewed for sediment quantification and analysis. These PAs are known by the EPA as Ocean Dredged Material Disposal Sites (ODMDS), and in some cases for more than 80 years, these sites have received tens of millions of cubic meters of sediments from federal dredging projects. In Texas for example, there are ODMDSs associated with the deep-draft navigation channels. These areas include: The Sabine-Neches Navigation Channel, Houston-Galveston Navigation Channel, Freeport Ship Channel, Matagorda Ship Channel, Corpus Christi Ship Channel, and the Brownsville Ship Channel (Brazos-Santiago) Channel. It is recommended that USACE policies should be modified to avoid (when possible) the disposal of more sediments in the ODMDSs, which results in the removal of valuable sediment from the active littoral system. Material that was traditionally placed in ODMDSs throughout the Gulf of Mexico could be beneficially used directly in restoration projects while at the same time, sediment previously placed in ODMDSs could be recycled for beneficial use in restoration sites in nearby coastal areas. An inventory and assessment of these sites and the character and chemistry of the sediments contained is recommended.

3.1.2.10 References

The following are papers cited in the text of the previous sections as well as other publications on Gulf of Mexico offshore sediment resources contained in USGS Open-File Report 03-300, "A Bibliography of Selected References to U.S. Marine Sand and Gravel Mineral Resources" (Williams et al., 2003).

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3.1.3 Dredging Activities

3.1.3.1 Introduction

Throughout the Gulf of Mexico, hundreds of millions of cubic yards of sediment are dredged form various ports, harbors, and waterways to maintain and improve the navigation system for commercial, national defense, and recreational purposes (EPA/USACE 2007). The U.S. Army Corps of Engineers and Environmental Protection Agency have regulatory responsibility for disposal of dredged material that occurs in the waters of the United States (Engler et al. 1988). This authority originates from Section 10 of the River and Harbor Act of 1899, Section 404 of the Clean Water Act, and Section 103 of the Marine Protection, Research, and Sanctuaries Act.

Dredged sediments are typically placed into pre-authorized confined disposal facilities or within the waters of the Gulf and adjacent rivers, wetlands, and estuaries. Growing scientific and engineering knowledge of using dredged material as a valuable resource, beneficial use of dredged material has become a viable option to traditional dredging and disposal options for many projects. It has been realized that dredged material can be used beneficially for a variety of applications which include habitat and restoration opportunities. Using dredged material can offset the need to mine or import sand or soil from other areas. Of the millions of cubic yards of material dredged within U.S. waters, approximately 20% is disposed of in ocean waters; 80% is disposed of or placed through other means in estuarine, fresh waters, upland or other areas; and approximately 30% of material placed is used for beneficial purposes (EPA/USACE 2007).

3.1.3.2 Dredging Information

Dredging activities are a potential source of sediment and should be considered in any conservation and restoration planning process. Currently this type of information is not consistently maintained or easily accessible. This focus area addresses the need and ability to proved improved data access and management for dredging activities and ways to better manage such information using a database approach that would be accessible to managers and planners. In an effort to begin assembling this type of information, the four Gulf Corps Districts began compiling information pertaining to Corps dredging projects to create a database of federal dredging activities at all federal navigation projects around the Gulf. This information was subsequently entered into a database with the intent that it be accessible by those who are planning and managing restoration projects within the vicinity of Federal projects. Initially, the type of dredging information identified for population of the database included:

- Project name and location
- Volume of sediment typically dredged
- Nature of sediment (sand, silt, clay, etc.)
- Associated placement areas
- Typical dredging schedule
- Existing beneficial uses
- Tracking of private and local dredging activities through dredging company records, regulatory processes, etc.

It has been recommended that such a database should also include more information on beneficial uses and beach nourishment projects, sources and volumes of material. Other additional information that would be helpful to include in the database includes dredging windows, contaminant information, shoreline restoration activities, and links to survey data. It is also suggested that the database be expanded to include private dredging activities. The database can be accessed at the following Web site: http://rsm.sam.usace.army.mil/projects/index.asp.

Due the recognition for the need to compile and manage dredging information, the Corps is developing a more comprehensive dredge information database. CE-Dredge is currently under development and is a collaborative effort between the U.S. Army Engineer Research and Development Center and the Mobile District. CE-Dredge focuses on data, tools, and applications for the planning and management of Corps dredging operations, and follows the fundamentals and architecture established for the eCoastal program.

Through access to dredging-related information and databases, the program will provide a standard dredging data management plan and data storage solution for all types (spatial and non-spatial) of related datasets. Similar to eCoastal, the CE-Dredge program will provide customized tools and applications designed and deployed to assist users in performing tasks relative to managing dredging operations. A CE-Dredge workgroup has been established to provide guidance in identifying pertinent information, data, and applications to meet Corps needs. Additional information and links pertaining to CE-Dredge will incorporated into this document as develop progresses.

3.1.3.3 Relevance of Dredging Activities to the GRSMMP

Sediment from dredging activities is a potential source of sediment that can be managed beneficially by combining restoration and conservation efforts with dredging projects. Substantial benefits may be realized from reduction in re-handling of material, extending dredging cycles, and associated equipment mobilization and demobilization. Costs may also be reduced by sharing information and reducing duplication of field data collection, or by reducing duplication in model and tool development. Keeping dredged sediments within the natural system or using it in the construction of restoration projects can improve environmental conditions, provide storm damage protection, and contribute to habitat conservation/restoration. When planned accordingly, emergency restoration efforts have been conducted to quickly and efficiently by utilizing dredged material to restore damaged habitats while re-establishing navigation capacity.

3.1.3.4 Dredging Activities Recommendations.

Recommendations to be considered when dredging materials include the following:

- Dredged material should be promoted as a valuable resource, <u>not</u> spoil, disposal material, or waste.
- When dealing with dredging projects, reporting requirements in the regulatory process should be levied to track actual dredging activities.
- Information should be developed on how state CZM programs/COE regulatory track dredging activities. Recommendations should be developed for minimum reporting requirements needed to adequately track dredging activities.
- Dredging projects should be included in the sediment sources inventory process.
- When utilizing dredged material, agencies should coordinate with local sponsors/stakeholders to acquire needed easements, rights of ways, etc.

- Dredged material should be included in the restoration planning process as a potential borrow alternative.
- The most beneficial disposal practices should be promoted, even if the material is not being used as borrow for a specific project.
- Placement alternatives should be considered that would keep dredged sediment within the natural system.
- Emergency use plans should be developed towards proactive permitting and environmental coordination.
- States should cooperate in the CE-Dredge workgroup to expand linkage into other dredging databases.
- The Port Authorities should be included in the beneficial use of dredged material management and planning.
- Data on the cost of dredging and disposal should be gathered for consideration when planning restoration activities.
- Information on Corps civil works vs. regulatory project processes, reporting, etc., in the different Gulf States should be gathered.
- Ports and navigation districts may have valuable data on private dredging activities which utilizes their DAs.
- ODMDS Site Management and Monitoring Plans (SMMPs) may be useful source of data.
- Annual dredging conferences should be organized to layout schedules, identify potential sediment sources, coordinate activities, regulatory processes, etc., for distinct geographical areas.

3.1.3.5 References

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3.2 Ecological Aspects of Coastal Sediment Management in the Gulf of Mexico

3.2.1 Introduction

Water and sediment resource planning are not only essential features of natural resource management but also essential to national security, public health, and economic development (Twilley and Rivera-Monroy, 2009). Traditional approaches to resource planning have lead to an array of ecological impacts including acidification of waters, unsustainable fisheries management, the wide spread pervasiveness of invasive species, and a cascade of biological effects from dams, reservoir, and aqueduct construction. Deforestation, urbanization and agricultural chemical contamination have also adversely affected coastal systems (Gleick, 1998).

Along the Gulf of Mexico coast, water and sediment resources play an important role not only in the ecology of the ecosystem but also the economy and livelihood of the cities and towns that utilize the resource. For example, five of Texas' seven major estuaries systems were given a "danger" ranking because of water-use practices potentially reducing future freshwater inflows (Johns, 2004). This has serious implications to the cities such as Houston and Dallas that utilize these bays for commercial and recreational fisheries. In Louisiana, artificial levee construction of the Mississippi River has prevented bank overtopping and subsequent floodplain sedimentation that naturally occurred prior to human development (Turner, 1990).

The impact of human activities on sediment resources in the Gulf of Mexico depends greatly on both the underlying geology and the contemporary sediment dynamics. The northern Gulf of Mexico, from the U.S./Mexico border to the Dry Tortugas of the Florida Keys can be divided into eight regions based on the underlying geology and surficial geomorphology of the area as discussed earlier and presented in (Figure 2-3). The influence of rivers on the geomorphology and in terms of sediment delivery is prevalent but is most apparent along the Texas and Louisiana coastlines. The location, extent, and variability of sediments within and on the periphery of the Gulf of Mexico are thoroughly described in both the previous and following chapters of the Gulf Regional Sediment Management Master Plan (GRSMMP).

The GRSMMP is designed to manage sediment resources for habitat conservation and restoration while maintaining an understanding of the sediment dynamics and the natural processes of the system. Taking into consideration these dynamics and processes is a crucial component of the plan as the implications of sediment management and the impact on the environment can be far reaching. This chapter aims to explore some of the anthropogenic activities that have affected sediment distribution, supply, and delivery, the ecological implications to multiple habitat types, and presents recommendations on how holistic approaches to sediment management can alleviate potential problems. First an overview of the habitat and ecological characteristics of the Gulf Coast will be presented, based on sedimentary environments, followed by a description of some frequently used human modifications that have lead to the manipulation of sediment distribution over the years. Some of the ecological implications of these anthropogenic activities will be explored, and potential changes will be identified that could provide a beneficial path for the future.

3.2.2 Natural System

3.2.2.1 Climate

The northern Gulf of Mexico is characterized as a warm-temperate region with a semi-tropical to tropical climate influenced mainly by tropical currents during the summer months and temperate climate during the winter (Yáñez-Arancibia and Day, 2004). Heaviest rainfall occurs from the Mississippi Delta to the Florida Panhandle, exceeding on average 160 cm yr^{-1}. West of the Mississippi Delta, the climate becomes markedly drier with rainfall in Lake Charles averaging 145 cm yr^{-1} and further south to Brownsville, TX rainfall decreases to 70 cm yr^{-1}. Similarly, the decreasing trend occurs east of the Florida panhandle ranging on average 145 cm yr^{-1} near Apalachicola, FL to 100 cm yr^{-1} in Key West, FL. Temperature trends are similar but less extreme with annual temperatures of 17-20°C across most of the Gulf Coast and increasing to 23-25°C near Brownsville, TX and Key West, FL (NOAA, 2002). Freezes, droughts, and tropical cyclones significantly influence the ecosystem and are highly erratic throughout the Gulf Coast. Large bodies of surface water (i.e., Gulf of Mexico) moderate freezing temperatures associated with winter cold fronts.

3.2.2.2 Coastal Environments and Habitats

Understanding the effects of changes in sediment supply and transport on ecological systems requires a basic appreciation of the characteristics of specific environments and the fundamental processes controlling the geomorphology and ecological interactions. Here the primary coastal habitats within which the effects of sediment management are most often manifested have been identified.

Shoreface – Beaches and Dunes

Beaches constitute a transitional habitat in coastal areas from terrestrial, more vegetated habitats to open water habitats. Beaches can be present on the seaward side of barrier islands or the mainland as well as along the land water interface in semi-enclosed or open bays. The beach extends from the berm crest (landward extent), which is exposed above the mean water line but is sometimes inundated during high tide or storm conditions, past the wave break point, offshore where waves behave in an oscillatory manner (Figure 3.2-1-1; Summerfield, 1991). Sediment is transported both on and offshore depending on wave conditions, which usually result in onshore movement of material during the winter associated with the passage of cold fronts and offshore during the summer (Aubrey 1979); with the exception of the passage of tropical storms and hurricanes, which have the capacity to move large amounts of material onshore (Stone et al., 2005).

Dunes form landward of the berm, as a result of transportation and accumulation of beach sediments due to eolian processes (U.S. Geological Survey, 2004). New accumulations of sediment are colonized by dune species; usually grasses that have large, rhizomatous root systems that help stabilize the sediment (Ritchie et al., 1989). Dunes will continue to build higher and wider as long as there is eolian transported sediment available and tend to be larger and more extensive in the eastern Gulf where offshore sand is more available that in the western Gulf of Mexico (Martinez et al., 1963).

Shorefaces are found in all regions of the Gulf of Mexico and range from sandy beaches with extensive dune systems in Florida to beaches derived from progressively finer sediments and smaller dune systems derived of fine sand to the west through Alabama, Mississippi, Louisiana, and Texas. Beaches in the southern portion of Florida are restricted to the shoreface of protective barrier islands from just north of Tampa Bay ending with Anclote Key and extending south to the Dry Tortugas (Figure 3.2-2). North of Tampa Bay, Florida, through the Tallahassee bend area no barrier islands, mainland beaches, or dunes present with marsh and intertidal flats extending to the Gulf of Mexico.

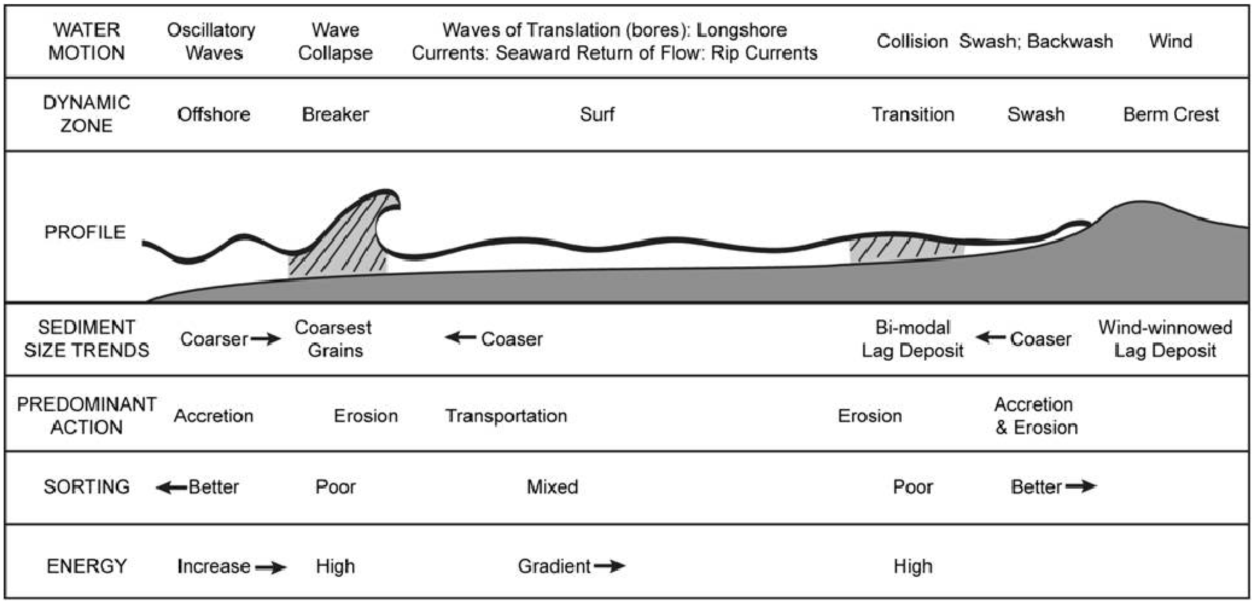

Figure 3.2-1. Diagram of a beach profile from the offshore where waves are oscillatory to the berm on the shoreface (from Summerfield, 1991).

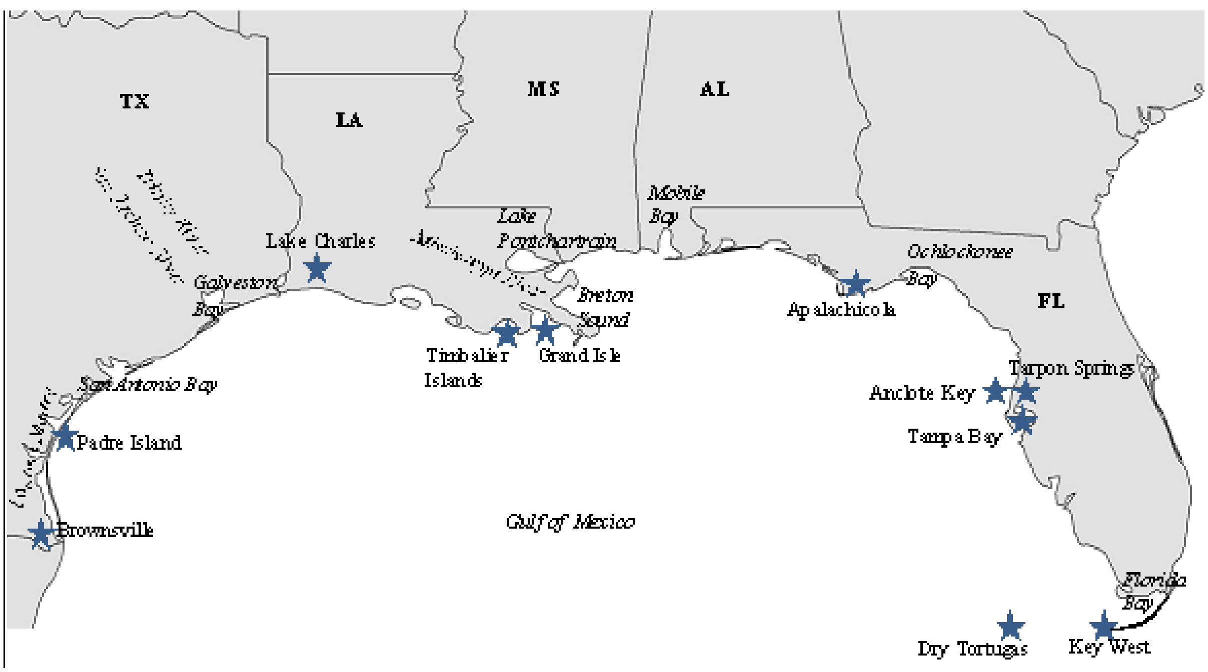

Figure 3.2-2. Geographic scope of the Regional Sediment Management Master Plan showing sites referred to in this chapter.

The barrier island and mainland beaches present from Ochlockonee Bay, Florida westward to Gulf Shores, Alabama just east of Mobile Bay are known as the Emerald Coast because of the clear green water and wide, gently sloping beaches. This area also supports extensive dune systems that are protected in many places with enclosures and fences. Mississippi has both barrier island and mainland beaches but dunes are restricted to the barrier islands. The barrier island beaches and dunes are made of coarser, better sorted sediment than the mainland beaches due to both the higher wave and wind energy on the islands.

Shorefaces in Louisiana and Texas consist of finer sediment than to the east as a result of river input, primarily the Mississippi River. Narrow beaches with low dune systems that include washover terraces, dune terraces, and low continuous dunes are present on both main land shorefaces and barrier islands. Barrier island dune systems in Louisiana and Texas often include a washover sheet on the bayside shoreline (Ritchie et al., 1995). As beach and dune systems are sub components of barrier islands along much of the Gulf Coast the ecological communities they support are described below.

Barrier Islands

Barrier islands are transgressive geologic features in the Gulf of Mexico and are natural migrating landwards as a result of wave overwash processes and rising sea level (U.S. Geological Survey, 2008). Barrier islands typically form parallel to the coastline. The gulf shoreface is a sandy beach in front of dunes, which may range from extensive, 10 m high systems in Florida to fragile, less than 1 m high systems in the western Gulf. The stable portion of the dune system is the highest elevation on the island. Behind the dune, the island slopes back to sea level but often sustains a variety of different vegetation assemblages between the dune and the back bay, such as maritime forest, swale and barrier flats, salt marsh, and salt or tidal flats (Figure 3.2-3; Ritchie et al., 1995). In Louisiana, barrier islands are typically narrow features of low relief and do not support maritime forest vegetation, with the exception of Grand Isle (Williams et al., 1992).

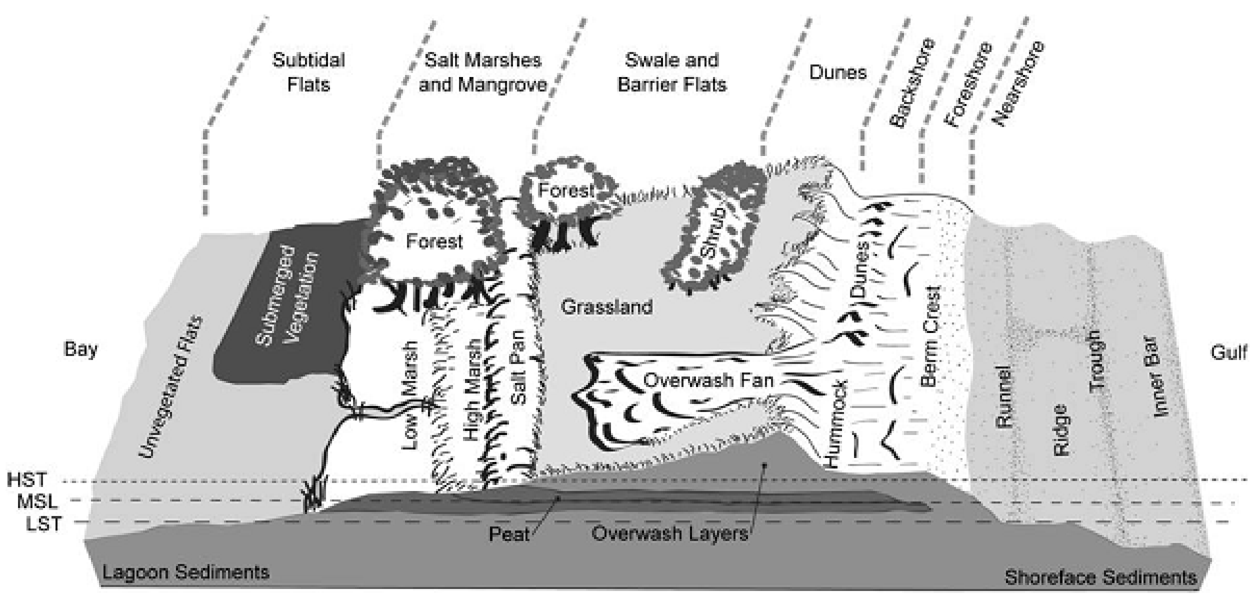

Figure 3.2-3. Barrier Island profile illustrating the variability of vegetation from the gulf side across to the bay.

Barrier islands serve as a critical stopover areas for neotropical passerine migrants, especially along the northern Gulf of Mexico, and are considered an important link in their annual cycle (Moore et al., 1990). Due to evolving nature of barrier islands, few adult animals are able to permanently reside. The exception includes, but is not limited to, the Pygmy mouse, Norway rat, and black-tailed jacket rabbit of the Texas coast (Britton and Morton, 1989) and beach mice of the Alabama/Florida coast (Oli et al., 2001). The islands also provide habitat for sand-dwelling Crustracea: mole crabs, ghost shrimp and clams (Britton and Morton, 1989). Leatherback, green, loggerhead and Kemp's ridley sea turtles either historically or recently have resided along the beaches of the U.S. Gulf of Mexico coast (Fritts et al., 1983).

Hardbottom

Hardbottom habitats in the northern Gulf of Mexico can be categorized as either made of coral and limestone structures in Florida and Alabama or hardbottoms made of molluscan shells, usually oysters (Rohmann and Monaco 2009; Schroeder et al., 1988; Puffer and Emerson, 1953). Southern Florida's shoreline from Tarpon Springs on the Gulf of Mexico through the Dry Tortugas and Florida Keys and extending some distance on the Atlantic shoreline is the only place in the U.S. that supports larges tracks of coral habitat (Figure 3; Rohmann and Monaco, 2009). These waters support a variety of geomorphic habitat types that range from unconsolidated shell, rock, and coral fragments to coral and hardened rock combination substrates (Gould, 1987). Reef-like outcrops of limestone, dolomite, coquina, and sandstone, with up to 2m of relief as well as more moderately sloping accumulations of surficial rock and shell are both common offshore of Alabama and Florida (Schroeder et al., 1988).

In regions of the northern Gulf of Mexico where sediment is finer and the sea floor tends to be dominated by unconsolidated material rather than rock, such as Louisiana and Texas, hardbottom habitats primarily occur as a result of the build-up of oyster reefs (Puffer and Emerson, 1953; Roberts, 1999). Salinity and temperature are the primary controls on oyster production and habitat development (Puffer and Emerson, 1953) and for this reason they are often confined to inshore areas where riverine influence modulate salinities. Roberts (1999) describes the positive effect that the development of oyster reefs has on reducing sediment erosion in coastal Louisiana where sediments are primarily fine and unconsolidated. While these reef environments are biogenic, they also support and provide nursery habitat for a variety of other fauna including burrowing shrimp, bittium snails, small estuarine fish (Blenniidae and Gobiidae families), as well as pelicans, cormorants, and oyster catchers (Britton and Morton 1989).

Bays

Behind the barrier islands of the Gulf of Mexico, shallow basins or bays develop and accumulate sediments from river and tidal currents (Figure 3.2-1). The substrate, sedimentation rates, water depth, and current flow shape the variety of habitats that develop within these bays (Britton and Morton, 1989). For example, the Laguna Madre of Texas (Figure 3) receives little freshwater inflow, minimal tidal exchange, and experiences high summer temperatures, contributing to hypersaline conditions and abundant seagrass beds with sandy soils, although spatial variations in these habitat characteristics are evident between the Upper and Lower Laguna Madre (Montagna et al., 2002; Onuf, 2007). Conversely, Galveston Bay, TX receives large amounts of freshwater from the Trinity and San Jacinto Rivers providing a slew of habitat types from tidal marshes to oyster beds and mud flats (Johns, 2004). Bays are not confined to the Texas coast and can be found across the entire Gulf of Mexico (e.g. Lake Pontchartrain, Mississippi Sound, Mobile Bay, Apalachicola Bay, and Florida Bay; Figure 3). The variety of habitats these bays can support provide food and shelter for numerous species including Atlantic croaker, flounder, sea trout, shrimp, blue crab, oysters, black drum, herons, cranes, and rails.

Marshes

The coastal region of the Gulf of Mexico contains nearly 14,200 km^2 of marsh (Alexander et al., 1986) extending inland up to 80 km (Chabreck, 1988). Most of these marshes were formed when rising sea levels inundated river valleys and the shallow coastal shelf after the last glacial period. In some cases river valleys filled with sediment and marshes were formed. In coastal Louisiana, after sea levels stabilized, Mississippi River sediments continued to build delta lobes, establishing an extensive marsh system along the coast (e.g., Roberts, 1997).

The tidal salt marshes of the Gulf of Mexico make up nearly 53% of the total salt marshes in the United States (Mitsch and Gosselink, 2000). They provide food and cover for multiple species of estuarine fish and invertebrates including shrimp, blue crab, red drum and spotted seatrout, all of which are commercially or recreationally sought. Salt marshes generally establish landward of coastal beaches and on the leeward shorelines of barrier islands. They are most abundant across coastal LA, the "Big Bend" area of FL between Ochlockonee River and Tarpon Springs (Figure 3; Clewell, 1997), and along the northeastern coast of Texas. The most common plant species in these areas include *Spartina alterniflora, Spartina patens,* and *Juncus roemarianus* (Yáñez-Arancibia and Day, 2004). Freshwater marshes occur in areas of high precipitation and/or areas with substantial riverine input. These systems can be tidal, meaning they receive tidal inputs but without the stress of oceanic salinity, or non-tidal, occurring further inland away from tidal influence. The largest extent of freshwater marshes can be found in the Everglades of south Florida and in the Mississippi River floodplain (Mitsch and Gosselink, 2000).

Forested Wetlands

Forested wetlands along the Gulf of Mexico include mangrove swamps, southern bottomland hardwoods, and cypress swamps. Mangrove swamps are primarily found along the southern tip of Florida but can extend as far north as Louisiana, about 30°N latitude (Mitsch and Gosselink, 2000). Along the Texas coast, black mangroves are most abundant in the Laguna Madre and Corpus Christi Bay system, but occur as far north as the Galveston Bay. They are limited by the frequency and severity of freezing temperatures. Mangroves swamps are recognized by their special adaptations to highly stressful coastal conditions: prop and drop roots of red mangroves, pneumatophores of black mangroves, and the viviparous propagule hanging in red mangroves (Mitsch and Gosselink, 2000).

Southern bottomland hardwoods are found in riparian ecosystems and are characterized by their hydroperiods. Areas lower in elevation and frequently flooded support cypress-tupelo swamps. Further inland, oak, maple, willow, sycamore, and sweetgum species dominate. The forests support an array of species from snakes, frogs, alligators, beavers and otters along frequently flooded areas to deer, rabbits, squirrels, woodpeckers and sparrows, to name a few, in areas of higher elevation (Mitsch and Gosselink, 2000).

Cypress swamps, dominated by *Taxodium* species are predominantly found in Texas, Louisiana, and Florida. The largest remaining cypress forest is in Big Cypress National Preserve, north of the Florida Everglades (Cronk and Fennessy, 2001).

3.2.2.3 Approaches to Sediment Management

Dredging

Dredging is a common shoreline sediment management tool that directly and deliberately affects sedimentary environments. It can be accomplished using a variety of dredging equipment and borrow pit and placement options but is primarily used for beach nourishment, barrier island restoration, and to keep navigable waterways open to shipping traffic (Nordstrom, 2000; Davis, 2003; USACE and LSU, 1997). Two primary types of dredges, mechanical and hydraulic, are used to excavate and place material. Mechanical dredges such as clamshell, cutter, and dustpan dredges mechanically scoop material off the bottom and then place individual loads either on a transport vehicle or to a placement site a short distance away (Clausner, 2005; Turner and Streever, 2002). Hydraulic dredges, such as the cutterhead, pipeline or hopper dredge use pumps to suction material off the bottom in a slurry and propel the slurry through pipeline transmission to the placement site, which can be long distances away (Clausner, 2005).

Hard Structures

Hard structures for shoreline protection and restoration do so by altering sediment transport pathways and deliberately changing the fate of coastal sediments. They primarily take the form of jetties and groins (shore-normal structures) and sea walls or breakwaters and sills (Nordstrom, 2000; French, 2001). Both structures can be made from a variety of materials ranging from specially made, patented technology to simple rock or concrete structures. Jetties and groins are structures placed perpendicular to the shoreline for the purpose of interrupting longshore transport and trapping sediment on the updrift side of the structure, however downdrift of the jetty there will always be erosion of the shoreline (Nordstrom, 2000; French, 2001). Jetties are primarily installed at the outlets of waterways to prevent channel infilling and reduce dredging costs. Groins are installed along linear shorelines to interrupt the longshore drift and reduce erosion. Sea walls and breakwaters can be made of impermeable material such as concrete sea or permeable material such as rock and gravel structures (French, 2001). Breakwaters can be installed as a field offshore of the shoreline to reduce wave energy and thus shoreline erosion (Goudas et al., 2003).

River Management

Sediments supplied by rivers shape and maintain deltas, feed local beaches, deposit nutrients, and influence coastal turbidity. Sediment discharge consists of suspended sediment (silt, clay, and some fine sand are suspended in the water column) and bed load (usually sands). These sediments provide essential building blocks for several coastal environments, e.g., deltas and beaches. As a result, sediment deprivation due to water management is a significant concern in many coastal areas (Sklar and Browder, 1998).

<u>Dams</u>. Dams have been constructed to store water and to increase “hydraulic head,” the difference in heights between the reservoir and the river downstream. These functions allow for the generation of electricity, supply water for municipal uses, control flooding, and assist navigation by manipulating flow (McCully, 1996). Although dam construction is not extensive along the Gulf Coast, those constructed inland can have serious implications on the coastal environments that utilize the dammed rivers’ and streams’ sediment inflows. The effects at the coast may not always be directly related to the sediment capture upstream. Phillips et al. (2004) showed that the retention of sediment in the Livingston Dam on the Trinity River had little effect on sediment supply and turbidity in Galveston Bay due to buffering effects in the lower river. In other parts of Texas the effects of dams on river sediment supply has been

more directly inferred (Morton 1979).

Diversions. River diversions have been used to manipulate river water and sediment for flood protection (e.g., the Old River Control Structure which controls flow between the Atchafalaya and Mississippi Rivers) and coastal restoration needs. Scientific studies have revealed freshwater diversions from the Mississippi have the potential to deliver fluvial sediments and nutrients to coastal marshes (Hyfield et al., 2008; Lane et al., 1999; Lane et al., 2001; Snedden et al., 2007; Villarrubia, 1998) contributing to vertical accretionary processes (Lane et al., 2006). This ability to manipulate the flow of river flow and sediments may allow benefits to accrue in some areas but in areas or times of limited supply, the benefits must be considered against the lack of sediment supply to the originally fed area. In the case of the Mississippi River where diversions are small relative to the size of the river resource these consequences may be trivial but diversions in other rivers could reallocate sediment resources and/or the flows required to move those sediments.

Levees. Artificial levees have been constructed to prevent flooding and enhance agricultural use of alluvial soils. The most prominent use of levees along the Gulf of Mexico coast occurs in Louisiana and Florida. Flood control levees have been built along the lower Mississippi River to prevent overbank flooding. In Florida, levees were constructed throughout the Everglades ecosystem to prevent flooding and control water levels (Light and Dineen, 1994). By preventing flooding, levees halt the delivery of suspended sediments to deltas and floodplains adjacent to rivers. For coastal wetlands, this may impact accretionary processes and the ability to survive sea-level rise.

Development

Development along the coast stems from the resources the habitat provides. Historically, coastlines served as major industrial and commercial centers for transporting goods and services. As the U.S. population expanded and technology advanced, a shift in the use of coastlines for recreation and natural resources occurred. Some of the prominent uses of our coast include commercial and recreational fishing, oil, gas and mineral extraction, and building construction as a result of tourism (Beatley et al., 2002).

3.2.2.4 The Context of Climate Change

The effects of sediment management activities on ecological processes must be considered in the context of other changes which are occurring at the coast. One of the most important of these is changes in climate. In many coastal areas, relative sea level rise (RSLR) is of great concern as it combines eustatic sea level rise with geologic subsidence. The rate at which RSLR occurs will have dramatic impact on the response of the coastal system. As sea level rises, barrier islands will either disappear or erode and retreat landward if unimpeded (depending upon sediment supply); coastal bays will diminish in size as a result of retreating barrier islands or expand into the Gulf as barrier islands disappear; marshes will be inundated unless able to accrete vertically at a rate greater than the inundation (also dependent on sediment supply), and freshwater marshes and forests will be subject to salt water intrusion and could suffer severe die offs (Callaway et al., 2007; Wanless et al., 1994). These impacts are exacerbated by human activities, described above, that alter freshwater and sediment input.

Changes in precipitation patterns will also potentially alter sediment delivery to the coast. Climate change is expected to change the intensity, frequency, duration, and amounts of precipitation (Trenberth et al., 2003); however, the degree at which this occurs has been difficult to predict on the regional level (Wilby and Wigley, 2002). Changes in rainfall as well as runoff will alter freshwater inflows and subsequently impact sediment and nutrient delivery downstream. An increase in the intensity and frequency of rainfall events could lead to an increase in erosion and ultimately sedimentation stress on fish, mollusks, and macroinvertebrates. An increase in runoff may lead to an increase in the estuarine flushing rates, reducing shrimp yields and others that favor high salinity waters (Mulholland et al., 1997). Coupled with RSLR, a decrease in sediment supply can have substantial impact on an already stressed ecosystem.

3.2.2.5 Implications of Sediment Management

Dredging

Two primary impact areas, the borrow site and placement area, must be considered in all dredging activities (Clausner, 2005). The borrow sites can range from nearshore in backbays, inlets, and transgressive shoals deposits, which can in places such as Louisiana be considered offshore sources (Nordstrom, 2000; Finkl and Walker, 2002). The main concern in many barrier island and other coastal restoration sites is to avoid consequences for the placed material and the functions it is trying to achieve by using borrow material too close to the restoration site or inside the depth of closure, which is the limit of the sand-transport system of the barrier island and can vary considerably depending on geomorphology and wave dynamics (Nordstrom, 2000; Finkl and Walker, 2002). Material dredged from navigation channels is a considerable source of material that must be disposed as spoil banks or used as material for restoration of nearby habitats (Nordstrom, 2000; Turner and Steever, 2002).

The configuration of material placement, most importantly post-construction consolidation, elevation and grain size, is critical to establishing target habitats and the success of ecological communities colonizing the material (Finkl and Walker, 2002; Fletcher et al., 2000; Turner and Streever, 2002). Rashleigh et al. (2009) documented that the distribution of fish and shellfish species responded to both salinity and elevation gradients (upland to offshore) in the Mobile Bay estuary in Alabama. Aggregated spatial distributions related species communities to different habitat characteristics, emphasizing the importance of maintaining a variety of habitat characteristics and distribution in restored areas (Rashleigh et al., 2009). Nanez-James et al., (2009) and Ross et al., (2009) stress the importance of maintaining vegetated, sandy, shallow habitats in the nearshore of barrier islands as compared to unvegetated, muddy bottoms for maintaining populations of southern flounder in Texas and gulf sturgeon in Louisiana, Mississippi, and Alabama.

LePeyer et al., (2009), Nordstrom (2000) and Finkl and Walker, (2002) emphasize the importance of maintaining beach profile elevation in nourishment projects, many of which employ the use of dredge material. The importance of maintaining elevation profiles that mimic the natural geomorphology is important throughout the Gulf both for developing sustainable vegetative cover and suitability as nekton habitat, which ultimately determines habitat type (Fearnley et al., 2009; Turner and Streever, 2002; Zimmerman and Rozas, 2000). Nekton species thrive in a variety of habitat types in the nearshore environment. Wells et al. (2009) documented the use of inshore mud, shell bank, and offshore mud habitats by a variety of fish species on a drowned barrier island along the Texas shelf. Equally important to creating productive nekton habitat is the maintenance of sandy bottom inlets between barrier islands and other shoreline features (Nanez-James et al., 2009; Ross et al., 2009).

Hard Structures

The consequences to ecological communities resulting from the pattern of accumulation and erosion induced by the placement of hard structures along shorelines are varied. Erosion on the downdrift side causes loss of beach habitat, and especially severe loss of dunes. This can have a localized effect on nesting habitat for sea turtles and mammals that live on the upper beach or in the dunes. This loss of habitat is not outweighed by the accumulation of sediment on the updrift side as the provision of habitat is not necessarily related to the volume of beach and dune material.

For many species the length of beach or the beach-dune and beach-intertidal transitions, rather than area, are more important factors in habitat utilization. Coastal dune vegetative species thrive at distances of approximately 150 to 200 m from the shoreline behind the frontal dunes (Miller et al., 2008). Nearshore nekton species make use of habitats with specific characteristics, which are heavily influenced by the beach profile. Surf zone fish assemblages are markedly different from assemblages in semi-permanent intertidal pools farther up the beach profile (Ross and Doherty, 1994). The alteration of the beach profile as a result of hard structure placement can result in the loss of species diversity due to the conversion of multiple habitats to a single beach habitat.

In some areas the placement of hard structures has led to a complete loss of natural shoreline habitat. The installation of jetties in the 1930s at Belle Pass in coastal Louisiana has resulted in severe erosion of the downdrift spit and Timbalier Islands to the west (Figure 3; Williams et al., 1992). Construction of breakwaters and sea walls along the shoreface of East Timbalier Island from 1960-1970 have resulted in lines of mostly submerged rocks parallel to the shoreline and separated by a shallow intertidal area (Williams et al., 1992). This effectively eliminates beach use by important species such as Florida pompano that use surf zone habitat in the northern Gulf of Mexico (Modde and Ross, 1980).

River Management

The effects of dams, levees and river diversions are manifested at the coast in terms of changing delivery of sediments – both the fine suspended load and the coarser bed load. For instance, the suspended sediment load of the lower Mississippi River has decreased by nearly 70% since 1850 (Kesel, 1988). Similarly, the construction of the Falcon Dam across the Rio Grande contributed to a decline in the suspended sediment by 95% (Morton, 1979). As these river systems provide a major source of sediments, the decline has serious implications for the coastal environments that rely on the continuous supply of sediment for growth and sustainability.

Some river diversions are undertaken to promote desired ecological effects in Louisiana. One example is the Caernarvon Diversion structure which was constructed in 1992 and designed to divert Mississippi River water to the Breton Sound Estuary (Figure 3). Although originally designed to promote oyster production (Chatry and Chew, 1985), studies have shown increased marsh productivity and sustainability (DeLaune et al., 2003; Lane et al., 2006). For the most part; however, the consequences of changes in sediment supply due to river management are inadvertent and unintended.

Morton (1979) has documented the effects of reduced sediment influx to the Texas shoreline associated with damming of rivers. This loss of coarse sediment contributed to beach erosion, which was also exacerbated by hard structures at the shoreline. Beach erosion results in the loss of beach and dune habitats for species such as the piping plover and St. Andrew beach mouse that depend on coastal sand dunes for foraging of crustaceans.

Reduced inputs of suspended sediment to coastal marshes and bays can have complex consequences. Most obvious is the reduction in the sediment required for marshes to maintain their elevation in the face of sea-level rise which will potentially lead to marsh decline. Marsh loss will have complex effects on some fishery species. Marsh-edge species that utilize the interface between the marsh and open water, including brown and white shrimp, Gulf menhaden and bay anchovy will potentially benefit from the conversion of marsh area to open water as more “edge” habitat is exposed. To an extent, an increase in marsh loss correlates to an increase in marsh edge and increase in suitable habitat for these species. However, Browder et al. (1989) reported that marsh edge will increase up to an extent and then subsequently decline as the percent of open water increases. At the point in which disintegration of the marsh occurs, a threshold between 30-50% open water, brown shrimp catch also reportedly declines (Browder et al., 1989). This non-linear relationship exemplifies the need for an understanding of the habitat thresholds for species utilizing areas that are subject to human modifications.

Also potentially important is the change in turbidity in coastal bays and estuaries associated with river management. Reduced turbidity will encourage the growth of seagrasses in shallow bays (Lee et al., 2007) and provide habitat benefits for juvenile red drum, macro-invertebrates and bivalves (Orth et al., 1984).

Development

Human development along the Gulf Coast impedes the natural evolution of these habitats. For instance, human activity on barrier islands may affect the link to adjacent islands and their link to the shoreface as well as the ecological and physical aspects of the barrier island itself (Stutz and Pilkey, 2005). More than 50% of the U.S. population resides along the coasts and as these numbers are projected to increase (Bookman et al., 1999) the need for protection from rising sea levels, hurricanes and tropical storms, and habitat degradation will increase as well. Protection of coastal properties involves structural barriers (e.g., seawalls), and shoreline reinforcement (beach nourishment). The construction of jetties can interrupt sand movement, depriving downcoast areas of this sediment supply causing erosion (Beatley et al., 2002). Although direct beach loss will influence species such as piping plovers and other shorebirds that utilize the habitats, whooping cranes could be adversely affected as they winter along the Texas coast in San Antonio Bay and feed off of crustaceans and mollusks that rely on beach sediments.

3.2.2.6 Case Study

Barrier Island Comprehensive Monitoring (BICM) Program-Timbalier Island Dune and Marsh Creation Project (TE-40), Timbalier Island, Louisiana

Timbalier Island is a transgressive barrier island located in south Terrebonne Bay, in the Mississippi delta plain, Louisiana. The island overall is losing sediment and becoming shorter and narrower over time while at the same time rapidly migrating west/northwest, prograding a long western spit and eroding marsh and shoreface on the eastern side, indicating a strong western longshore sediment transport direction (Louisiana Coastal Wetlands Conservation and Restoration Task Force (LCWCRTF), 2008; Williams et al., 1992).

Restoration of Timbalier Island began in 1996 with a planting demonstration project, Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA) Project No. TE-18, that placed more than 7,000 linear feet of sand fencing and planted *Spartina patens* and *Panicum armanum* the following year on dunes created using dredge material from the bay behind the island (LCWCRTF, 2002c). Between June and December 2004, as part of the TE-40 project, 4.6 million cubic yards of material was dredged from borrow pits to the east of the island in Little Pass Timbalier and placed to restore 2.2 miles of beach rim, dune systems, and marsh platform on the bay side of the island (Figure 3.2-4; LCWCRTF, 2008). The design of this project was unique to barrier island restoration projects in Louisiana because it used a terraced design (see cover photo) to mimic the elevation profile of natural barrier islands where the dune is the highest elevation point; the island slopes more gently towards the bay transitioning through back barrier marsh and the gulf shoreface slopes more steeply through the beach to the Gulf of Mexico (Richie, 1995).

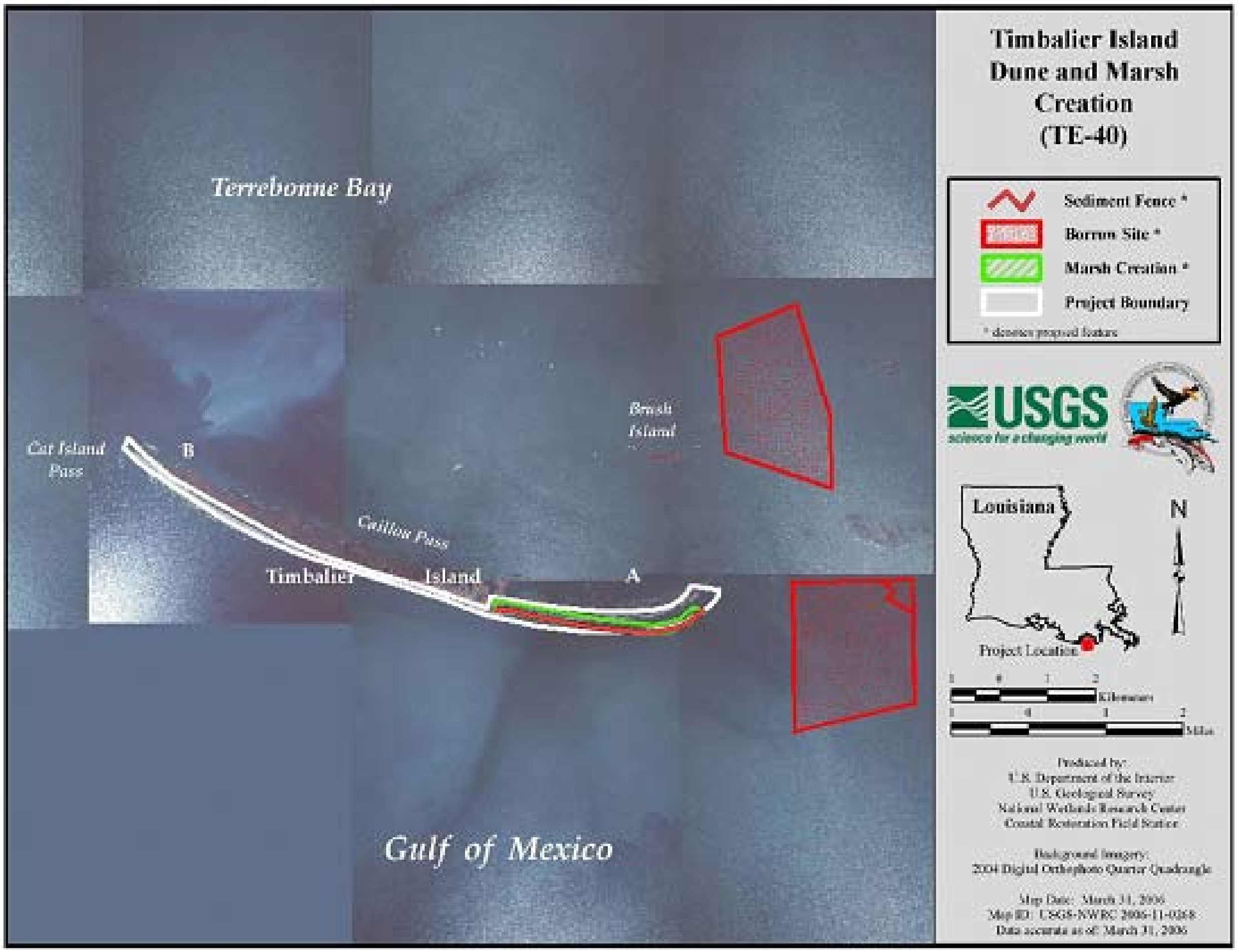

Figure 3.2-4. Map of Timbalier Island with the placement areas for the dune and marsh shown in green and yellow and the borrow areas in Little Pass Timbalier to the east of the island shown in red.

The Barrier Island Comprehensive Monitoring (BICM) program funded the analysis of Timbalier Island imagery from 1996, 2002, 2004 (pre-construction), and 2005 (post-Katrina). CWPPRA was partially responsible for funding the analysis of the TE-40 specific imagery from another 2005 date (post-construction) and 2006 (one year post-construction). Imagery (mosaics) were classified using remote sensing software to determine habitat change between 1996-2002, 2002-2004, 2004-2005, 2005-2006, and 1996-2005.

The western portion of Timbalier Island is more stable than the eastern portion as a result of the wider and continuous marsh platform. The 2004 restoration (TE-40) is apparent in Figure 3.2-5 as an increase in the acreages of bare land habitat in 2004 compared to 2002 and 1996. Overwash as a result of the passage of Hurricanes Katrina and Rita resulted in an increase in the acreages of beach habitat in 2005 compared to the other analysis years. Marsh and intertidal flat habitats remain relatively stable throughout all periods of analysis (Fearnley et al., 2009). The habitat classification for 2005 clearly shows the placed dredge material as a broad expanse of bare land surrounded by a thin extent of beach habitat (Table 1).

By 2006, the dredged material has begun to be redistributed throughout the island by wave and wind processes and the acres of bare land habitat decrease. Accumulations of sand form beach habitat along the eastern point of the island and beach habitat is encroaching on the bare land all along the Gulf shoreline

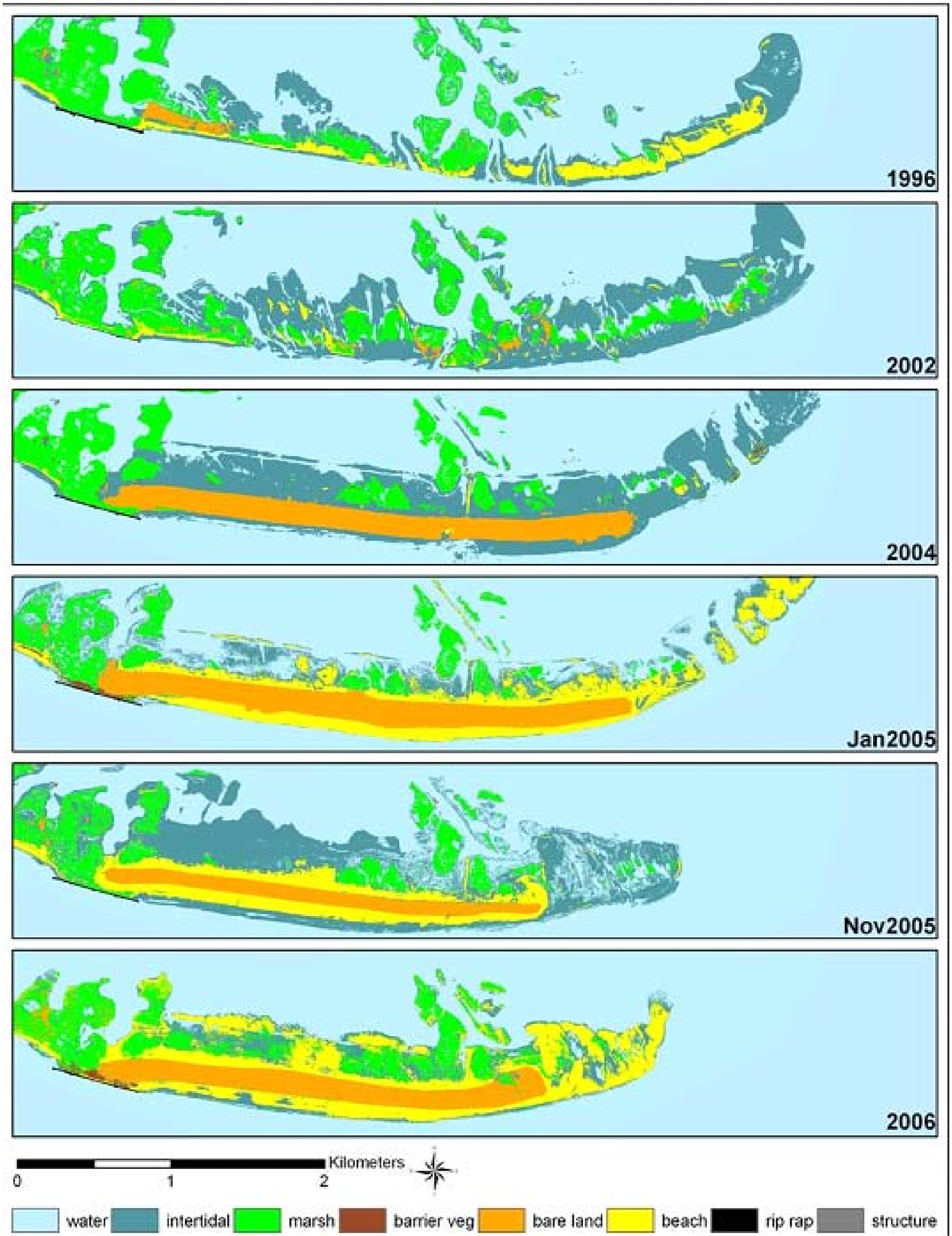

Figure 3.2-5. Map of the habitat classifications of Timbalier Island for 1996, 2002, 2004, Jan. 2005, Nov. 2005, and 2006. The habitat classifications include water, intertidal flat, marsh, barrier vegetation, bare land, and beach.

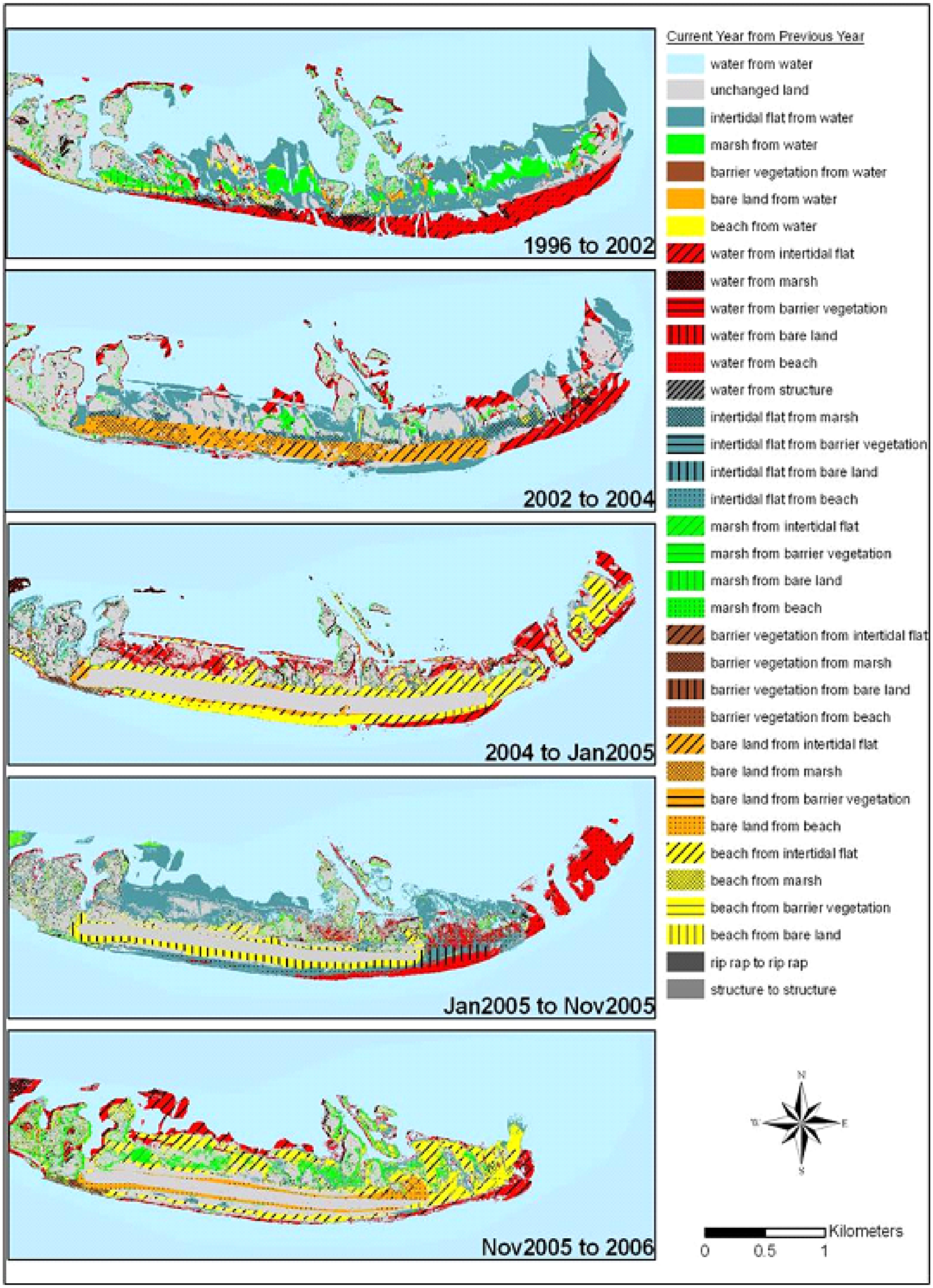

Figure 3.2-6. Map of the habitat change classification of Timbalier Island for the time periods 1996-2002, 2002-2004, 2004-Jan. 2005, and Jan. 2005-Nov. 2005, and Nov. 2005-2006.

(Figure 3.2-6). Further sand accumulations are apparent along the bay side of the island; some covering marsh habitat but most filling in low areas that were open water in 2005 (Fearnley et al., 2009b).

By the second time period in 2005, material placed in 2004 is beginning to redistribute to the bayside of the island increasing the width, but removal of material from the eastern point of the island results in little increase in the overall area of the island. Much of the material that made up a recurved spit on the eastern end of the island has disappeared by 2006; likely moved to the west by the dominant longshore current in the area. Acreages of intertidal flat, marsh, and barrier vegetation remain stable between the two time periods. More than 50 acres of open water is replaced with beach between 2005 and 2006 and there is an increase in bare land at the expense of beach and intertidal habitat (Figure 3.2-6), which is in agreement with the general redistribution of dredged material placed on the island (Fearnley et al., 2009b).

Ecological monitoring reports on the completed project have yet to be published, but the Louisiana Department of Natural Resources (LDNR) published an ecological review of the project prior to construction based primarily on the performance of other restoration projects that incorporated some of the techniques used in the TE-40 project (Brass and Krumrine, 2003). CWPPRA projects on the Isles Dernieres and Timbalier Islands during the 1990s demonstrate the importance of elevation, vegetative planting, and the use of sand fencing in developing post-construction habitat that provides functions similar to natural barrier islands (Brass and Krumrine, 2003). Vegetative plantings and installation of sand fencing within one year post-construction significantly improves habitat development on the restored island through sustenance of dune integrity and provision of habitat for wildlife (Brass and Krumrine, 2003).

3.2.3 Relevance of Ecological Aspects of Coastal Sediment Management to the GRSMMP

The importance of the sediment-dependent ecology of the Gulf of Mexico coast and its vulnerability to loss from future climate change and ongoing human activities points to the need for sediment management that both appreciates the value of the ecological system and allows the natural dynamics of coastal ecosystems to continue into the future. This can be achieved by a concerted effort to meet the following recommendations.

3.2.4 Recommendations

- The ecological consequences of existing sediment management actions, not only those planned for the future, should be evaluated and potentially mitigated.
  - In many areas, the current nature and long-term sustainability of coastal habitats and the organisms that depend on them are threatened by the way in which sediment is currently managed both at the coast, e.g., the use of hard structures, and in contributing watersheds, e.g., river management. Effective coastal sediment management must address these impacts as well as plan for fewer impacts in the future.
- The ecological consequences of sediment management actions must be considered in the context of future climate change and how they may exacerbate or diminish their effects.
  - Coastal sediment management must consider how future changes in climate, e.g., sea-level rise, changes in temperature and the availability of freshwater, will alter coastal habitats and their associated fauna and flora. Managing sediments to improve the current status of habitats may not be adequate to sustain them in the future.
- Changes in habitat resulting from sediment management should not always be considered

detrimental – the present situation may not be ideal.

    - All coastal environments provide habitat of some type and the current situation may be a result of past sediment management or other changes in the coastal system. If coastal sediment management seeks to improve the condition of coastal ecosystems it is important to consider which habitats or conditions are currently limiting, and to recognize that any change in sediment management will likely result in a change in the configuration of habitats. Both the adverse and beneficial consequences of such changes must be considered.

- The potential ecological benefits should be considered when planning any dredging or sediment management activity as it can be an important tool for habitat restoration.
    - The case study presented here illustrates the scale and pace of habitat improvement which can be achieved by effective planning of sediment placement.
- The effects of sediment management, both positive and negative, on fauna and habitat may not be immediate and monitoring plans to detect ecological effects must be based on the expected response/recovery time of the habitat.
- Monitoring is essential to capture the beneficial effects of sediment management on coastal habitats. Monitoring plans should consider the natural dynamics of the expected communities, the pace of succession and the potential influence of natural disturbances. Just as sediment movement at the coast is not a continuous process, ecological change varies from habitat to habitat and is dependent on external factors such as climate. To effectively detect the potential ecological benefit of coastal sediment management, monitoring may need to occur over years rather than only immediately after the management action.

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3.3 Information Management Related to RSM

3.3.1 Introduction

A principle component of Regional Sediment Management (RSM) is to collaborate and share project data throughout all levels of government and the numerous interested stakeholders. This section discusses opportunities available for storing and sharing valuable information through existing information management tools.

Integrating the appropriate type of technology to assist in the efficient retrieval and distribution of RSM-related data is a key component to the success of an information management plan. Enterprise Geographic Information System (EGIS) is one type technology foundation that supports the fundamentals of RSM. EGIS is defined as the integration of geospatial technology infrastructure to deliver spatial information products, services and standard datasets to all business elements and processes of an organization. The concept of EGIS is to take a complete organizational approach to sharing, using and managing spatial information. If these principles are applied to the information management of GRSMMP data, the ability to collaborate and share assets across participating GRSMMP team members is significantly enhanced.

The U.S. Army Corps of Engineers has developed and/or participated in a number of enterprise GIS efforts including the eCoastal, CE-Dredge, and PHINS programs. Each of these efforts has the necessary architecture that allows adjacent coastal projects to effectively share and access data. These programs are further discussed in greater detail below.

The Priority Habitat Information System (PHINS) is a tool that has been identified as a potential platform/portal for making information available to a variety of users. PHINS is a metadata-driven system that links to data sources and can provide information as to what data is available and how it can be accessed. Other GIS-based support can be made available to support RSM activities, such as the eCoastal Enterprise GIS developed by the Mobile District USACE. eCoastal uses a watershed approach and provides tools for data storage, data management, and analysis.

3.3.2 Enterprise GIS

In order to adequately support the data needs of the Gulf Regional Sediment Master Plan, it is recommended that each contributing organization have a defined internal structure that adequately supports the storage and management of their spatial data holdings. Specifically, the integration of enterprise GIS technology (centralized managed data storage, organizational data standards, accessible flagship datasets, etc.) with the addition of a publicly available web mapping element needs to be established.

An EGIS is how an organization addresses the hardware, software, data, people and methods needed and used. Hardware and software provide the concrete blueprint for the system, establishing the technical foundation. Product selection of these two components is at the discretion of the system engineer. A properly designed enterprise system should be compatible with a variety of hardware configurations.

Software includes a database management system (DBMS), tools for the input and manipulation of geographic information, tools that support geographic query, analysis and visualization, and a graphical user interface (GUI) for easy access to those tools.

The advantages of deploying an EGIS include having a common infrastructure on which to build and deploy GIS solutions; extending geospatial capabilities to nontraditional users of GIS; improving capabilities of other enterprise systems by leveraging the value of geographic information; and increasing overall operating efficiency through the more effective and consistent use of GIS across an organization. An EGIS is the framework of improved business workflows since it applies the geographic approach to relate legacy and new information for better decision making; greater efficiency with money, time and resources; and more effective communication.

3.3.3 eCoastal and CE-Dredge Enterprise GIS

An example of a data management tool developed and widely used by the U.S. Army Corps of Engineers is the eCoastal program. The eCoastal program provides a foundation for a data management plan designed to function as an enterprise GIS. It was developed to concentrate on the specific needs of coastal managers and engineers. eCoastal is an architecture developed by the U.S. Army Corps of Engineers that addresses spatial data standards, geodatabase structure and custom coastal GIS applications. The system can also support various tools for tracking sediment at various scales and has the ability to combine various types of data to view spatial correlations such as habitat types, threatened and endangered species, critical habitats and many other types of data pertinent restoration and conservation actions. Use of this existing system can promote collaboration to avoid duplication of effort and data sharing and compatibility issues.

Following the developmental model of eCoastal, USACE has recently begun the design process for a new program, named CE-Dredge (Corps of Engineers Dredge). This program will expand upon the existing capabilities and data model of eCoastal to more adequately support the dredging mission by improving coordination, communication and decision making in the planning, implementation and management of dredging operations.

One focus of an enterprise GIS is to allow access to data from users inside or outside an organization. Technology enables data to be easily accessible and distributable in a variety of formats. The eCoastal program offers support in understanding the available technologies, such as metadata clearinghouses or Web mapping services, and provides additional guidance on system configuration to bring concepts to fruition. In the case of USACE organizations, eCoastal also provides system design and documentation that is compliant with all Army information technology regulations.

In addition to the technology components, the eCoastal program is a compilation of lessons learned and recommendations for managing a variety of coastal-related datasets in a geodatabase environment. eCoastal provides training to users on the default tools of ArcGIS and custom tools of the eCoastal toolbars to educate coastal engineers in data analysis procedures performed in a GIS environment.

eCoastal is a brand name applied to a number of aspects of GIS technology. This branding allows parties interested in a GIS data management solution for coastal data to easily identify each other within a user community. This user community, which is highlighted on the eCoastal Web site (http://eCoastal.usace.army.mil), can work together and make recommendations to the program, such as geodatabase design, desktop application needs, and interagency collaboration requirements.

3.3.3.1 The eCoastal Data Model

In lieu of using a proprietary data model, the eCoastal database structure is an excerpt from the SDSFIE (*Spatial Data Standard for Facilities, Infrastructure, and Environment)* database model. Under the eCoastal program, a database filter (a product produced using the SDSFIE Filter Maker) is distributed which extracts only the coastal and basemap-related features in the SDSFIE database model (Figure 3.3-1). This provides users with a manageable set of features to begin geodatabase development and population. If a user already has an SDSFIE-compliant geodatabase in place, the eCoastal geodatabase simply refers to the coastal-related features contained in the system.

If the enterprise GIS is initially deployed to only manage coastal data, eCoastal then also assumes the role as the enterprise GIS for the organization. As this type of enterprise GIS program progresses and begins to include various other themes of data, such as military or environmental, then eCoastal migrates to become a subset of the organization's enterprise GIS program.

In each release of SDSFIE, modifications are made to the data model based on recommendations of subject matter experts. In the past, under the eCoastal program, recommendations for changes to feature class properties and attribution have been submitted, integrated and released. These suggestions for modifications were compiled from coastal users' requests and coastal data formatting requirements (e.g., the shoreline feature class required the addition of a date attribute).

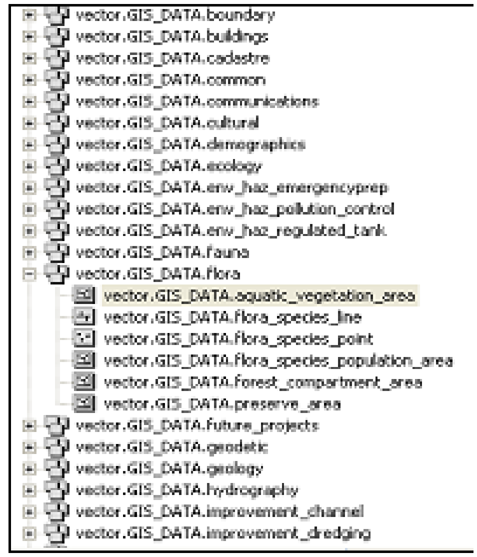

Figure 3.3-1. Nomenclature used by SDSFIE 2.6 for standardized feature datasets and feature classes.

Upon completion of the CE-Dredge program, the coastal data model will be expanded to meet the direct needs for data organization and storage for dredge-specific datasets.

3.3.3.2 Components of eCoastal

The SDSFIE eCoastal Database Filter. The SDSFIE data model contains a wide variety of structure to store a vast amount of different types of data. Using the eCoastal filter, the data model becomes focused on coastal-related data types. This provides users with a manageable set of standards to contain coastal data.

SDSFIE-compliant geodatabase populated with an organization's spatial data holdings. eCoastal does not supply data, rather is supplies a structure to store data and techniques for accessing and distributing data. Figure 3.3-2 is an example of some of the feature classes and corresponding names used by the SDSFIE data model, and distributed under the eCoastal program.

Data management techniques for maintaining compliancy to SDSFIE. The eCoastal engineer manual outlines recommended methods of populating the SDSFIE geodatabase. Populating the geodatabase will require that the content and format of data be examined up front in order to efficiently migrate data into the eCoastal schema and SDSFIE structure.

eCoastal Tools (ArcGIS Desktop Toolboxes and Web Applications). The eCoastal program frequently surveys the coastal engineering community to determine what other technologies, models and/or applications exist that engineers are integrating into their data analysis procedures. There are a number of custom applications that have been developed over the years, as shown in Figure 3.3-3. Applications that require little configuration can be downloaded from the eCoastal Web site. Literature is provided for other more complex applications that require additional configuration, such as database design, lookup tables or Web services.

Note: CE-Dredge will follow much of the same components of eCoastal. Considerable effort will be dedicated to linking to existing enterprise dredging databases. This connection and leveraging of data will ensure users are viewing the authoritative data source, and data entry is only required at a single point.

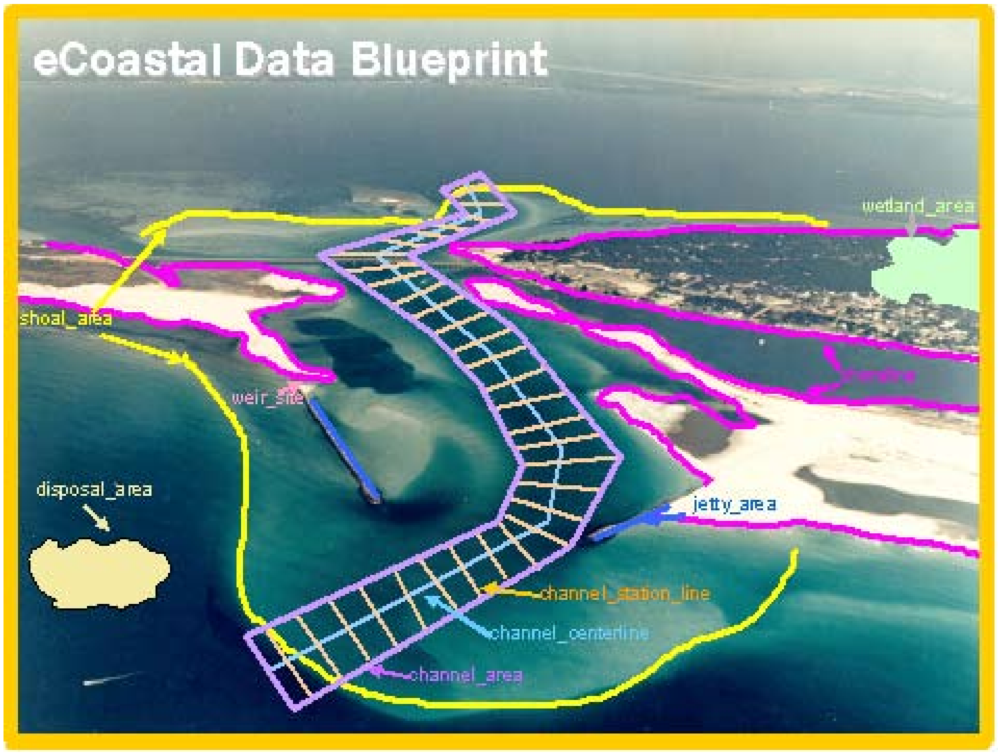

Figure 3.3-2. Example of some of the feature classes and corresponding names used by the SDSFIE data model.

Figure 3.3-3. Example of a custom application developed for navigation.

3.3.4 Management Tools

Regional applications of numerical models and tools can help define the regional system and can be used to evaluate natural and engineering impacts to the system. Regional modeling can be initiated by gathering all available accurate data on waves, shoreline change, engineering activities and natural events such as breaching, sediment type and circulation patterns. This section provides a summary of some of the more widely used models used in RSM applications.

3.3.4.1 Why Use Regional Models and Tools?

Regional models and tools help to develop a systematic approach to a problem, focusing knowledge from different sources. The models and tools can simulate future scenarios with and without project behavior, helping to predict the consequences of an action and helping to determine priorities and data needs. Their use can also identify missing information and provide a guideline to implement best management practices.

3.3.4.2 Categories of Tools

Implementing RSM requires the application of engineering tools for management and analysis including the use of a geographic information system and tools for determining sediment budgets, evaluating watersheds and ecosystems. All tools need both contemporary and historic information.

Sediment Budgets. These tools are helpful in identifying and quantifying pathways and patterns of sediment movement. They apply a suite of hydrodynamic models including: water circulation (Gulf, inlets, and bays); shoreline change (historic and contemporary); wave transformation (deep to shallow water); water level fluctuations (tides, SLR, meteorological); and sediment transport (cross shore, longshore). Other useful information provided includes inlet and structure stability, sand bypassing activities, dredging and placement and other known sources and sinks. Sediment budget tools also define regional impacts from process modifications, help decision makers evaluate those impacts (natural and engineered) and identify data gaps.

Watershed Tools. These tools simulate hydrology, including hydraulics, sediment transport (suspended and bedload) and nutrient loads. The tools require various inputs, such as land use information; water flow; sediment transport rates and budgets; water budget (groundwater, surface water, etc.); water quality; erosion/accretion rates; mapping information (topographic and hydrographic) and imagery (aerial, satellite). The tools assess differences in hydrologic and sediment transport due to changing land use and determine sources and rates of nutrient and pollution input. This in turn helps the implementation of best management practices.

Ecological Tools. These give the user a better understanding of dynamics, structures, and functional interrelationships of ecological processes. Ecological tools consider the effects of physical processes on habitats and ecological processes and help to predict the ecological consequences of other proposed actions (not just physical ones). The tools improve resource management including water, land, biological and sediment transport systems and show environmental resilience, vulnerability, self-repair and damage limitation. They also allow the user to perform habitat evaluation to establish impacts and benefits of habitat quality, quantity and units. Ultimately, ecological tools help support resource management decisions.

GIS. Geographic Information Systems, or GIS, provide a system of data management for an organization's spatial data, including surveys, charts/maps, imagery and shoreline position, generic information such as infrastructure; relevant natural resources including sediment and environmental; and other related information such as dredging records, reports, etc. Having a GIS in place helps establish a baseline, compute differences and volumes and provides an interface with tools and models, ultimately supporting impact evaluations.

3.3.5 PHINS Map Viewer

The PHINS Map Viewer is a Web-based tool for discovering, visualizing, and sharing online geospatial data as illustrated in Figure 3.3-4. It is comprised of two main components: a query interface which searches and filters metadata records provided by NOAA's Geospatial One Stop, and a visualization and presentation system which allows users to create, save and view mashups of available data layers. It supports common geospatial formats such as OGC's WMS standard, ESRI map services and KML.

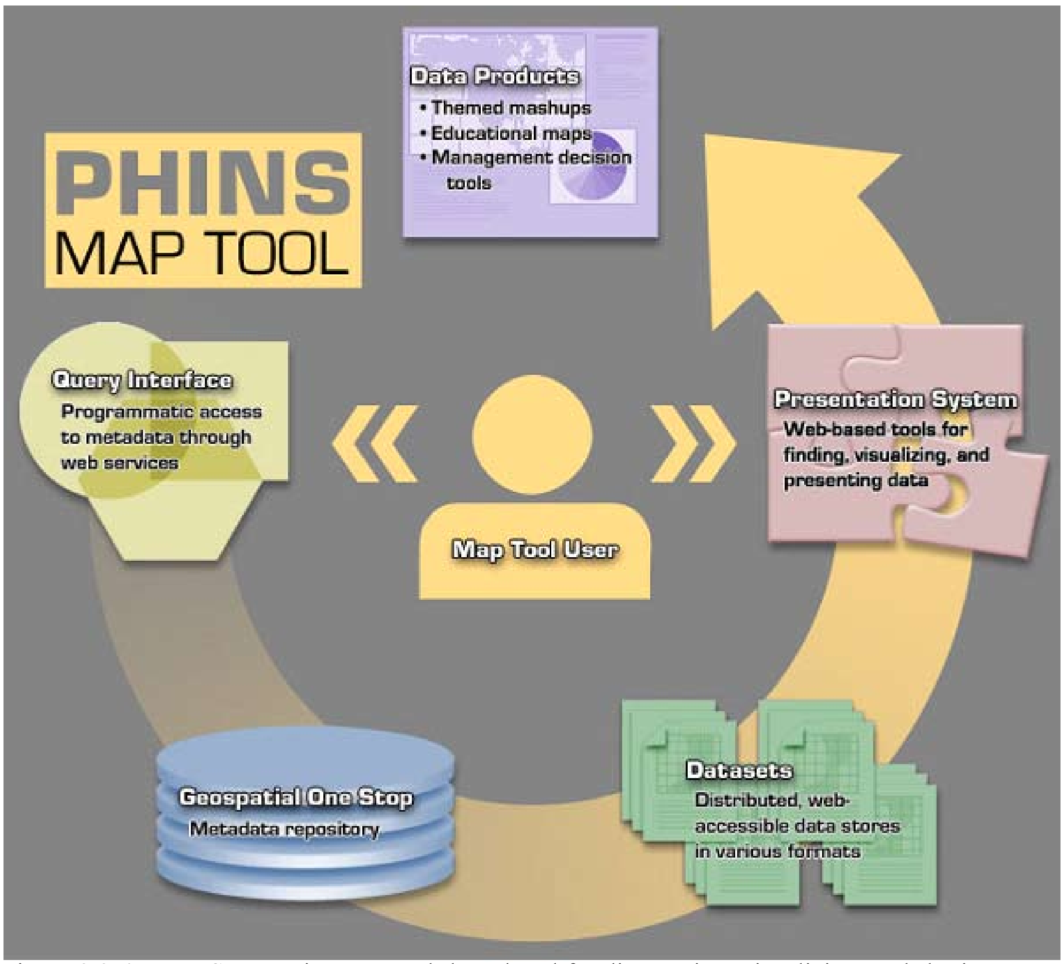

Figure 3.3-4. PHINS Map Viewer, a Web-based tool for discovering, visualizing, and sharing online geospatial data.

Ideally, the viewer will support three tiers of users which represent the stakeholders and beneficiaries of the GRSMMP: students and educators, policy-makers and research scientists. The viewer's interface will reflect this user base. For scientists, a flexible and open-ended query system is paramount. For students and educators, simplicity and pre-built thematic queries might be most useful. Managers and policy-makers would benefit from an interface that lies somewhere in the middle of the power-versus-simplicity spectrum.

3.3.6 Relevance of Information Management to the GRSMMP

To efficiently empower users within the GRSMMP to make educated decisions and perform data analysis to support various projects along the Gulf Coast, participants must have easy access to available datasets. A number of organizations within adjacent geographic areas are simultaneously collecting and distributing data. If an enterprise, organized approach for data management is included within the GRSMMP and all members support this recommendation, participants should easily be able to view, connect and retrieve all types of pertinent information using internet technologies.

Enabling a firm data management plan that includes the publication of planned data acquisition, inventory of available offline data products, and direct access to organization flagship datasets will allow members of the GRSMMP team to locate desirable datasets across many agencies and save time and money previously dedicated to new data acquisitions.

3.3.7 Recommendations

Web Map Services (WMS) allow an organization to publish layers of spatial data information into an open source map. If designed as a publicly accessible service, any user can connect, retrieve and plot the mapping geometry into their preferred mapping technology, such as ESRI's ArcMap, Google Earth, etc. simply by knowing the URL of the map service. If multiple agencies participate in this type of technology, and data exists for the same geographic area, a composite map can be user-generated and associated project information can acquired to meet the specific needs of a selected project. The following are specific recommendations towards implementing regionalized information exchange:

- Encourage regionalization of data and information availability at all levels of project management.
- Selection of universal platform to link and share RSM-related information.
- Promote permissibility of organizations to publish layers of spatial data information into an open source map.
    - Any user can connect, retrieve and plot the mapping geometry into their preferred mapping technology.
    - Allows capabilities for user-generated composite maps to meet the specific needs of a selected project.
- Encourage use of GIS databases and supporting tools to be part of the planning and management process.
- Continue to identify and promote development of data management and associated planning tools.
    - Work with state and Federal agencies that have the resources to assist in this type of research and development.
- Make recommendations for standardization of future data collection, including metadata.
- Link project managers, GIS staff and data managers to develop more user-friendly databases and GIS systems.

3.4 Policies, Authorities, and Funding

3.4.1 Introduction

This focus group identified existing authorities, policies, and funding mechanisms relevant to Federal and Gulf of Mexico (GOM) State dredging activities that affect the implementation of RSM actions and restoration projects. This focus area will be looking at ways to leverage existing state and federal authorities and policies, as well as ways to make them more flexible to facilitate implementing the recommendations that come out of the master plan.(e.g. at the recent meeting there was discussion of potentially placing greater emphasis on consideration of environmental benefits in sediment management decisions). Examples of successful coordination efforts between USACE, non-federal sponsors, and local stakeholders in the GOM States were also highlighted. Recommendations to make policies and authorities more flexible were provided to support suggestions that come out of the overall master plan.

In July 2007 and May 2009 the GRSMMP workgroup met to identify and discuss the major issues associated with this focus area. Discussions at these workgroup meetings indicated a desire to place greater emphasis on the consideration of environmental benefits in RSM decisions. The group prioritized what they thought were the highest priority issues associated with RSM. The top two highest priorities with supporting recommendations consisted of:

- Identifying the limitations in the Federal Standard policy that hinder the beneficial use of dredged material (BUDM) projects and restrict the implementation of RSM principles;
  - Make recommendations to change the policies under which USACE operates.
  - Rethink the least costly alternative mandate for USACE.
  - Present the need for greater flexibility in the Federal Standard as well as the need for additional funding to USACE to support ongoing RSM/BUDM.
  - Regard dredged sediment as a valuable natural resource and even a commodity instead of a waste product.
  - Incorporate ecosystem benefits and services into the cost/benefit analysis.
  - Re-evaluate existing Operation and Maintenance (O&M) projects to include RSM aspects.
  - Identify inconsistencies between and within districts on how the standard is implemented.
  - Involve non-federal sponsors such as port authorities in these discussions.
  - Encourage the states to actively present potential policy changes to their Congressional delegations since USACE and other Federal agencies cannot lobby Congress.
- Highlighting the need for better coordination and communication between USACE, non-Federal sponsors, State and Federal resource agencies, and local stakeholders to implement RSM principles and BUDM projects.
  - Include port authorities, navigation districts, and non-Federal sponsors in discussions with stakeholders to identify RSM and BUDM opportunities.
  - Adopt better planning processes that incorporate local restoration needs in the plans for proposed new or modified channel designs submitted for Congressional authorization.

    - Increase coordination between USACE districts in order for RSM dredging policies to be consistently applied across the Gulf region.
    - Enhance communication among the Gulf states to share knowledge and provide examples of successful RSM coordination efforts.

Other issues and needs deemed important by this group included:

- Submerged lands ownership issues;
- Funding of USACE Continuing Authorities Program;
- Multi-purpose (navigation and restoration) planning for new projects to build BUDM/restoration features into the projects.

3.4.2 Policies

The Federal Standard. Among the priority policy issues raised in developing the GRSMMP was the Federal Standard, the policy associated with USACE dredged material disposal or placement. Because the majority of dredging projects in the GOM coastal region are conducted by USACE to construct, modify, and maintain federally-authorized navigation channels and ports, these activities are significant to the GRSMMP. The Federal Standard is defined in USACE regulations as the least costly dredged material disposal or placement alternative (or alternatives) identified by USACE that is consistent with sound engineering practices and meets all federal environmental requirements, including those established under the Clean Water Act (CWA) and the Marine Protection, Research, and Sanctuaries Act (MPRSA) (see 33 CFR 335.7, 53 FR 14902). The term "base plan" defines the disposal or placement costs that are assigned to the "navigational purpose" of a specific project. The costs assigned to the navigational purpose of the project are shared with the non-federal sponsor of the project, with the ratio of federal to non-federal costs depending on the nature and depth of the project.

Ecosystem restoration is recognized as one of the primary missions of USACE under its planning guidance (ER 1105-2-100), and the placement or disposal option that is selected for a project should maximize the sum of net economic development and national environmental restoration benefits. Therefore, a beneficial use option may be selected for a project even if it is not the base plan option for that project.

If a beneficial use is selected for a project and that beneficial use happens to be (or be part of) the Federal Standard or base plan option for the project (because it is the least costly alternative that is consistent with sound engineering practices and meets all federal environmental requirements), the costs of that beneficial use are assigned to the navigational purpose of the project and are shared with the non-federal sponsor.

If a beneficial use is selected for a project, and that beneficial use is not the base plan option, the costs for the beneficial use option are divided into two categories for the purpose of determining the federal and non-federal sharing ratios. First, the costs assigned to the navigational purpose of the project (i.e., the amount it would have cost to implement the Federal Standard option) are shared with the non-federal navigation sponsor. Second, the costs beyond the navigational purpose costs (termed "incremental costs") are shared with a non-federal sponsor with interest in the beneficial use.

Each USACE dredging project has a dredged material management plan (DMMP) with a designated list of dredged material placement areas (DMPAs) in which to deposit dredged sediments. DMPA types include: confined upland sites bordered by containment levees; confined or partially confined open water sites; open bay disposal areas; ocean dredged material sites; and beneficial use of dredged material

(BUDM) sites such as beach nourishment/dune restoration areas and wetland habitat restoration sites. Each existing DMPA site eligible for use with a dredging project was previously coordinated by USACE with state and Federal resource agencies under the National Environmental Protection Act (NEPA) by means of an environmental assessment (EA) or environmental impact statement (EIS) to evaluate potential environmental impacts. Initial coordination on many DMPAs occurred during the 1970s soon after the implementation of NEPA. Although DMPAs used by USACE base plans have been determined through an EA or EIS to be environmentally acceptable, the placement of dredged materials under traditional practices has often been identified as a contentious issue in the GOM region.

Only the non-Federal cost-sharing sponsor of a navigation project can request a re-evaluation of an existing O&M base plan to change a DMMP to include BUDM alternatives and RSM features. A significant obstacle to implementing BUDM and RSM into existing O&M projects is the inability to adequately quantify proposed ecosystem benefits to justify the increase in the O&M project budget appropriated by Congress.

Previously acceptable dredged material base plans and placement options have been under increasing scrutiny by state and Federal agencies, local citizens, and environmental groups. Many stakeholders have grappled with selecting a disposal method for dredged materials that is the most cost-effective, but impacts the environment the least. Open water disposal, once the accepted norm for dredged material disposal, is no longer favored among the GOM states due to potential negative ecological consequences to marine habitats such as oyster beds and coral reefs. Additionally, recognition of sediment as a valuable, and in some regions a scarce natural resource commodity, reinforces the desire to prevent loss of the sediment from the system through such deep water placement. Dredged material is now sought for beach nourishment, wetland habitat restoration projects, and sediment bypassing to restore natural sediment transport systems.

Although USACE is authorized to conduct BUDM projects as alternatives to established dredging base plans, the Federal Standard requires that the additional "incremental" costs associated with alternatives, such as sediment processing or transportation to a BUDM alternative disposal site, be borne by a non-federal sponsor. Most states, local governments, and port authorities - the likely non-federal sponsors - have difficulty generating sufficient funds to cover these additional costs.

Planning for new Federal navigation projects and improvements to existing projects does allow for the incorporation of BUDM and RSM principles as part of the new or revised base plans that are developed under the USACE General Investigation (GI) program. USACE and the local sponsors solicit ideas for beneficial use sites and RSM components from resource agencies, citizens, environmental groups, and other stakeholders during the public scoping portion of the planning process. Many of these ideals reflect the need to provide mitigation from historic environmental impacts from erosion or replace lost resources such as wetlands, oyster habitat, and bird rookeries. These conceptual ideas are then evaluated during the feasibility study phase of project development with the most technically viable alternatives included in the final design of the overall project. The resulting Congressional authorization and appropriation encompass the BUDM and RSM components as integral portions of the new or improved project design. Since the incorporation of beneficial use alternatives can increase the project cost, the resulting cost-share for the local non-federal sponsor--typically port authorities or navigation districts--often determines the degree of alternative placement options that are included in the final proposed project design.

Additional information regarding the Federal Standard as it relates to BUDM can be found in The Role of the Federal Standard in the Beneficial Use of Dredged Material in US Army Corps of Engineers New and Maintenance Navigation Projects: http://www.epa.gov/owow/oceans/ndt/publications/pdf/2007_fed_standard.pdf

Federal Regulations. A number of Federal and state laws and agencies address or affect dredging and sediment management activities, and thus may be relevant to the GRSMMP. The most significant Federal laws, in addition to NEPA, affecting dredging include: the Clean Water Act (CWA); the Clean Air Act (CAA); the Rivers and Harbors Act; the National Historic Preservation Act; the Endangered Species Act; the Fish and Wildlife Coordination Act; the Magnuson-Stevenson Fishery Conservation and Management Act; and the Coastal Zone Management Act. Similarly, a number of state laws address or affect dredging and sediment management. A summary of Federal and Gulf State laws and agencies with jurisdiction over dredging and sediment management activities is provided in Table 3.4-1. It may be helpful to examine the interrelationships of these policies and regulations in relation to the GRSMMP recommendations, and Alliance priorities.

The main purpose of these regulations in regard to dredging projects is to limit potential adverse effects to critical resources such as endangered species, wetlands, aquatic habitats, fisheries, water quality, and historical cultural resources. Proposed BUDM alternatives and RSM features must also comply with these regulations to ensure that any derived benefits are not negated by adverse impacts to other critical resources.

State Policies. The GOM states have identified the need to use dredged material as a beneficial resource commodity for restoration purposes and to keep the sediments within the natural beach, bay, and estuarine depositional systems. These preferences for BUDM components have been incorporated into the respective state coastal zone management programs (CMP) goals and policies.

Table 3.4-1. Federal and Gulf of Mexico state policies, authorities and responsibilities for sediment management in the Gulf region

Authority/Policy	Responsible Agency	Sediment Relevant Requirement	Comments
Federal			
Clean Water Act; Rivers and Harbors Act: NEPA	USACE	Section 404 and/or Section 10 permits; NEPA document	NEPA may be led by other Federal agency such as MMS
Clean Water Act	EPA	Coordination and comment	
Clean Air Act?	EPA		
Endangered Species Act; Fish & Wildlife Coordination Act	FWS; NOAA-NMFS	Possible Section 7 consultation	Coordination if Federal wildlife refuges affected
Magnuson-Stevens Fishery Conservation and Management Act	NOAA-NMFS	Possible coordination on essential fish habitat	
Outer Continental Shelf Lands Act	MMS	Authority to dredge material	
NGPRA	THPO; tribal representatives	Coordination if tribal interested involved	
Coastal Zone Management Act	NOAA	Authorizes state level review of Federal dredging projects	
States			
NHPA; NGPRA	State SHPO	Coordination if historic properties affected	

State Wildlife regulations	State Wildlife agencies	Coordination if state wildlife refuges affected	
Alabama			
401, CZM, state submerged lands	ADEM	404/10 permit coordination	AL has a state Coastal Area Management Program
Florida			
401; CZM; state submerged lands, CAA	FDEP	404/10 permit coordination	
Louisiana			
401, CAA	LDEQ	404/10 permit coordination	
CZM	LDNR	404/10 permit coordination	
Mississippi			
401, CZM	MDMR	404/10 permit coordination	
Texas			
CAA, 401	TCEQ	404/10 permit coordination	
CZM	Coastal Coordination Council	404/10 permit coordination	
State submerged lands	TGLO	404/10 permit coordination	Has a coastal dune restoration program

A review by state agencies of Federal activities and actions, such as dredging, affecting a state's coastal zone must be consistent with the state's CMP goals and policies. A Federal action or activity could be prohibited from proceeding if the activity is found to be inconsistent by the state. Although Federal consistency review has rarely been used by states as a means to halt a dredging project or cause the modification of dredging base plans, some GOM states are considering use of the CMP review process to encourage more BUDM for Federal dredging projects. Due to the fairly recent national emphasis on RSM, most state CMP policies have yet to incorporate those principles. A listing of GOM state policies with regard to dredging activities can be viewed at: http://coastalmanagement.noaa.gov/resources/docs/finaldredge.pdf.

Other state laws and policies affecting dredging and sediment management in the GOM region include: state water quality certification under Section 401 of the CWA; air emissions permitting under the CAA; state historic preservation office authorization; and use of state-owned submerged land permitting. Some GOM states have enacted specific legislation mandating BUDM where practicable.

3.4.3 Authorities

Since the passage of the landmark Water Resources Development Act (WRDA) of 1986, there has been a major evolution of law and policy concerning the beneficial use of dredged material. Additionally, environmental restoration is now a priority mission of USACE, along with the traditional mission areas of flood damage reduction and inland and coastal navigation. New laws have established the authority of USACE to use dredged material for environmentally beneficial purposes, and programs have been initiated to implement these laws. The remaining challenges to increasing the number of beneficial use projects include educating those with an interest in these new opportunities and creating partnerships to develop and implement them.

Congress has provided USACE with a number of general and specific authorities for planning and implementing projects involving sediments, beneficially using dredged material, and for ecosystem restoration. In most cases, the implementation of projects must be cost shared with a non-federal sponsor, and typically the cost share ratio is 35% non-Federal/65% Federal. Most projects are individually authorized, and implemented with specified rather than programmatic appropriations. With the exception of projects implemented pursuant to a "continuing authority," Congress specifically authorizes projects for ecosystem restoration, ports, harbors and waterways, and coastal storm risk reduction. Financial responsibility for project components is specified in the Water Resources Development Act (WRDA) of 1986, and subsequent amendments.

USACE has several "programmatic" authorities grouped under the "Continuing Authorities Program" (CAP), which enables planning and implementation without additional specific Congressional authorization. CAP environmental restoration authorities include: 1) Section 204, Beneficial Uses of Dredged Material, WRDA of 1992, as amended; 2) Section 206, Aquatic Ecosystem Restoration WRDA of 1996, as amended; 3) Section 1135, Project Modifications for Improvement of the Environment Water Resources Development Act, WRDA of 1986, as amended; and, 4) dredging of contaminated sediments under Section 312, WRDA of 1990, as amended.

The authorizing legislation for each of these authorities contain specific Federal financial participation limits which apply to (1) the amount of Federal participation allowed for each specific project implemented under a CAP authority (per project limit); (2) the amount of Federal participation under a CAP authority in any one fiscal year (annual program limit); or (3) both a per project limit and an annual program limit. More details regarding these authorities can be found in Appendix F of ER 1105-2-100 http://140.194.76.129/publications/eng-regs/er1105-2-100/a-f.pdf .

Relative to specifically authorized projects, CAP projects are of limited size, cost, scope, and complexity. Although there is no specific minimum project size or cost, very small projects recommended in the GRSMMP may be better be implemented by other Federal, state or other agencies or entities. USACE involvement in large or complex problems should be pursued under specific authorizations. CAP authorities may be used to provide additional improvements to a completed portion of a specifically authorized Corps project so long as they do not impair or substantially change the purposes or functions of the specifically authorized project.

Additional authorities that may be relevant to the Alliance development and implementation of the GRSMMP include authorities for:

- Watershed and river basin assessments (Section 202 WRDA 2000). Section 202, WRDA 2000, as amended provides authority to assess the water resource needs of river basins and watersheds including ecosystem protection and restoration, flood damage reduction, navigation and ports, watershed protection, water supply, and drought preparedness.
- Planning Assistance to States (Section 22). Section 22, WRDA 1974, as amended, authorizes the cooperation with states and Indian tribes in preparing plans for the development, utilization, and conservation of water and related land resources of drainage basins, ecosystems and watersheds.
- Investigating the modifications to completed projects or their operation due to significantly changed physical or economic conditions and for improving the quality of the environment (Section 216, the Rivers and Harbors and Flood Control Act of 1970:
- Section 2037 of WRDA 2007 amended the Section 204 CAP program to authorize development of regional sediment management plans to identify and evaluate opportunities for beneficial uses

of sediment from USACE projects. It also expanded the purposes for beneficial uses of sediments to include flood control and hurricane and storm damage reduction, in addition to the original authority for environmental protection and restoration. Through the new provisions, USACE can cooperate with states in preparing comprehensive state or regional sediment management plans.

- The WRDA 2007 also amended some of the USACE general and specific project authorities, as well as added others (e.g. and added others that can support implementation of the GRSMMP in Texas (Sec 4091 Coastal TX ecosystem restoration and protection, and Louisiana (e.g. Title VII, Sec 7001-7016, Louisiana Coastal Area). Appropriations must be provided to implement these authorities.

Congress has also authorized other Federal agencies to undertake restoration activities. Some of the most notable restoration programs are conducted by the National Oceanic and Atmospheric Administration (NOAA), The U.S. Fish and Wildlife Service (USFWS), the Environmental Protection Agency (EPA), and the U.S. Minerals Management Service.

NOAA facilitates restoration efforts through the NOAA Restoration Center administered by the National Marine Fisheries Service to fund and implement quality restoration projects to ensure healthy and sustainable fishery resources. The technical staff of the Restoration Center help to improve project design, ensure environmental compliance, and advance restoration techniques while using scientific monitoring to evaluate restoration project success and efficient use of funding. NOAA collaboration with public, private, and agency partners helps to prioritize projects and leverage resources. Several of the programs administered by the NOAA Restoration Center include the following:

- Large-scaled regional restoration projects conducted under the Coastal Wetlands Planning, Protection, and Restoration Act reduce coastal erosion and reverse wetlands loss nationwide, but especially in Louisiana where tens of thousands of acres of wetlands are lost through subsidence, erosion and marsh die-offs each year.
- The Community-based Restoration Program applies a grass-roots approach to restoration and is designed to actively engage communities in on-the-ground restoration of local habitats.
- NOAA's Damage Assessment, Remediation and Restoration Program works to restore marine resources that have been injured due oil spills, toxic releases, or ship groundings.
- The Restoration Science Program advances emerging restoration technology, science, and cost-effective practices.
- For more information on these programs see http://www.nmfs.noaa.gov/habitat/restoration/

Table 3.4-2. Potential funding sources of beneficial use projects and other habitat restoration projects involving sediment

Authority	Agency	Comments
Section 1135, WRDA 1986 (PL99-662); as amended by Section 202 of WRDA 1992 and Section 204 of WRDA 1996: Project Modifications for Improvement of the Environment	USACE	Non-federal cost share of 25% for incremental costs and non-federal sponsor must operate, maintain, repair, rehabilitate and replace the completed project
Section 204, WRDA 1992 (PL102-580) as amended by Section 207 of WR DA 1996 and Section 209 of WRDA 1999; Beneficial Uses of Dredged Material. Annual appropriation limit of $15 30M.	USACE	Non-federal cost share of 35% of construction costs including providing of land, easements and necessary relocations; 100% of O&M.
Section 206, WRDA 1996, Aquatic Ecosystem Restoration (no linkage to USACE projects required)	USACE	Non-federal cost share of 35% of construction costs.
Section 216, Rivers & Harbors Act and Flood Control Act of 1970(PL910611): Authority of Study Project Modifications	USACE	Needs Congressional authorization of a navigation project modification to use dredged material for environmental restoration
Harbor Maintenance Trust Fund	USACE	
Gulf of Mexido Alliance Governor's Action Plan	NOAA	NOAA Coastal Service Center provided funding in 2008
The Catalog of Federal Domestic Assistance	OMB	Information on all federal assistance programs
The Catalog of Federal Funding for Watershed Protection	Various	Searchable database of all federal financial assistance sources (grants, loans, cost-shoring) available to fund a variety of watershed protection projects. Can be found at: http://www.epa.gov/owow/funding/databases.html

Table 3.4-2. continues

Table 3.4-2. continued

Authority	Agency	Comments
Section 307(a) of Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA or "Breaux-Johnson Act" (PL101-646))	Nationally: USFWS Louisiana: Federal/state task force with USACE oversight	Carry out projects for protecting, restoring, or enhancing aquatic and associated ecosystems. Task force must give wetlands protection, restoration, and creation projects equal consideration with navigation, irrigation and flood-control projects. Establishes a program for Louisiana coastal wetland projects (70%) as well as matching grant program for projects by coastal states (305). Funded through Aquatic Resources Trust Fund (DOI small-engine gas tax). 85% federal/15% state cost share for states with approved Coastal Wetlands Conservation Plans. For states w/out plans, cost-share ratio is 75:25. State contributions must consist of not less than 5% in cash.
Department of the Interior, Environment, and Related Agencies Appropriates Act, 2006 (PL109-54)	EPA	Targeted Watersheds Grant Program. Open to any nonprofit, public or private organization
Coastal Impact Assistance Program (CIAP)	MMS	Federal program providing offshore oil producing states with a portion of outer continental shelf revenues;
CEPRA: coastal erosion planning and response act	Texas	TX General Land Office managed
Coastal Management Program	NOAA	Grant funds available to local communities and organizations for beneficial coastal projects
Galveston Bay Estuary Grant Program	Sponsored by TX CEQ	Grants to create solutions to local water pollution problems in Galveston Bay watershed
Alternative Financing Ideas for Beneficial Use Projects (from Identifying, Planning and Financing Beneficial Use Projects Using Dredged Material)		
Clean Water State Revolving Fund (CWA 1987 amendments); Section 319 money	States	States have established SRF programs. Loans may be issued to public, nonprofit or private entities for non-point source and estuary projects. These funds may be used for beneficial use projects, but have not commonly been funded in the past.
Establish and special assessment district	State/local	Have the power to levy taxes and collect fees and special assessments to pay for developing and operating beneficial use projects.
Implement tax-increment financing	Local	Create a special district to maintain two sets of tax records; one that reflects the value of assets up to the time of the enhancement (project), and a second that reflects any growth in assessed property value in the district after the enhancement.

Table 3.4-2. continues

Table 3.4-2. continued

Authority	Agency	Comments
Create Habitat or Parks and Recreation stamps patterned after duck stamp programs	States	Sell stamps as a source of revenue to supplement O&M, provide grants or loans or as matching funds for additional projects.
Community Bond Bank	Local	Small-denomination bonds backed by local taxes, park entrance fees, license fees and other dedicated revenues can be “pooled” in a bond bank and offered as a single bond issue to finance a beneficial use project.
Issue mini-bonds for wetlands creation, park development, beach replacement, etc.	Local	For purchase by general public and dedicated to a specific beneficial use project. Designed to be collectable or used as gifts as well as provide small investment opportunities.
Issue credit card benefiting environmental fund dedicated to a particular project	Private company or environmental organization	Works with bank to issue the card, fixed amount per card and small percentage of spending on the card is donated to the fund.
Alternative Financing Ideas for Beneficial Use Projects (from Identifying, Planning and Financing Beneficial Use Projects Using Dredged Material)		
Create/expand commemorative license plate program	States	Revenues placed in a fund for O&M or new grants
Create an endowment fund	Private	Same as above
Public Sector Service fees	State/local	Fees associated with public sector oversight could be modified to cover more of the costs.
Require a beneficial use “checkoff” for certain products	State/local	Products used at a site created or enhanced by dredged material include a fee applied to O&M.
Dedicated sales tax surcharge	State/local	Added to existing prepared food and beverage sales tax
Establish public-private partnership		Under a tax-exempt lease arrangement, a public partner can finance a beneficial use project by borrowing funds from an investor or financial institution. Title is obtained when the loan is repaid.

USFWS is active in coastal restoration through the National Coastal Wetlands Conservation Grant Program which was established by Title III of P.L. 101-646, Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) of 1990, also known as the Breaux-Johnson Act. Under the program, USFWS provides matching grants to states for acquisition, restoration, management or enhancement of coastal wetlands. The Act also establishes a role for the Fish and Wildlife Service in interagency wetlands restoration and conservation planning in Louisiana.

The EPA's National Estuary Program (NEP) was established by Congress in 1987 to improve the quality of estuaries of national importance. Section 320 of The Clean Water Act directs the EPA to develop plans for attaining or maintaining water quality in estuaries. This includes protection of public water supplies and the protection and propagation of a balanced, indigenous population of shellfish, fish, and wildlife. It also allows recreational activities, in and on water, and requires control of point and nonpoint sources of pollution to supplement existing controls of pollution.

An NEP initiative can involve participation from more than one state. Each program establishes a comprehensive conservation and management plan to meet the goals of Section 320. These plans can inform development of GRSMMP recommendations and potentially facilitate implemention of restoration efforts. NEPs focus on the watershed, use science to inform decision-making, emphasize collaborative problem solving, and involve the public.

There are seven NEP Study Areas in the Gulf of Mexico region. The CCMPs developed to date contain wide-ranging actions to address habitat loss and degradation. These include efforts to acquire or preserve open space, develop conservation easements for riparian buffer areas, and restore or create habitats through revegetation programs; efforts to improve water quality through upgrades in wastewater treatment plants, or improved stormwater and septic systems; the monitoring and mapping of critical areas; and public outreach and education activities. All of these efforts are carried out through partnerships between federal, state, and local agencies with assistance from private and nonprofit sectors and citizens.

MMS was given responsibility for the Coastal Impact Assistance Program (CIAP) with the passage of the Energy Policy Act of 2005 that amended Section 31 of the Outer Continental Shelf Lands Act (43 U.S.C. 1356a, Appendix A). Congress recognized that impacts from Outer Continental Shelf (OCS) oil and gas activities fell disproportionately on the coastal states and localities nearest to where the activities occurred, and where associated facilities were located. The CIAP legislation appropriated money for eligible states and coastal political subdivisions for coastal restoration/improvement projects. The MMS will disburse $250 million to eligible producing states and coastal political subdivisions.

3.4.4 Funding

Navigational dredging is a relatively expensive activity due the difficulties of conducting heavy construction in harsh marine environments. The overall cost of dredging has increased over time as fuel, labor, and material costs rose. It has become increasingly difficult for USACE to obtain adequate dredging O&M funding through the standard Federal budget process to properly maintain existing Federal channels at authorized depths. Congressional delegations for coastal states routinely must seek project-specific appropriations through "earmarks" to try to maintain funding for O&M programs for the USACE districts in their states.

Since most BUDM alternatives and RSM features require additional funding above that required for existing dredging base plan disposal options, the Federal Standard limits USACE financial participation in alternative disposal options to the amount required to execute the O&M base plan. The additional funding needed for BUDM and RSM projects above the base plan cost, often referred to as the "incremental cost," must be provided by a non-federal entity or sponsor for the BUDM option to be performed by USACE. The lack of non-federal funding available to local sponsors to pay for the incremental costs severely limits the amount of BUDM activity conducted by USACE.

As previously mentioned in the Authorities section, a number of Federal funding and assistance programs, including USACE's CAP, have been established to assist with funding of RSM and BUDM activities. Other Federal programs that could be used to help fund restoration efforts using RSM and BUDM include: CWPPRA, CIAP, and NEP funding.

Another Federal funding source that could be used to help fund RSM and BUDM activities is the Harbor Maintenance Trust Fund (HMTF) that was established in 1986 to fund O&M of Federal ports and harbors. The HMTF is funded through the collection of the Harbor Maintenance Tax against the value of imported and domestic cargo arriving in Federally maintained ports and harbors. In 2009 the HMTF had a balance of approximately $4.7 billion, but over the past five years, annual expenditures for channel maintenance from the HMFT have averaged less than $800 million. Full use of the HMFT could expand the amount of O&M funding available to USACE and its non-federal sponsors.

A summary of potential funding mechanism for RSM and BUDM activities is provided in Table 3.4-2.

Some states have developed funding sources to help pay the incremental costs associated with BUDM projects. In 1999, Texas enacted the Coastal Erosion Planning and Response Act (CEPRA) Program funded at $15 million biennially to implement erosion response projects. CEPRA funds have been used to pay the incremental costs for beach nourishment projects at Rollover Pass in Galveston County, South Padre Island in Cameron County, and wetland restoration at the Texas Point NWR in Jefferson County. The Texas General Land Office also established a memorandum of agreement with the USACE Galveston District that streamlined the planning and fund transfer process for BUDM projects on all Federally maintained channels in the state.

3.4.5 RSM and BUDM Enabling Tools

BUDM projects and RSM principles have been successfully implemented in sub-regions of the Gulf Coast by using a variety of administrative tools. This has been facilitated by the development of coordination teams to engage state, Federal and local partnerships to identify and promote beneficial use alternatives and improve the management of sediment resources. These partnerships have been in the forms of Interagency Coordinating Teams (ICTs), Beneficial Uses Groups (BUGs), working groups, and dredging conferences to accomplish the sub-regional sediment management objectives. Some examples of such partnerships in the GOM states are described below:

- **The Houston-Galveston Navigation Channel (HGNC)** ICT was created to address key environmental issues and concerns associated with the proposed widening and deepening project of the Houston Ship Channel in the early 1990s. The 12-member team was formed from state and federal resource agencies, local stakeholder groups, as well as the Port of Houston Authority and the Port of Galveston. In order to find solutions to the identified key issues associated with the HGNC Project, the ICT formed several subcommittees, comprised of members from state and federal agencies with scientific expertise in different environmental and biological disciplines. Subcommittees included, the BUG, the Oyster Committee, Cumulative Impacts Group and the Benthic Recovery Group, among others. The task of the BUG was to help guide formulation of the Beneficial Use Plan for the construction of wetlands and bird habitat and maintenance of those sites over the project lifespan. For more information on the HGNC BUG see: http://www.betterbay.org/html/media/BUGProjectOverview.DOC.

- **The State of Louisiana and New Orleans District Working Group** has compiled a list of beneficial use projects and set in motion an ongoing process to find and/or create opportunities for the beneficial use of dredged material resources from navigation channel O&M dredging episodes. The group has been coordinating efforts to get projects “environmentally cleared” and “on the shelf” ready for any and all funding opportunities that might be able to implement the projects.
- **The Beneficial Users Group for Coastal Mississippi (BUG)** is coordinated by the Mississippi Department of Marine Resources, Bureau of Coastal Preserves with the aim of maximizing the potential to use dredged and other (concrete rubble, etc.) material for habitat restoration projects. The Bureau of Coastal Preserves initiated meetings of the BUG with regional partners and stakeholders. Attendees included staff from USACE, NOAA NMFS, USFWS, Senator Thad Cochran’s Office, Congressman Gene Taylor’s Office, MS Department of Environmental Quality, MS Secretary of State, EPA Gulf of Mexico Program, and the MS Department of Marine Resources. Coastal counties, ports and local entities have been invited to participate in this effort as well. The BUG meets quarterly and the fourth consecutive meeting was held on June 17, 2009.
- **Coastal Preserves** is currently working with USACE and other BUG partners to find ways to replace the material lost from the Deer Island marsh restoration site during Katrina and restore site elevation back to the original project design. A contractor working on a Jackson County dredging project placed approximately 30,000 cubic yards of sandy material within the restoration site. The dredged material was placed beneficially at the Deer Island site at no additional cost. In fact, the contractor’s cost to use Deer Island is lower than their cost to use their original non-beneficial upland disposal site.
- **USACE Galveston District Annual Dredging Conference** is an example of another tool that has been used to facilitate BUDM and RSM actions. The Galveston USACE District hosts dredging contractors, port authorities, navigation districts, waterway users, and state and Federal resource agencies to discuss upcoming dredging schedules and potential BUDM opportunities. Dredging schedules for the following two years are discussed to so that adequate time is allowed for environmental coordination, engineering design, contracting, and funding acquisition to help BUDM opportunities succeed.
- The Sediment Compatibility and Opportunistic Use Program (SCOUP) is an example of a collaborative effort from southern California that could be used in the GOM region. SCOUP is the result of California’s Coastal Sediment Management Workgroup (CSMW), USACE, and the San Diego Association of Governments to present a process crafted to streamline regulatory approval of small (less than 150,000 cubic yards) beach nourishment projects using opportunistic materials. Technical and regulatory concerns associated with BUDM were identified. Addressing those concerns in a systematic and consistent manner is part of CSMW’s thrust to streamline sediment management activities across California. Regional management of sediment is the stated goal of the State of California Resources Agency and USACE, the founding partners of the CSMW. For additional information on SCOUP see: http://www.dbw.ca.gov/CSMW/PDF/Final_SCOUP_Master_Plan.pdf.

3.4.6 Relevance of Policies, Authorities, and Funding to the GRSMMP.

It is useful to identify sources of existing related information and examine means to provide greater flexibility to support restoration projects. In doing so, existing authorities and policies can be brought together, ultimately showing how they might be modified to promote RSM actions. The information presented here provides greater insight at ways to make policies and authorities more flexible to facilitate recommendations that come out of the master plan.

3.4.7 Policies, Authorities, and Funding Recommendations

The following is a list of recommendations that were developed from workshop and teleconference discussions of the GRSMMP work group and the Policies, Authorities, and Funding Focus Area work group:

- Language regarding RSM principles should be placed into all Gulf State CZM Plans through enhancement polices and/or enforceable policies. Model policy language could be developed by the GRSMMP work group as a starting point for consistent RSM themes to be adopted by states.
- GOMA should provide leadership for integrating environmental benefits and coastal zone management policies into the Federal Standard decision-making process.
- Regional beneficial uses groups should be established across the Gulf Coast.
- The most beneficial sediment placement practices should be used, even if the material is not currently being used as borrow for a specific project.
    - Keep sediment in the natural system to maintain sediment transport systems or to utilize sediments in a way to benefit ecological systems.
- Develop more flexible dredged material management alternatives.
- Find innovative ways to utilize fine-grained sediments.
- Develop recommendations to the Principles and Guidelines used by USACE to place more emphasis on environmental restoration benefits.
- Revisit O&M base plans, National Ecosystem Restoration plans, and National Economic Development plans for existing projects. Base plans may contain elements that are no longer considered environmentally acceptable.
- Recommend funding levels to adequately implement BUDM/RSM principles at all projects.
- Fully use the HMTF for its intended purpose of funding Federal channel O&M.
- Make recommendations that environmental considerations be taken into account in benefit-cost analyses. When projects are reviewed by the Office of Management and Budget, environmental considerations and benefits are not adequately taken into account, and OMB does not know how to quantify environmental benefits for O&M. BUDM is currently considered as project cost without credit given for ecosystem restoration benefits or storm damage reduction benefits.
- The economic value of sediments should be considered. Sediment as a natural resource is a commodity that has a monetary value.
- Non-service values and net intrinsic values should also be considered in cost-benefit analyses.
- Environmental benefits should be considered through cost incremental and cost effective analysis. An example of this is the Florida cost-benefit analysis for living shorelines.

- The quantification of ecological benefits of BUDM should be captured and considered in cost -benefit analysis. More work by environmental economists and planners is needed to better develop standardized processes to quantify environmental benefits.
- The non-Federal project sponsors need to be engaged early and brought into the RSM and BUDM planning process.
- GOMA could provide leadership to push the monetization of environmental benefits of RSM/BU forward. State and Federal Natural Resource Damage Assessment programs could provide the model for this process.
- Loss of wetlands and the loss of dredged sediments should be viewed as an economic loss such that not using dredged sediments in BUDM is a negative project cost. Justification for not using sediments in a beneficial manner should be required. A unit cost could be placed on sediment not used beneficially.
- A national goal of No Net Loss of Sediments through anthropogenic processes should be developed similar to the No Net Loss of Wetlands goal.

4.0 MANAGING GULF SEDIMENTS IN THE FUTURE

4.1 Next Steps

This document presents the technical framework necessary to understand the impact and significance of wise sediment management practices in a regional context and does not yet put forth the desired guidelines on how to implement regional sediment management throughout the Gulf. The intent is for the Alliance partners to use the information presented here concerning the regional sediment processes consisting of sediment inventories, sediment budgets and transport processes, navigation activities, and ecological processes as well as other regional priorities, and evaluate what this means in relation to current management practices within the sub-regions around the Gulf. Outcomes from these evaluations will be the beginning of a process of formulating guidelines and recommendations on how management and planning practices can be improved to make better decisions on a regional scale. This approach will be critical towards improving the design, maintenance, and overall regional management practices throughout the Gulf.

This framework outlines the technical underpinnings that must be considered and presents some of the benefits and challenges associated with implementing the RSM philosophy. The intent is to promote consideration of this approach as a part of planning and management process for all projects involving sediment. Doing so requires a corporate commitment and establishing partnerships with associated stakeholders at all levels of government. Implementing regional sediment management requires the proper balance of engineering, technology, information, and tools to feed the management decisions necessary in achieving the RSM approach. Without this balance and levels of commitment, the benefits of RSM cannot be fully realized. This management approach is not well established within the resource management community and the general public. It is, therefore, important for such practices to be promoted through continued public outreach programs which would contribute to solving these issues and educating people on the benefits of RSM.

The next phase in the development of the GRSMMP will involve establishing guidelines based on future development and refinement of the recommendations presented within this technical framework. The GRSMMP will also reflect the goals and objectives set forth by the Governors' Action Plan II as established for the Habitat Conservation and Restoration Team (HCRT). The activities associated with accomplishing these goals and objectives are actively being formulated by the HCRT. Some of the suggested activities include organizing workshops, conference calls, and webinars to discuss and develop specific recommendations regarding RSM applications, coordination improvements, information gaps and other items needed to facilitate RSM in the region.

Such activities could be held at various levels, by state, Corps Districts, or other forums that may be appropriate. Identified activities may be organized by sub-region to address what the sediment regimes in that region (process, sediment resource inventories) and how this information might influence sediment management activities in the region. This includes but is not limited to dredged material management, beneficial uses, restoring and sustaining coastal habitats, freshwater diversions, sediment diversions, erosion control actions, and other potential sediment management improvements. Some potential forums include annual dredging meetings, estuary programs, beneficial users groups (BUG), and port authorities around the Gulf.

It is envisioned that the GRSMMP will be a "living" product that can be cultivated as more information and experience become available. Future versions of the GRSMMP will include and address topics that include:

- Characteristics of successful GRSMMP implementation
- Roles in implementing the GRSMMP
- Comprehensive recommendations from focus areas to the GRSMMP
    - Gulf-wide recommendations
    - Sub-regional recommendations
    - Local recommendations
- Economic considerations in sediment management
    - Improved functional ecological systems
    - Ecosystem services
    - Restored habitats
    - Restored resources
    - Improvements to sediment management systems socio-economic values
    - Sediment as a resource
    - Resiliency and coastal protection
- Social considerations in sediment management
    - Improved functional ecological systems
    - Ecosystem services
    - Restored habitats
    - Restored resources
    - Improvements to sediment management systems socio-economic values
    - Value of non-structural management actions
    - Resiliency and coastal protection
- RSM priorities
    - Gulf-wide priorities
    - Sub-regional priorities
    - Local priorities
- Capitalizing on opportunities

4.2 Other Suggested Sediment-Related Efforts

It is important to establish forums that facilitate sharing information and networking about technical studies relevant to understanding regional sediment systems and regional approaches to sediment management. The notion is to provide a means for technical experts to coordinate and collaborate, and to provide ways to translate and share this information with resource managers, sediment managers, regulatory agencies, etc.

- *Mississippi River Suspended Sediment* **-** A regional approach to managing sediments in the Gulf region requires consideration of both bedload and suspended sediments. This is particularly important to habitat conservation and restoration in Louisiana, but may also be relevant in other states, particularly in discussions of sediment and freshwater diversions. Results should soon be available from a Mississippi River sediment load study that can help inform future GRSMMP information needs and management approaches.
- Mississippi River Management, Modeling and Assessment Workgroup - A regional Mississippi River work group may be useful to improve coordination about model development for the river so that there aren't multiple models of the same thing on the river, and so interested parties can discuss pooling resources and collaboratively shaping models to support assessment of diversion effects on the river bathymetry, hydrodynamics, and other dredging needs.

GLOSSARY OF TERMS

Beneficial use – Utilizing dredged sediments as resource materials in productive ways. In this plan, it is used synonymously with beneficial "reuse" of dredged material.

BUG – Beneficial Use Group

Region - A geographic area characterized by the sediment system associated with the project or activity. Regional and sub-regional boundaries should be refined through the development of quantified sediment budgets that are based upon the identification of sediment transport pathways and volumes. Defining a sediment region will enhance considerations of the effects of the sediment regime on the project over time, the interactions among projects and actions within a region, and the effects of projects and activities on the sediment regime relative to regional objectives or concern. The region should be defined over the appropriate geographic scale to capture major interactions and dependencies of different parts of the system over time.

RSM - Regional Sediment Management (RSM). A systems-based approach to managing sediment resources within the context of regional strategies (watershed, esturarine, coastal) that address integrated sediment needs and opportunities.

Sediment Budget - The qualitative or quantitative characterization of the sediment transported into and out of an area. A sediment budget is used to analyze current conditions, hindcast historical conditions, and predict future performance of proposed projects or activities. The premise behind a sediment budget is that sediment is transported into and out of areas, potentially resulting in areas that erode or accrete. Balancing the inflow and outflow of sediment resources for a given region can be important to maintaining system stability for a variety of project and resource management objectives and for predicting future system behavior and associated effects on projects. The amount of sediment in a given area is a balance between the inflow, outflow, and amount stored in the littoral cell, reach, etc.

Sediment Management Activities - Includes the projects and activities that affect the transport, erosion, removal, and deposition of sediment in a region. Examples include: dredging and placement; construction of structures that divert or trap sediment; erosion protection structures or methods for riverbanks, shorelines, sea beds, channels; habitat stabilization and restoration; Sand and gravel mining for construction or other purposes.