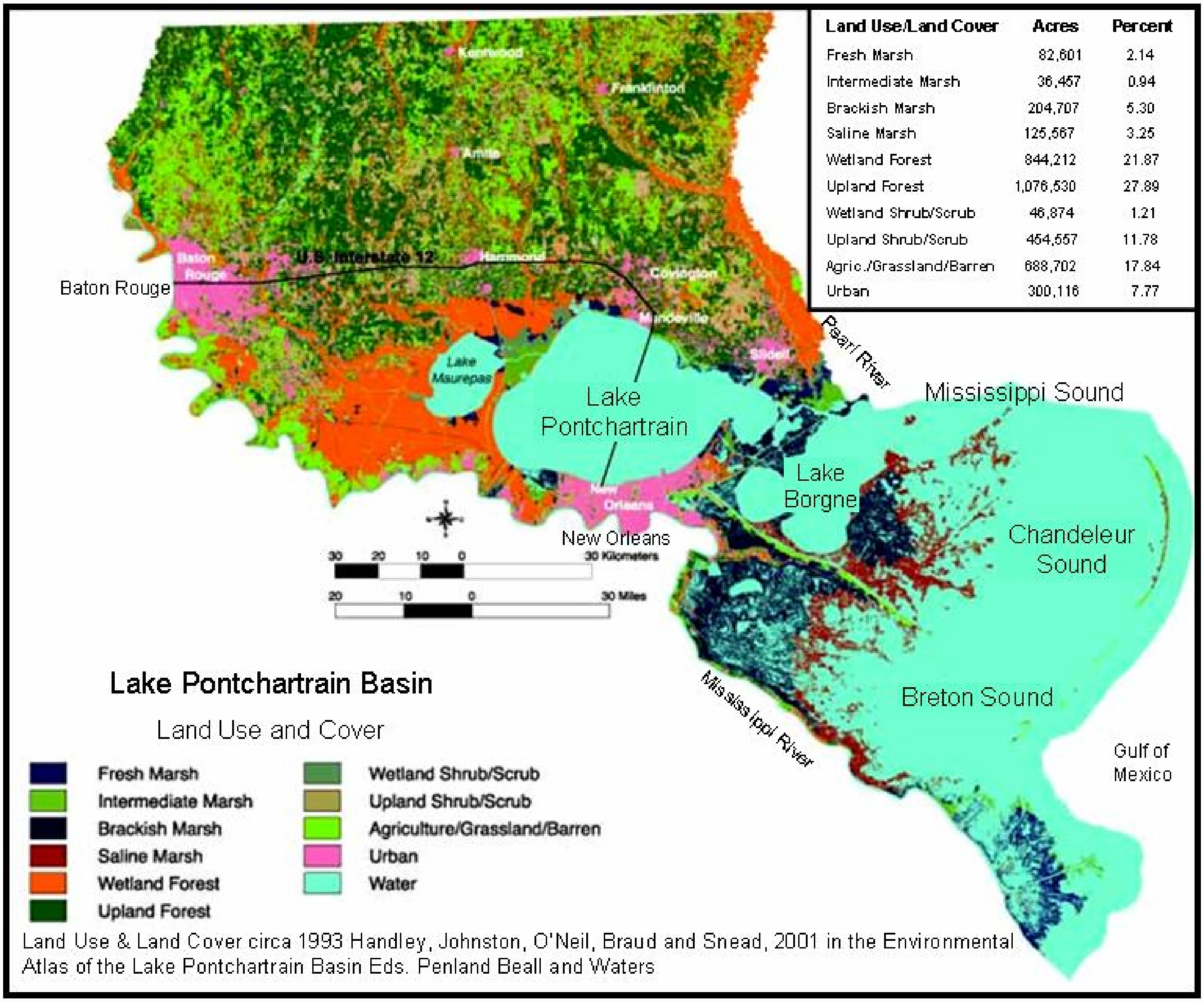
COMPREHENSIVE HABITAT MANAGEMENT PLAN FOR THE LAKE PONTCHARTRAIN BASIN



Land Use/Land Cover	Acres	Percent
Fresh Marsh	82,601	2.14
Intermediate Marsh	36,457	0.94
Brackish Marsh	204,707	5.30
Saline Marsh	125,567	3.25
Wetland Forest	844,212	21.87
Upland Forest	1,076,530	27.89
Wetland Shrub/Scrub	46,874	1.21
Upland Shrub/Scrub	454,557	11.78
Agric./Grassland/Barren	688,702	17.84
Urban	300,116	7.77

LAKE PONTCHARTRAIN BASIN FOUNDATION

FEBRUARY 28, 2006 - FINAL

SAVE OUR LAKE
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Numerous color figures in this report will not be as effective in black and white print or Xerox.
This report is in color on-line at saveourlake.org where it may be downloaded or printed.

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MISSION STATEMENT

Given that the mission of the LPBF is to restore and conserve the natural resources of the Pontchartrain Basin, the Comprehensive Habitat Management Plan (CHMP) should provide a blueprint to execute this mission by providing general guidance as well as specific actions deemed appropriate to best restore and conserve the natural habitats of the Pontchartrain Basin within a 50 to 100 year time frame.

The CHMP provides a selection of goals, strategies and methods based on the collective expertise of natural resource specialists who share LPBF's mission. The CHMP report includes recommendations and goals that are potentially far-reaching, visionary, and wherever possible, coupled with strategies that are most likely to align resources required to achieve the LPBF mission.

(The habitat component of the CHMP does not include water quality for human health as a goal since this is covered by other sections of the 1995 CMP report.)

EXECUTIVE SUMMARY

The greater Pontchartrain Basin includes a watershed extending southward from central Mississippi to the distant wetlands at the mouth of the Mississippi River in southern Louisiana. In this report, "Pontchartrain Basin" refers to the area of the basin within Louisiana, which includes all of the area in Louisiana, east of the Mississippi River excluding West Feliciana Parish. The Pontchartrain Basin has been divided into four sub-basins to analyze the baseline conditions, impairments and restoration needs of each. The objective of the report is to present a comprehensive habitat management plan that will direct progress towards restoring the historic form and function of the Pontchartrain Basin habitats.

The Pontchartrain Basin is an ecosystem dominated by an estuarine system that is essential to the future of southeast Louisiana. The Pontchartrain Basin is 19% (9,700 square miles) of Louisiana's area and has within it 46% of the state's population (or 2.1 million people). Based on imagery from 1992 to 1995, the entire basin was estimated to hold 2,100 square miles of marshes and swamps (including the Pearl River alluvial swamps) (Handley and others, 2001). The area of all wetlands and open water (lakes, etc.), which composes the Pontchartrain Basin estuary, is 5,800 square miles. From 1932 to 2001, 415 square miles of these wetlands were converted to open water or upland habitat, and we have discovered that the rate of loss has dramatically increased in the last decade (1990 - 2001). Preliminary estimates suggest that Hurricane Katrina in 2005 caused at least as much loss of marsh as in this entire prior decade (~80 square miles). Because the Pontchartrain Basin contains the great port cities of New Orleans and Baton Rouge, the fate of the Pontchartrain Basin is of national significance. Decades of poor stewardship of the region's natural resources triggered the founding of the Lake Pontchartrain Basin Foundation (LPBF) in 1989, which was given the mission to restore and preserve the Pontchartrain Basin.

From 1991 to 1995, LPBF developed a Comprehensive Management Plan (CMP) for the Pontchartrain Basin. Phase III of the CMP was the final step in this initial CMP development for LPBF. In Phase III, three particular environmental issues were developed in further detail. One of these was the issue of "Saltwater Intrusion and Wetland Loss". This section was drafted by a select committee of professionals. Since 1995, extensive research has been published on the Pontchartrain Basin and new issues have been identified, resulting in a need to revise the section regarding "Saltwater Intrusion and Wetland Loss". Further, it was determined that this addendum to the CMP should be expanded to include all the habitats of the Pontchartrain Basin. This report is an addendum to the 1995 CMP, but supersedes the older section of the report addressing wetlands. This report will serve as LPBF's blueprint for restoration and conservation for all habitats within the Pontchartrain Basin. In continuance of these efforts, in 2005, LPBF established a Coastal Sustainability Program for the Pontchartrain Basin.

In 2004, a Comprehensive Habitat Management Plan (CHMP) - Draft Committee was created to evaluate impairments and restoration alternatives for habitats in the Pontchartrain Basin (see addendum for members). During the analysis and drafting process, new data were made available which indicate accelerated land loss rates in the Pontchartrain Basin and thus added greater justification and urgency to the completion of this initiative.

The committee began deliberations in January 2004 and submitted a draft report to expert reviewers in July 2005 (see addendum). The reviewers were requested to individually review the entire CHMP draft report or appropriate sections related to their expertise. Their comments were reviewed and appropriate changes were made by the CHMP Draft Committee.

Public Meetings were being scheduled for August and September 2005 when Hurricane Katrina struck Louisiana on August 29, 2005. Due to the highly scattered population, the draft CHMP was posted on the LPBF website. Public meetings will be held when feasible. In response to the impacts of Hurricanes Katrina and Rita, the CHMP draft committee was questioned about what changes should be made to the CHMP. Appropriate changes were made including an addendum on impacts of Hurricane Katrina and Rita.

The Pontchartrain Basin habitats range from pine upland to estuarine to marine. For purposes of CHMP plan development, the Basin was divided into four Sub-basins including: Upland Sub-basin (north of Interstate 12), Upper Sub-basin (Lake Maurepas region), Middle Sub-basin (Lake Pontchartrain region) and Lower Sub-basin (St. Bernard and Plaquemines Parishes). The following section summarizes the proposed restoration for each of the four Sub-basins.

Upland Sub-basin Forest Recommendations (North of Interstate 12)
The overall goal in the Upland Sub-basin is to expand the current range of longleaf pine upland forests, flatwood savannahs and associated habitats while expanding the awareness of these lost habitats to a public which has never known the park-like virgin pine forests. Specific goals call for expansion of existing conservation areas to a minimum of 5,000 acres each and creation of one or two large conservation areas (ca. 50,000 acres each) where landscape-scale, fire-dependent ecosystems can be re-established with indigenous flora and fauna. Establishment of a prescribed fire council is recommended as a key means to facilitate and expand effective use of prescribed fire. The red-cockaded woodpecker and other rare, threatened or endangered species warrant additional efforts to reestablish longleaf pine and associated habitat and expand their populations.

Upland Sub-basin riverine recommendations (North of Interstate 12)
The rivers and streams of the north shore are highly degraded and their history of environmental impacts is poorly documented. A primary recommendation is to document historical and ongoing impacts from mining activities in particular. Many mine sites (sand and gravel dredging) should be targeted for remediation to improve riverine habitats and water quality. Freshwater mussels have been significantly reduced and further protection and habitat restoration is necessary to re-establish the range of mussels including the endangered inflated heelsplitter mussel *(Potamilus inflatus).* In addition to mining, the Bogue Chitto and Pearl Rivers have been impacted by the Pearl River Navigation project. Hydrologic restoration is recommended to re-establish the natural migration of fish, including the threatened Gulf sturgeon (*Acipenser oxyrinchus desotoi).*

Upper Sub-basin (Lake Maurepas and adjacent wetlands)
It is recommended that the area of wetlands in the Upper Sub-basin, which lies on or adjacent to the natural levee of the Mississippi River, be reestablished with its natural connection to the river by spring reintroductions into the wetlands. These alluvial river swamps would be sustained by several small diversions recommended between Baton Rouge and Garyville where the Hope Canal project is to be constructed. The reintroductions are intended to increase plant growth (primary productivity) and rebuild a mature Bald cypress –Tupelo (*Taxodium distichum – Nyssa aquatica*) swamp. The benefited areas should be in conservation. Breaching of the bank of the Amite River Diversion Canal is recommended to increase circulation into the adjacent swamp. It is

recommended that the wetlands north of Lake Maurepas be optimally managed using treated sewage or stormwater runoff, where appropriate, to introduce nutrients and freshwater. In all of the Upper Sub-basin, cypress logging should be prohibited in areas which are classified as relic forest. A moratorium is recommended on all other cypress logging until Best Management Practices (BMP's) are established to assure a sustainable forestry. Avoidance, BMP's and local mitigation are recommended to prevent further loss of wetland habitat by urbanization.

Several position statements are also included for the Upper Sub-basin. Key statements are the continued ban on shell dredging and any commercial dredging within Lake Maurepas. The continued use of pipeline/powerline corridors is supported. The policies recommended by the Science Working Group for Coast Wetland Forests are supported, but it is also recommended that legislation be passed to permanently ban cypress logging in relic forest and place a moratorium on all other areas of cypress logging in the Pontchartrain Basin.

Middle Sub-basin (Lake Pontchartrain and adjacent wetlands)

The wetlands positioned between Lake Pontchartrain and the Mississippi River are considered vital to sustaining the ecology of Lake Pontchartrain because it is through these wetlands that river reintroductions may occur most beneficially to Lake Pontchartrain. Re-establishment of the detrital food base for Lake Pontchartrain can be accomplished by freshwater reintroductions into these wetlands to stimulate primary productivity and detrital export. As a result, the Lake is expected to increase in secondary productivity and fisheries. Several small diversions are recommended, including three which use the Bonnet Carre' Spillway corridor. Segments of the Lake's natural shoreline (littoral) habitat should be restored along the south, southeast and northwest shorelines. This recommendation includes marsh creation and re-expansion of SAV extent. Some other key local projects are the restoration of estuarine fisheries in Bayou St. John and an interim project to construct a sill in the Inner Harbor Navigation Canal (IHNC) or Lake Pontchartrain, which would reduce the 100 square-mile dead zone and restore environmental benefit provided by clams. Avoidance of wetlands, BMP's to reduce wetland impact, and local mitigation when wetlands are impacted are the recommended order of priority to prevent further loss of wetland habitat by urbanization.

Several position statements are also included for the Middle Sub-basin. Key statements are the continued ban on shell dredging and any commercial dredging within Lake Pontchartrain. The continued use of existing pipeline/powerline corridors is supported for justified expansion of these facilities. The continued ban on new oil and gas leasing in Lake Pontchartrain is supported as is the limited use of gill nets as currently legislated. Continued improvements to sewage treatment and stormwater systems are strongly endorsed for both the north and south shores of Lake Pontchartrain. Beneficial use of treated sewage and stormwater should be pursued wherever wetlands and water quality may be enhanced. The Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) has a successful nutria bounty program and is supported. However, more vigorous efforts are recommended to reduce other invasive species such as the Chinese tallow *(Sapium sebiferum)*.

Lower Sub-basin (St. Bernard and Plaquemines Parishes)

The paramount restoration feature of the Lower Sub-basin is to restore the integrity of the Bayou la Loutre ridge by reducing the Mississippi River Gulf Outlet (MRGO) navigation channel dimensions to Intracoastal Waterway width and depth at the Bayou la Loutre ridge. Contraction of the MRGO channel would directly improve the environment by reducing ship wakes and reducing the dead zone in Lake Pontchartrain, but also allows the essential opportunity to manage the marshes east of the MRGO with river reintroductions. A larger river diversion is recommended at Violet which, along with the contraction of the MRGO channel, will be designed to reestablish historic habitats of Lake Borgne, Biloxi marsh and, (if supported by Mississippi) Mississippi Sound. Discharge from the Caernarvon freshwater diversion may be increased to achieve habitat goals and rebuild marsh. All reintroductions are recommended to mimic the natural spring flooding with maximum flow from April to June.

The ecologic function of the Chandeleur – Breton barrier island chain should be maintained. The role of these islands in reducing wave energy and protecting interior marsh, such as the Biloxi marsh, from wave erosion should be considered in the need and design of barrier island restoration. Due to the cumulative impact of hurricanes from 1998 to 2005, including Hurricane Katrina, restoration is urgently needed for the Chandeleur and Breton Islands. The identified landbridges within the Biloxi marsh must also be restored and protected due to the weakened condition of the Chandeleur Islands.

The delta region of the Lower Sub-basin should be restored through natural and cost effective projects due to the historic and ongoing high rates of wetland loss. Crevasse projects and sediment diversions are recommended. The proposed Sediment Trap project (CWPPRA) in the Mississippi River should be moved upriver to target areas of need and to be where the soil foundation is superior. If a large scale study of the delta is undertaken to examine alternatives such as “hang-a-left” or “hang-a-right”, which would remove navigation from the lower river by a new dredged channel located east or west of the Mississippi River, the alternative of selectively closing passes should be evaluated.

Research and Data Needs

Critical research and data needs have been identified for the Pontchartrain Basin. This list of 23 items is not meant to be all inclusive but contains significant apparent deficiencies that were identified during discussions and analyses by the draft committee. This list is intended to guide research to further the understanding of the nature of the Pontchartrain Basin habitats and how these habitats might be restored and sustained. The list includes: Annual mapping of the Lake Pontchartrain dead zone; Economics of coastal wetland forests; Fish assemblage research; Acquisition of bathymetry of lakes and passes; Barrier island ecology; Rangia clams in St. Bernard and Plaquemines Parishes; Natural oyster reefs; MRGO habitat quality; Analysis of accelerated wetland loss; Non-commercial species in St. Bernard and Plaquemines Parishes; blue crab *(Callinectes sapidus)* in Lake Pontchartrain; West Indian Manatee (*Trichechus manatus);* Rio Grande Cichlid (*Cichlasoma cyanoguttatum)*threat , Striped Bass *(Morone saxatilis)* and Gulf sturgeon (*Acipenser oxyrinchus)*, Sea turtles on barrier islands; Hydrologic modeling for habitat restoration; Impact of poorly planned growth; Identification of biotic hotspots; Copper contamination in Lake Pontchartrain; Sand and gravel mine impact; Subsidence and relative sea-level rise; Mississippi River Delta management study: and a 10-year reoccurring comprehensive habitat inventory.

Post-Hurricanes Katrina and Rita

Appendix E was added to the CHMP after the preliminary impacts of Hurricanes Katrina and Rita were estimated. Hurricane Katrina had greater impact to the Pontchartrain Basin than Rita, and it may have caused the loss of more than 60 square miles of marsh (converted to open water) throughout the Basin. These results are preliminary and may be an overestimate due to residual high-water on the marsh. Nevertheless it appears that in one day more land lost occurred than in the prior decade (1990-2000), which was already period of accelerated lost. In addition to the addendum, several adjustments were made to the CHMP recommendations due to the effect of the 2005 hurricane season.

Hurricane Katrina and Rita made the need to integrate coastal restoration and engineered flood protection very apparent. Prior to these events LPBF had developed a planning strategy to address this need. A report titled “The Multiple Lines of Defense Strategy to Sustain Coastal Louisiana” was completed in November 2005 and is available on the LPBF website (SAVEORLAKE.ORG). Application of this strategy resulted in the selection of ten priority project areas for immediate project development and construction. These priority projects compose the “Pontchartrain Coastal Lines of Defense Program” (see saveourlake.org), and are intended to be the first phase of implementation of the CHMP.

This report is considered a draft report during the public comment period, which ended December 31, 2005. In February 2006, the report was made final.

INTRODUCTION

The greater Pontchartrain Basin includes a watershed extending southward from central Mississippi to the distant wetlands at the mouth of the Mississippi River in southern Louisiana (**Figure 1**). However, the Lake Pontchartrain Basin Foundation's (LPBF) mission only includes the Louisiana portion of the Pontchartrain Basin. In this report, "Pontchartrain Basin" refers to the area of the basin within Louisiana, which includes all of the area in Louisiana, east of the Mississippi River excluding West Feliciana Parish. The Pontchartrain Basin has been divided in four sub-basins to analyze baseline conditions, impairments and restoration needs of each. The objective of the report is to present a comprehensive habitat management plan that will make progress towards restoring the historic form and function of the Pontchartrain Basin habitats.

The Pontchartrain Basin is 19% (9,700 square miles) of Louisiana's area and represents 46% of the state's population (or 2.1 million people). Within the Basin are the great historic cities of New Orleans and Baton Rouge, which is also the state capital. The habitats range from pine upland to estuarine to marine. Based on imagery from 1992 to 1995, the entire basin was estimated to hold 2,100 square miles of marshes and swamps (including the Pearl River alluvial swamps) (Handley et al., 2001). The area of all wetlands and open water (lakes, etc.), which compose the Pontchartrain Basin estuary, is 5,800 square miles. The basin has undergone many anthropogenic alterations that have affected its hydrology. However, the basin is still characterized as an upland watershed coupled with a tidal estuary. For purposes of analyses, the Pontchartrain Basin was sub-divided into four sub-basins **(Figure 2)**. The Upland Sub-basin is non-tidal, whereas the other three sub-basins are tidally influenced portions of the estuary.

Figure 1: Pontchartrain Basin. The Comprehensive Habitat Management Plan includes the Pontchartrain Basin area within Louisiana. This includes all land and water east of the Mississippi excluding West Feliciana Parish.

The Upland Sub-basin (north of Interstate 12) is sometimes referred to as the Florida Parishes. The topography is generally less than 300-feet above sea-level, slopes southward, and contains several small rivers or bayous that drain southward into Lakes Maurepas and Pontchartrain. Water levels in Lake Pontchartrain are typically within one or two feet over mean sea-level. The Upper Sub-basin includes Lake Maurepas and its adjacent wetlands. The Middle Sub-basin includes Lake Pontchartrain and its adjacent wetlands.

The direct flow of freshwater to these lakes by the upland rivers is a key distinction from the lakes further south in the Lower Sub-basin. Lakes Borgne and adjacent marshes indirectly receive runoff from the upland watersheds and all of the lakes receive tidal exchange through passes or sounds.

The Lower Sub-basin is southeast of the Orleans landbridge in St. Bernard and Plaquemines Parishes and includes an expanse of estuaries connected to the Gulf of Mexico through a maze of deltaic channels and man-made canals. The marshes, which dominate here, have less than five-feet of relief above sea-level. South and east of the estuaries are two large sounds defined by the most gulf-ward geomorphic element of the basin, an arcuate-shaped trend of shoals and barrier islands. All of this area is considered Lower Sub-basin.

Figure 2: Pontchartrain Basin boundary and the sub-basins areas analyzed in the Comprehensive Habitat Management Plan.
Sub-basins include:
Upland Sub-basin
(Forest and Riverine habitats treated separately)
Upper Sub-basin
Middle Sub-basin
Lower Sub-basin

The hydrologic character of the Pontchartrain Basin's boundaries is variable. The western and southern boundary of the Pontchartrain Basin is dominated by the man-made levees of the Mississippi River, which prevent the river's natural overbank flow except for the spillway opening for river flood control or along the most southern un-leveed reach of the River south of Pointe a la Hache. A controlled river diversion at Caernarvon, Louisiana diverts Mississippi River water seasonally through the flood control levee into the local estuary. The northeastern boundary is the Pearl River watershed. The southeastern boundary is the Gulf of Mexico, which has tidal, wind and storm-driven exchange with seawater from the Gulf of Mexico. Internally, some areas of the basin are entirely or partially impounded artificially and water exchange is very low or non-existent.

Due to intense commercial logging from 1890 to 1940, the Upland Sub-basin is dominated by a highly altered habitat comprised of young, off-site pine forests. For a variety of reasons, among them the absence of regular fire, these forests do not support the kinds and diversity of plant and animal species that were supported by the historic longleaf pine forests. These artificial forests are generally managed for timber production, which often further reduces their ecological value through a variety of mechanisms. Early "cut-out and get-out" commercial logging resulted in wholesale loss of the virgin longleaf pine forests in the Pontchartrain Basin. Nearly 2 million acres of habitat was converted to open range or artificial forests. Further loss and degradation of remaining habitats is occurring due to rapidly expanding residential development.

The Upper, Middle and Lower Sub-basins are dominated by a Gulf Coast estuary created by deltaic processes of the Mississippi River. The estuary is tidally influenced by fresh water at its western extent (Upper Sub-basin), and saline at its eastern extent (Lower Sub-basin). The estuary contains fresh swamps and marsh, intermediate marsh, brackish marsh, and saline marsh (and barrier islands). A comprehensive inventory of the biological resources may be found in Environmental Atlas of the Lake Pontchartrain Basin (Penland et al., 2001). Due to the areal extent of the Pontchartrain Basin estuary and its position adjacent to the Gulf of Mexico, the Pontchartrain Basin is important as a nursery to the Gulf of Mexico and as a productive fishery to the nation. Important recreational species are largemouth bass *(Micropterus salmoides),* spotted seatrout *(Cynoscion nebulou*s), red drum *(Sciaenops ocellat*a), southern flounder *(Paralichthys lethostigm*a), blue catfish(*Ictalurus furcatus*), channel catfish (*Ictalurus punctatu*s), flathead catfish (*Pylodictus olivari*s), and blue crab(*Callinectes sapidu*s). Important commercial species are brown shrimp *(Farfantepenaeus aztecus*), white shrimp *(Litopenaeus setiferu*s), Gulf menhaden or pogy *(Brevoortia patronu*s), striped mullet *(Mugil cephalu*s), blue crab *(Callinectes sapidu*s), and American oyster *(Crassostrea virginic*a).

Estuaries can be regarded as transition zones between highly evolved marine and freshwater communities. Most estuarine organisms spawn offshore or in the higher salinity estuary. Habitat quality is particularly important in the lower, more saline habitat where reproduction and recruitment may be affected for both sport and commercial species that may later move further up into the estuary. In addition to these general estuarine functions, the Lower Sub-basin has rare communities and habitats such as true sea grasses, pink shrimp (*Farfantepenaeus duorarum)*, scallop (*Argopecten irradians*) and hard clam *(Mercenaria campechiensis)* fisheries, and essential fish habitat.

The Pontchartrain Basin has had a significant loss in the areal extent of wetlands. Most of this loss was induced by human activities occurring during the period from 1932 to 1983 when industrialization of the Louisiana coast occurred. Some of the drivers for loss are the effects of an extensive network of canals, impoundments, relative sea-level rise, loss of overbank flow of the Mississippi River and others. **Table 1** summarizes the cumulative loss of wetlands from 1932 to 2001. The total loss of wetlands in the Pontchartrain Basin, excluding the Pearl River alluvial swamps, is estimated to be 266,000 acres, which represents 28% loss of the wetlands present in 1932. The rate of wetland loss declined from 1974 to 1990. Therefore, it is alarming that the most recent documented rate of wetland loss increased in the last decade (1990 to 2001). Most of this loss is occurring in the Lower Sub-basin, where from 1990 to 2001, an average 4.3 square miles were lost per year. This rate is nearly as high as the rate of loss during the peak of loss during the Coastal Industrialization Period (1932-1983). The cause for this new high rate of loss is unknown but appears to not be due to new industrial type impacts such as construction of new canals. The salinity of the Pontchartrain Basin estuary has been anthropogenically altered, which has caused habitat shifts - moving more saline habitats further upward into the estuary.

One significant impairment relevant to the entire Pontchartrain Basin estuary is the substantially reduced sediment load in the Lower Mississippi River due to dam and reservoir development on the Upper Mississippi River. This has reduced sedimentation in the active Mississippi River delta and reduces the restoration potential of river reintroductions throughout the leveed portion of the estuary.

Table 1: Pontchartrain Basin Wetland loss 1932 to 2001 1932 – 1990 wetlands converted to open water	188,355 acres
(Penland et al, 2001) (This may be an overestimate of approximately 10,000 acres. A discrepancy was found between 2005 reported land loss and Coast 2050.)	
1932-1990 wetland converted to spoil bank (200% factor) Estimate 200% of estimated direct canal impact Penland (2001) for Pontchartrain Basin & estimate of loss due to MRGO spoil bank (MRGO Re-evaluation, 2001)	39,412 acres
1990 -2001 wetlands converted to open water in the Upper and Middle Sub-Basin (Source NWC/USGS net loss-gain). This includes 333 acres apparent loss in Bayou Sauvage Refuge.	8,494 acres
1990 -2001 wetlands converted to open water in Lower Sub-basin only (USACE 2001 data)	29,916 acres
Total est. loss 1932- 2001 (pre-Hurricanes Katrina and Rita)	**266,177 acres**
Preliminary Estimate of loss from Hurricanes Katrina and Rita	**50,688 acres**
Total losses 1932 to 2001 & 2004 to 2005 (post-Katrina)*	**316,865 acres**
* land loss from 2001 to 2004 unavailable	

The single greatest man-induced impact to the Pontchartrain Basin estuary was the construction of the federally authorized and operated, deep-draft navigation channel known as the Mississippi River Gulf Outlet (MRGO). The MRGO has triggered major shifts in habitats and fisheries, caused wetland loss, increased salinity intrusion and created a 100 sq. mile dead zone in Lake Pontchartrain. The total area affected by the MRGO is estimated to be 618,000 acres.

The time frame considered for restoration is 50 to 100 years so that long-term concepts can be considered. However, the extended target for restoration cannot be construed as a luxury of time available for restoration. To the contrary, greater urgency is warranted because of accelerating rates of habitat loss and potential dire consequences to the ecology, culture, and economy of southeastern Louisiana.

METHODOLOGY

The Comprehensive Habitat Management Plan was developed considering the entire Pontchartrain Basin, but was subdivided into Sub-basins for detailed discussion and analysis. Each Sub-basin discussion includes the following three components:

1) Baselines: Two historical baselines were targeted for all of the Sub-basins as a reference target for restoration. A **habitat form** baseline includes habitat types, areal extent, etc. for the time period 1900 to 1932. This time period was chosen since it post-dates initiation of collection of habitat data and pre-dates industrialization of the coast when widespread detrimental impacts occurred.

The **habitat function** baseline includes hydrology, trophic dynamics, organic transport, etc. for the time period pre-1800. This period was chosen because it pre-dates significant alteration of the overbank flow by flood protection levees.

It was necessary to have these two historical baselines because the timing of man-induced alteration (early 1800's), and the much later initiation of collection of habitat data, precludes a single time period that can reasonably represent both the critical form and function of the Pontchartrain Basin. It is only through some level of habitat form and function that sustainability of the habitat may be achieved. Each Sub-basin includes a description of the form baseline circa 1900-1932 and a function baseline circa pre-1800.

It is unrealistic to attempt to recommend a restoration plan that exactly replicates all of the historical baseline conditions, especially for an estuary which is naturally dynamic. Therefore, the baselines were used as strong guidance to define the extent of target habitats and the types of ecological functions necessary to support the habitats. The intended result is an ambitious, but realistic restoration plan which, when completed, results in habitats of sufficient extent and appropriate functional form to sustain the indigenous ecosystem and unique culture of the Pontchartrain Basin. It is implicit that a healthy society needs a healthy ecosystem, and vice versa.

2) Impairments: Impairments are historical or ongoing impacts to the natural habitats of the Pontchartrain Basin and should generally be considered departures from the baselines established for both the form and function of that Sub-basin. Examples of impairments are wetland loss, altered hydrology, significant conversion of habitat, water quality impairment where it impacts habitat quality, etc.

3) Restoration Recommendations: Restoration recommendations are intended to direct and promote restoration of habitats in the Pontchartrain Basin toward the baseline conditions, and to generally preserve and restore natural habitats and habitat quality. Recommendations may be broad goals, but, wherever possible, include specific strategies or projects that are intended to preserve or restore habitats. The time frame for restoration is 50 to 100 years so that long-term concepts can be considered.

SUB-BASIN ANALYSES

Upland Sub-basin Analysis Forest Habitats (North of Interstate 12)
(Note: The Upland sub-basin is treated in two sections. The first section discusses the Forest Habitats and the following section discusses the Riverine Habitats)
In addition to the regular CHMP Draft Committee, Latimore Smith of The Nature Conservancy, Patti Faulkner of the Louisiana Natural Heritage Program of the LA Department of Wildlife and Fisheries and Danny Breaux of the U.S. Fish and Wildlife Service (Big Branch Marsh National Wildlife Refuge) participated in the discussions and supplied information as noted in the text below regarding forested habitats. A comprehensive review of longleaf pine forest habitat, which dominated the Upland Sub-basin, can be found in Smith (2002) and includes the following:

"A dramatic intersection of human history and natural history has played out in the piney woods of the eastern Florida Parishes from the early 1800's up to the present day. During this period, a once magnificent natural treasure of the region, the longleaf pine (Pinus palustris L.) forest, has been reduced by human endeavor from the dominant forest type of the area to what is today an endangered ecosystem. Most current residents of the area have little understanding of the magnitude of the changes that have been wrought to our local native forests, most of which have occurred in the last 100 years. Today on the whole, thick pine-hardwood forests, agriforestry plantations of pines other than longleaf, agricultural fields, and developed landscapes stand in the place of the virgin longleaf "piney woods". There remain, however, a few areas that support very significant longleaf pine habitats and an incredibly high plant diversity of native species. Over 2 million acres of longleaf pine forests and savannas were historically present in the hills and flatwoods of the eastern Florida Parishes when white settlers first arrived in the area."

Figure 3 is an historic photograph illustrating the typical open forest and grassland of the virgin longleaf pine forests in the Pontchartrain Basin.

<u>Function Baseline of the Upland Forest circa 1800</u>
Naturally generated wildfire was arguably the key function or process that was essential to promoting and sustaining longleaf pine habitat. The benefit of fire to the longleaf pine systems includes (Smith, pers. comm.):

- Kills off-site shrubs, hardwoods, other pines
- Encourages longleaf pine to exit "grass stage"
- Kills brown spot needle blight on young longleaf
- Stimulates flowering/seeding by many plants
- Prepares open seedbed for longleaf and others species
- Removes smothering duff layer and increases native plant diversity
- Creates open conditions favored by many wildlife species
- Frequent fire controls fuel build-up and reduces wildfire intensity
- Accelerates nutrient cycling and nutrient availability

<u>Form Baseline of the Upland Forest circa 1920</u>
Upland topography ranges from essentially flat and very gently rolling in the Pleistocene Prairie Terraces in the south, to the gently to moderately rolling hills of the High Pleistocene Terraces in the north. This landscape is dissected by north to south flowing streams and associated stream valleys. Soils range from hydric versions supporting wetland systems (e.g., longleaf pine flatwood

savannas, slash pine-pond cypress forests, spruce pine-hardwood flatwoods, hillside seepage bogs, bayhead swamps), to non-hydric types that support upland (non-wetland) systems (e.g., longleaf pine flatwoods, upland longleaf pine forest/woodland, shortleaf pine/oak-hickory forest, mixed hardwood-loblolly pine forest). Soils are typically strongly acidic, nutrient poor, fine sandy loams and silt loams. Longleaf pine woodlands and savannas were characterized by an uneven-aged tree component, with trees up to 400 years of age, and by very high plant diversity including numerous grasses, sedges and forbs. These habitats include many rare plant species. Appendix D includes a table of rare plants indigenous to the Eastern Longleaf Savannah and Upland habitats in Louisiana as compiled by the Louisiana Natural Heritage Program. **Table 2** includes the areal estimated extent of virgin forest types in the Upland Sub-basin pre-settlement and for 1920.

Figure 3: Historic 1934 photograph of Virgin Longleaf pine Forest near Slidell LA., (Source Wahlenberg, 1946)

Table 2: Areal Extent of Upland Forest Habitat Types and Estimate of 1920

	Pre-settlement	1920 (66%)*
Fire dependent		
Upland Longleaf Pine Forest/Woodland	800,000-1,000,000	600,000 ac
Longleaf Pine Flatwoods/Savanna	400,000-500,000	300,000 ac
Shortleaf Pine/Oak-Hickory Forest	200,000-250,000	150,000 ac
		1,050,000 ac
Non-fire dependent		
Spruce Pine-Hardwood Flatwoods	200,000-250,000	150,000 ac
Mixed Hardwood Flatwoods	150,000-200,000	120,000 ac
Small Stream Forest	200,000-300,000	165,000 ac
Bottomland Hardwood Forest (several)	100,000-200,000	100,000 ac

* Lopez (2003) estimates that by 1920 approximately 2/3's of the pine forests had not yet been logged in the Pontchartrain Basin.

Impairments to the Upland Forest

Although a wide variety of ecologically important native forest types once occupied the Upland Sub-basin, longleaf pine habitats stand out as the most ecologically significant **(Figure 3)**. All of the upland forests were extensively logged, but as already discussed, the once-dominant longleaf pine (*Pinus palustrus*) suffered tremendous loss. In a comprehensive analysis of environmental impacts in the Pontchartrain Basin, Lopez (2003) states, "Considering the areal extent and the ecologic significance, the longleaf pine deforestation probably represents the single greatest environmental loss to the Pontchartrain Basin". The combined deforestation of the Upland Sub-basin of pine habitats was 1,500,000 to 2,000,000 acres and is ten times greater than the 188,000 acre wetland loss documented (1932-1990) in the Pontchartrain Basin (Penland et al, 2001). The ecological value of longleaf pine habitat is derived from:

Biological diversity – represented by a huge diversity of herbaceous plants (including grasses, sedges, insectivorous plants, lilies, orchids and numerous others), and associated fauna (including, among others, insects, reptiles, amphibians and grassland birds) many of which are declining and are restricted to fire-driven longleaf pine habitats.
Aesthetic value – These forests were found to be naturally "park like" with many open vistas through tall stands of majestic pines.
Rarity: Longleaf pine forests were logged ubiquitously throughout their range in the Southeast U.S., to the point that these habitats are now considered threatened ecosystems. Of what was present in the Florida Parishes in 1850, less than 1% remains today (Smith, pers comm.).

One of the most distinguishing characteristics of longleaf pine habitats is their critical dependence on frequent light surface fires. Fire suppression programs started around 1920 and were widely effective after 1940. Fire suppression critically hindered natural recovery of longleaf pine habitats after deforestation.

It is estimated that currently within the Pontchartrain Basin there is no remaining virgin longleaf pine habitat, but there are 10,000 to 20,000 acres of relatively intact longleaf pine savannas and forests (representing less than 1% of the original extent; Lopez, 2003 and Smith, pers. comm.). Most of this remaining habitat is immature stands that are scattered within the longleaf range, with stands ranging in size from approximately 3,000 acres to less than 50 acres (Smith, pers. comm.). **Figure 4** indicates the officially identified remaining longleaf pine habitat within the Pontchartrain Basin, which is 6,089 acres (source LA Natural Heritage Program). These remnant areas generally do not include a management program of prescribed burning, and therefore are not optimally managed.

As a result of this dramatic loss of habitat (and other factors) many species of concern have been identified. **Table 3** lists species of conservation concern as identified by the Louisiana Natural Heritage Program (data provided by Patti Faulkner of the LNHP).

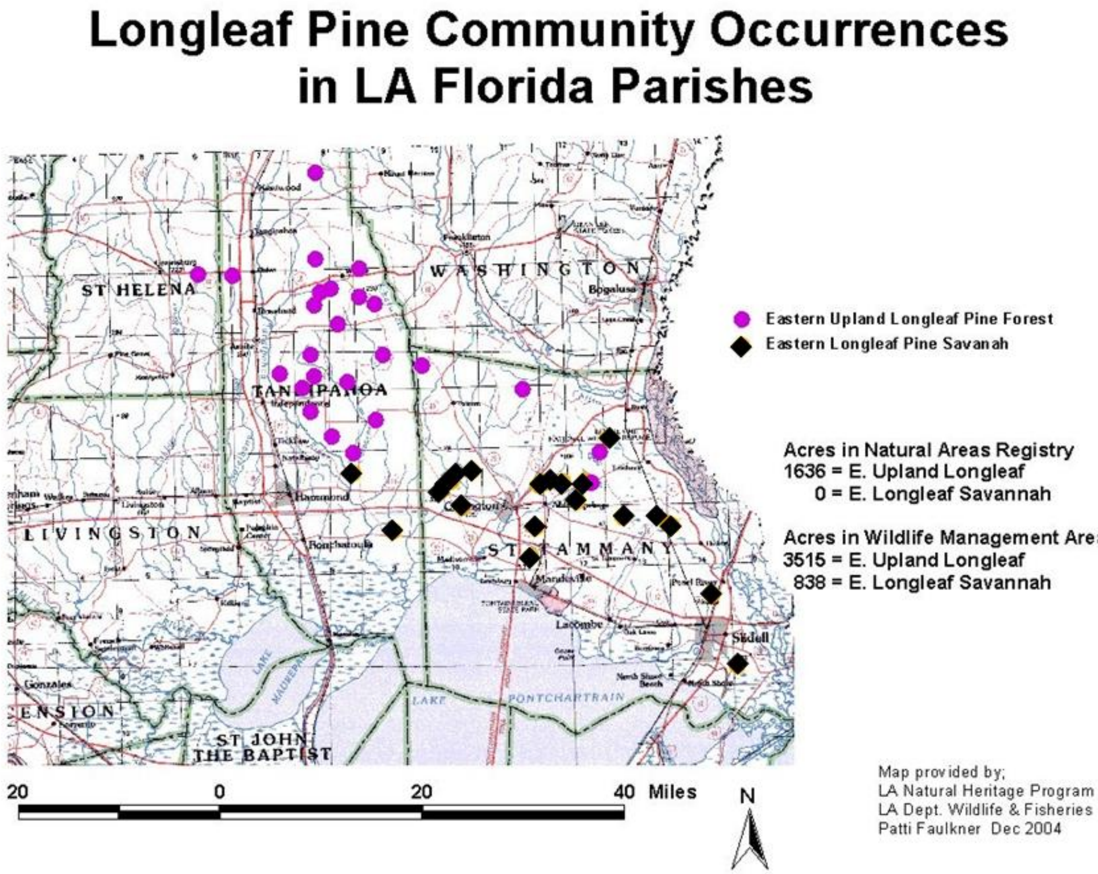


Figure 4: Map of Remnant Longleaf Pine Forests and Savannas in the Pontchartrain Basin, circa 2004 (source, LA. Natural Heritage Program). Recommendations include expanding selected remnant areas to a minimum of 5,000 acres in extent. Additional field work may locate other remnants or degraded pine forests, particularly in the southeastern, western and northeastern areas of the Upland Sub-basin that may be restored to longleaf stands by appropriate methods including prescribed fire.

Table 3: Species of Conservation Concern in LA. Eastern Longleaf Pine Savannahs and Uplands

COMMON NAME	SCIENTIFIC NAME	Global Rank	State Rank
Amphibians			
Eastern Tiger Salamander	*Ambystoma tigrinum*	G5	S1
Four-toed Salamander	*Hemidactylium scutatum*	G5	S1
Ornate Chorus Frog	*Pseudacris ornata*	G5	S1
Dusky Gopher Frog	*Rana sevosa*	G1	SH
Birds			
Red-cockaded Woodpecker	*Picoides borealis*	G2	S2
Brown-headed Nuthatch	*Sitta pusilla*	G5	S5
Bachman's Sparrow	*Aimophila aestivalis*	G3	S3
Henslow's Sparrow	*Ammodramus henslowii*	G4	S3N
Mammals			
Southeastern Shrew	*Sorex longirostris*	G5	S2S3
Big Brown Bat	*Eptesicus fuscus*	G5	S1S2
Hispid Pocket Mouse	*Chaetodipus hispidus*	G5	S2
Eastern Harvest Mouse	*Reithrodontomys humulis*	G5	S3S4
Reptiles			
Gopher Tortoise	*Gopherus polyphemus*	G3	S1
Eastern Glass Lizard	*Ophisaurus ventralis*	G5	S3
Southeastern Scarlet Snake	*Cemophora coccinea copei*	G5T5	S3S4
Mole Kingsnake	*Lampropeltis calligaster rhombomaculata*	G5T5	S1S2
Black Pine Snake	*Pituophis melanoleucus lodingi*	G4T3	SX
Pine Woods Snake	*Rhadinaea flavilata*	G4	S1
Crustaceans			
Flatwoods Digger	*Fallicambarus oryktes*	G4	S2S3
Butterflies			
Dusky Roadside Skipper	*Amblyscirtes alternata*	G3G4	SU
Dusted Skipper	*Atrytonopsis hianna*	G4G5	SU
Arogos Skipper	*Atrytone arogos*	G3G4	SNR
Cobweb Skipper	*Hesperia metea*	G4G5	SNR

STATE ELEMENT RANKS:

S1 = critically imperiled in Louisiana because of extreme rarity (5 or fewer known extant populations)

S2 = imperiled in Louisiana because of rarity (6 to 20 known extant populations)

S3 = rare and local throughout the state or found locally (21 to 100 known extant populations)

S4 = apparently secure in Louisiana with many occurrences (100 to 1000 known extant populations)

S5 = demonstrably secure in Louisiana (1000+ known extant populations)

(B or N may be used as qualifier of numeric ranks and indicating whether the occurrence is breeding or non-breeding)

SA = accidental in Louisiana, including species (usually birds or butterflies)

SH = of historical occurrence in Louisiana, but no recent records verified within the last 20 years

SR = reported from Louisiana, but without conclusive evidence to accept or reject the report

SU = possibly in peril in Louisiana, but status uncertain; need more information

SX = believed to be extirpated from Louisiana

SZ = transient species in which no specific consistent area of occurrence is identifiable

Non-longleaf pine forest habitats in the Upland Sub-basin are not considered to be fire dependent with the exception of shortleaf pine / oak hickory forests in the northwestern region of the Sub-basin, and slash pine-pond cypress forests in the southeastern portion of the Upland Sub-basin. **Table 4** summarizes the Upland Sub-basin forest impairments.

Table 4: Upland Forest Impairments Summary

- Deforestation of all virgin upland forests including longleaf pine habitats of exceptionally diverse and rare species composition
- Displacement of virgin forests by artificial forests, originating either by planting or by succession without fire, which are not fire dependent
- Significant alteration of flora and fauna such as loss of virgin longleaf pine forest, American bison (*Bison bison*), and purple pitcher-plant (*Sarracenia purpurea*; last seen in LA in late 1800's), and severe diminishment of many associated plant and animal species, such as death-camus (*Zigadenus leimanthoides*), Red-cockaded woodpecker (*Picoides borealis*), gopher tortoise (*Gopherus polyphemus)*, grassland birds such as Henslow's Sparrow (*Ammodramus henslowii*) and numerous others
- Invasion by numerous exotic plants, such as privet hedge (*Ligustrum sinense*), Chinese tallow tree (*Triadica sebifera*), and cogon grass (*Imperata spp.*).
- Extensive dairy and agricultural land use
- Extensive Commercial and Residential land use
- Development and expansion of municipalities, sprawl, highways, power lines, etc., resulting in increased runoff rates, possibly reduced groundwater recharge, increased in evapotranspiration and decreased in stream water quality
- Incompatible forest management. Current forest management utilizes dense plantations, herbicides, bedding, and fire suppression
- Hydrologic impacts to pine flatwood wetlands caused by various anthropogenic activities are unclear. However, many activities may affect natural hydrologic regimes of flatwood wetlands and impair key water movement processes that maintain these specialized wetlands

<u>Restoration Recommendations of the Upland Forest (See Figure 7 for a summary map)</u>

1. Develop an expanded outreach and education program to elevate awareness and support for restoration of upland forest habitats, in particular longleaf pine habitats and the importance of prescribed burns. This might include newsletter articles, field trips, and student programs. Much of this should be done jointly with the Lake Pontchartrain Basin Foundation, The Nature Conservancy, through the National Wildlife Refuge programs, and through establishment of a Prescribed Fire Council (see recommendation below).

2. Establish a Prescribed Fire Council that would bring together government, private interests, and NGO's to advise to maintain, promote, and increase the level of prescribed burns to enhance longleaf pine habitat in ways compatible with modern society.

3. The 1920 baseline suggests restoration of 1 million acres of fire dependent forest habitat in the Upland Sub-basin within the next 50 to 100 years. The CHMP Draft Committee considers this is an unrealistic goal. Instead, the total recommended longleaf forest

restoration projects is approximately 150,000 acres or 15% of the 1920 baseline. This goal represents 10% of the original extent of fire dependent Upland Sub-basin forest habitats (~1,500,000 acres). Even this goal will require significant restoration effort. For example, this would be an approximate 10-fold increase in the areal extent of longleaf pine habitats that currently exist. Nevertheless it is worth noting that in Mississippi the Desoto National Forest, within the historic longleaf pine habitat range, includes 378,000 acres and has annual prescribed burns of over 100,000 acres.

4. Two or three existing longleaf pine flatwood/savannah habitats conservation areas should be selected for expansion with a target of a minimum size of 5,000 acres. If possible, they should be sufficiently large or buffered so that a fire program may be utilized to have regular prescribed burning. Possible areas for expansion may include The Nature Conservancy tract at Talisheek, LA Department of Wildlife and Fisheries' Sandy Hollow Wildlife Management Area or U.S. Fish and Wildlife Service's Big Branch Marsh National Wildlife Refuge. In addition to the critical conservation role these areas would play, they should also be used for outreach, education, and research sites with relative convenience to municipalities and research centers.

5. One or two rural areas within the longleaf pine flatwood/savanna habitat ranges should be targeted as modest-sized restoration projects for conservation. This would most likely be north of Interstate 12 within St. Tammany or Tangipahoa Parishes. The target size of these conservation areas is 10,000 to 20,000 acres and they would be located such that regular managed burns could occur with acceptable impact to nearby residents. One region that should be considered to identify these conservation areas is within the southeastern part of St. Tammany parish, in the area bounded by LA 41 on the east, LA 435 on the north, LA 59 on the west, and Interstate -12 (southern boundary). Another region to consider is east of the Tangipahoa River within Tangipahoa Parish (north of Robert, Louisiana). This area is in reasonable proximity to Southeastern Louisiana University, which may supply technical advice or support.

6. Two large-scale conservation areas are proposed to be established to restore and manage upland longleaf pine forest/woodland systems. The areal extent is recommended to be 50,000 acres each. Perhaps the most likely option is that these areas be acquired, owned and administered by the federal government as National Forests, National Refuges, National Parks, or through other federal programs. Alternatively, it may be possible that such areas could be acquired, owned and managed by a state agency, such as the Louisiana Department of Wildlife and Fisheries or Office of State Parks, or by a private group such as The Nature Conservancy. Potential locations for these may be found in rural areas of Washington, northern Tangipahoa, or St. Helena Parishes. These landscape-scale conservation areas would be restored to fully functional, fire-managed forests with maximum re-establishment of original indigenous flora and fauna. It is recommended that the goal to establish such landscape-scale conservation areas be a key strategy in the state's Wildlife Conservation Plan.

7. Other indigenous, non-longleaf habitats should be inventoried in the Upland Sub-basin. The ecologic value and rarity should be assessed for these habitats. The Louisiana Natural Heritage Program has an ongoing assessment program which is nearly complete.

8. Integrate and expand restoration initiatives for the red-cockaded woodpecker, gopher tortoise and other rare and endangered species indigenous to the forested uplands of the Upper Sub-basin.

Upland Sub-basin (north of Interstate 12) Riverine Habitats

<u>Function Baseline of Upland Riverine Habitats circa 1800</u>

Rivers and streams of the Upland Sub-basin were generally continuously free-flowing and sourced from both rainfall and freshwater springs. Water generally drained from acidic soils and was therefore itself probably slightly acidic. The water was likely high in dissolved organics and tea-colored, but low in suspended sediment. The water character was highly favorable for freshwater mussels, which probably also supported robust populations of otters and raccoons. Most of the natural drainage was into Lakes Maurepas and Pontchartrain, except for the Bogue Chitto / Pearl River drainage into The Rigolets pass and Lake Borgne. Spring fed creeks such as Big Creek, a tributary of the Tangipahoa River, are reported to have been spring fed with cooler and clearer water (circa, 1950) than other streams carrying runoff (Kopfler, pers. comm.).

<u>Form Baseline of Upland Riverine Habitats circa 1920</u>

The Upland Sub-basin had a natural drainage including six rivers and several bayous, which drained generally southward and into Lakes Maurepas and Pontchartrain, and The Rigolets (pass).

<u>Impairments of the Upland Riverine Habitats</u>

Restoration of the riverine habitats within the Upland Sub-basin is hindered by a lack of pre-impact baseline definition and by poor documentation of current conditions. However indications are that these streams have been significantly degraded from excessive sedimentation and other impacts. Historical gravel and ongoing “material” mining operations of gravels, sand, or soil from the streambeds or streambed deposits appears to have significant impact to the stream ecology and to the adjacent landscape **(Figures 5 and 6)**. Navigation projects have also had major impacts on two rivers. In addition, inadequate sewage treatment is also contributing to water quality degradation. Most north shore rivers were classified as “not supporting” their intended use for fish and wildlife in 2000 and 2002 by LA Department of Environmental Quality (Lopez, 2003).

Mining of Riverine Habitats for Sand and Gravel

The U.S. Army Corps of Engineers undertook an ecologic restoration of the Blackwater Conservation Area project of an abandoned gravel mine along the Comite River in East Baton Rouge Parish. The impact of the mining operation included:

- Topographic changes such as creation of deep ponds or areas of poor drainage
- Soil modification such as loss of topsoil and increase in acidity (ave. pH of 5.4)
- Complete land clearing with little re-vegetation
- Vegetation of low ecologic value such as Chinese tallow *(Sapium sebiferum*) (invasive species)
- Use of abandoned pits for sewage sludge disposal

In sum, the footprint of the mine was a barren landscape almost devoid of vegetation, of little ecologic value and almost certainly contributing excess sediment load to the Comite River, and thus reducing water quality. Similarly impacted riverine habitat, but not remediated, are readily apparent in high altitude infrared imagery of the rivers in the Upland Sub-basin **(Figure 5).**

Figure 5: 1998 color-infrared imagery of Amite River in southeastern East Feliciana Parish with extensive impacts due to sand and gravel mining operations.

LPBF requested data regarding mined volumes and current activity from mining operations from the LA Department of Natural Resources.

The following is a memo (11/2004) from Dale Bergquist of the LA Office of Conservation in response to a request by the committee of the current status of mines and mining activity in the Upper Sub-basin.

(Note: AML refers to Abandoned Mine Lands Program, which is described as the following: The purpose of the Abandoned Mine Land (AML) program is to abate hazardous conditions related to past mining and to protect and enhance the public health, safety and general welfare from these adverse effects by promoting the reclamation of mined areas left in an unreclaimed state prior to the enactment of PL 95-87 (the Surface Mining Control and Reclamation Act) on August 3, 1977.)

LA Office of Conservation memorandum regarding mining the Pontchartrain Basin:

"The mine activity seemed to be primarily located as follows:

- *Amite River along the parish line between St. Helena and East Feliciana Parishes,*
- *Tangipahoa River in Tangipahoa Parish (north of Independence)*
- *Bogue Chitto River in Washington Parish (a little bit of mining in northern St. Tammany)"*

The Surface Mining Division's Abandoned Mine Land Program consultant has completed significant mine inventory and assessment efforts in the Pontchartrain Basin Area through contractual efforts for both DNR and DEQ. A map of inventoried mine sites in the watershed areas specified is attached. These data are available for export from our GIS.

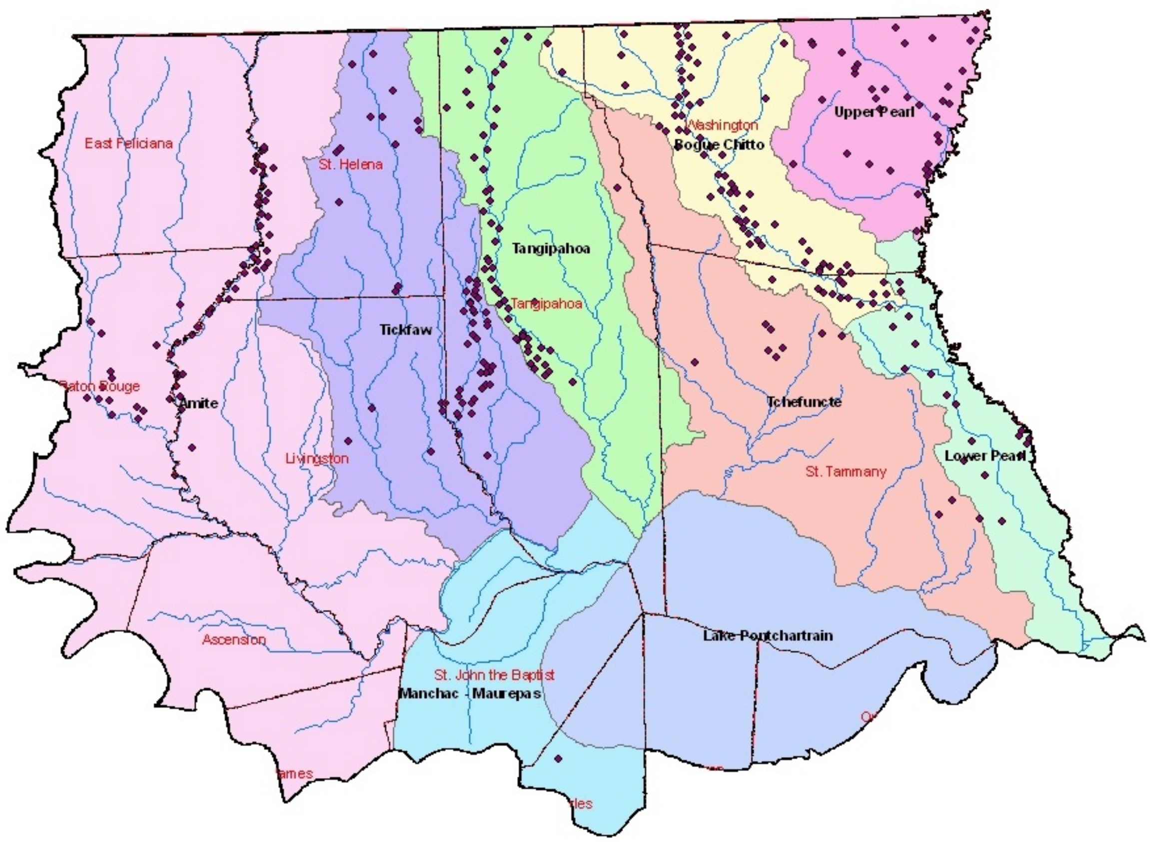


Figure 6: Map supplied by LA Office of Conservation (LADNR) depicting historic and active sand and gravel mines identified by the department (black diamond symbol). The map also depicts hydrologic river basins in color.

Please note that the Bogue Chitto River, is a tributary of the Pearl River, and does not flow into Lake Pontchartrain. However, the Bogue Chitto has been extensively impacted by sand & gravel mining activities, for which no reclamation requirements currently exist. The Amite, Tickfaw, and Tangipahoa Rivers flow into Lake Pontchartrain, along with the Tchefuncte River. The watersheds of the Amite, Tickfaw, and Tangipahoa Rivers have been extensively mined, with little to no reclamation. Mining is much less prevalent in the Tchefuncte River Watershed, as indicated by the map provided.

*Our inventory efforts have primarily focused on identification of those mine sites abandoned prior to enactment of the federal Surface Mine Control and Reclamation Act (SMCRA), i.e. August 3, 1977, in that (*Act*), is the eligibility cutoff date for the program under which our current funding is derived. Some more recent mines are evident on aerial photography which has not been included in our inventory to date. These inventory updates are not included in our current scope of work, but will be included as soon as the 2004 imagery is available, and as schedules and budgets permit.*

Three hundred twenty three (323) of the 1,227 mines included in our current statewide inventory occur within the watershed areas of the Pontchartrain and Pearl River Basins. These sites have been classified as follows:

- *Adequately Reclaimed* — *68 sites*
- *Post '77 Priority 1 or 2 Problems* — *119 sites (which would include active sites)*
- *Priority 3 (environmental) Problems* — *106 sites*
- *AML Candidates under review* — *30 sites.*

Our current program efforts are focused on addressing needs associated with the 30 candidate sites only.

We have initiated efforts to define various aspects of ongoing mining operations, including:

- *the number and location of active mine operations,*
- *identity of mine operators whom would be affected by the proposed legislation,*
- *quantities of various minerals being mined, so as to evaluate the fiscal impacts of production based reclamation fees.*

Three basic sources of information regarding active mine operations have been identified:

- *Mine Safety and Health Administration (MSHA) records;*
- *DEQ Discharge Permit Records; and*
- *LA Revenue Department, Severance Tax Records.*

Various activities have been initiated in recovery of data from these sources in order to develop an inventory and map of active mine operations. However, none of the reports requested by John Lopez exist at this time. "

Summarizing the LA Office of Conservation report (above), the historical or ongoing impact of mining in the Upland Sub-basin streams has just begun to be assessed, but it appears that of the 323 identified mine sites (79%) have not been “adequately reclaimed” and that 1/3 of the remaining sites have “Priority 3 (environmental) problems. It appears historically that the gravel mining industry in the Pontchartrain Basin has been generally under-appreciated, under-regulated and under-mitigated. It is encouraging that the LA Office of Conservation has begun to inventory and classify mines in the Upland Sub-basin.

Possibly the strongest biological indicator of the habitat degradation of these north shore streams is the dramatic decline of freshwater mussels. Brown and Banks (2001) concluded that gravel mining is the greatest threat to freshwater mussels in Louisiana streams, such as, the Amite and West Pearl Rivers. The decline of the inflated heelsplitter mussel (*Potamilus inflatus)* in the Upland Sub-basin was noted around 1976 (Lopez, 2003) and is now considered a “threatened” species by the Louisiana Natural Heritage Program and under the federal Endangered Species Act. Mussels are thought to have been prevalent throughout most of the continuous flowing reaches of the Comite, Amite, Tangipahoa, Tickfaw, Bogue Chitto, Pearl, and Tchefuncte Rivers. Anecdotal information suggests that the freshwater clams were common wherever “relatively clear water flowed across firm sandy bottom”. This would be the expected habitat for these mussels.

Decline of the freshwater clams is due to several factors including (source LA DWF website, 11/2004):

1. Sand and gravel mining operations
2. Channel alterations
3. Impoundments
4. Flood control projects

Also contributing to the freshwater mussel decline was the “mother-of-pearl industry” which may have started as early as 1850 and extended to at least 1950 when plastic began to displace it as a raw material. Although the USGS reports that by 1993 Louisiana was still in the top 4 state producers nationally of mother-of-pearl, it is not known if this production is from the Pontchartrain Basin. Commercial “Musseling” is prohibited according to 2004 Louisiana Commercial Fishing Regulations. Areas in the Pontchartrain Basin closed to freshwater musseling include:
“Areas officially recognized as saltwater areas” such as Lake Pontchartrain
“Amite River from the junction with Bayou Manchac to the Mississippi State Line.”

The Comite River is excluded from the musseling prohibition although it was part of the original habitat of freshwater mussels. It is unknown if there is a recreational “musseling” or illegal commercial musseling occurring in any of these rivers.

Navigation Project Related Impairments of the Pearl River and Bogue Chitto River

Negative environmental impacts have occurred in both rivers due to the Pearl River Navigation Project authorized by the River and Harbors Act of 1938 and completed in 1956 **(Table 5)**. For this project the Pearl River Canal was constructed as a lateral (bypass) canal along the west side of the lower Bogue Chitto and West Pearl Rivers. The Bogue Chitto River is a major tributary of the Pearl River. Sills were placed in the Pearl and Bogue Chitto Rivers to impede flow in the rivers and therefore, create backwater in the navigation bypass canal to maintain a minimum depth for navigation. Locks were also constructed on the Pearl River Canal and have not generally been operated. In 1974, the project was nominated for de-authorization because of a decline in barge traffic. This de-authorization failed but the COE also has not been able to initiate maintenance dredging and de-snagging. In November 2003, the Vicksburg District of the U.S. Army Corps of Engineers completed an "Initial Appraisal Report" to de-authorize the project, and includes the following record:

1) The last maintenance dredging was in 1989.
2) The last recorded barge movement was in 1991.
3) The project has been officially in a "caretaker" status since 1995.
4) The project has no commercial traffic.
5) Little prospect exists for the project to return to becoming a viable commercial waterway.
6) The reach near Poole's Bluff (near Bogalusa) sill includes three wildlife management areas (two in Louisiana), the Bogue Chitto National Wildlife Refuge, the Pearl River WMA, and five rivers (or streams) designated as "natural and scenic" by the state of Louisiana.
7) The three locks were determined to be "marginally safe due to continuous erosion of the sheet pile walls", and one lock was predicted to become unsafe possibly as early as 2004.
8) Accidental drowning deaths have occurred by boaters attempting to cross a partially submerged sill.
9) Due to understaffing of facilities vandalism is significant.
10) $2.7 million has been spent to "minimally maintain" the West Pearl River Navigation Project over the past ten years.
11) An EIS completed in 1994, identified 23 species and 1 subspecies either threatened or endangered that possibly exist in the study area.

The Initial Appraisal Report is signed by the District Engineer who recommends "that a reconnaissance study, under Section 216 of the Flood Control Act, be undertaken as soon as possible. These investigations will be directed at deauthorization and disposal of the project" USACE, 2003). In January 2004, Edwin A. Theriot, Director of Programs in Vicksburg, concurred with the recommendation and directed that the study be budgeted for FY06.

Table 5: Environmental Impacts to the Bogue Chitto and Pearl Rivers by the Pearl River Navigation Project

1) Reduction in stream velocity
2) Increased sedimentation upstream of the sills
3) Probable increased down-cutting and bank stability downstream of the sills
4) Impedance of migration of migratory fish species, including the threatened Gulf sturgeon

Numerous species of fish migrate up and down these rivers and have had their natural movement interrupted by the sills. One species of particular significance is the Gulf sturgeon (*Acipenser oxyrinchus desotoi)*. Gulf sturgeon was federally listed as threatened in September 1991 and is also considered threatened by the Louisiana Department of Wildlife and Fisheries. In February 2003 the U.S. Fish and Wildlife Service and the National Marine Fisheries Service designated all of the Pearl and Bogue Chitto Rivers in Louisiana as critical habitat for Gulf sturgeon. Also included is Little Lake and the eastern half of Lake Pontchartrain.

Gulf sturgeon are anadromous and migrate upstream from the Mississippi Sound into the Pearl River from April to June to spawn. Gulf sturgeons prefer well–oxygenated, hard gravel bottoms with clear water for spawning. These conditions are more likely to be found further upstream of the sills. Gulf sturgeon are also impacted by illegal fishing in the Pearl River and as by-catch from shrimp trawls, gill nets or shrimp wing nets in the adjacent sounds and lakes (U.S. FWS, 1995). Two other species of anadromous fish, one catadromous, and twelve potadromous species of fish use the Pearl River system **(Table 6)**. All sixteen migratory species may be adversely impacted by the sills constructed on the Pearl or Bogue Chitto Rivers.

Table 6: Migratory Fish in the Pearl River System

1). Anadromous (migrate from salt to freshwater to spawn), 3 species	
Alabama Shad	*Alosa alabamae*
Gulf sturgeon	*Acipenser oxyrinchus desotoi*
striped bass	*Morone saxatilis*
2). Catadromous (migrates from fresh to saltwater to spawn), 1 species	
American eel	*Anguilla rostrata*
3). Potadromous (migrates within river), 12 species	
blacktail redhorse	*Moxostoma poecilurum*
blue catfish	*Ictalurus furcatus*
channel catfish	*Ictalurus punctatus*
flathead catfish	*Pylodictis olivaris*
highfin carpsucker	*Carpiodes velifer*
paddlefish	*Polyodon spatula*
pearl darter	*Percina aurora* (extirpated)
quillback	*Carpiodes cyprinus*
river redhorse	*Moxostoma carinatum*
southeastern blue sucker	*Cycleptus meridionalis*
spotted sucker	*Minytrema melanops*
skipjack herring	*Alosa chrysocloris*

modified from Kohl (2003)

As part of the Pearl River Fishway Project (Maygarden 2003) funded by the Gulf of Mexico Program, Kohl (2003) evaluated various alternatives to improve migratory opportunity for the migratory species of the Pearl River. In particular he evaluated the Poole Bluff sill just south of

Bogalusa, LA. He concluded that a rock ramp (fish ladder) was the best option. He did not evaluate removal of the sill due to concerns of mercury contamination in sediments that could be remobilized by removal of the sill. Mercury was used at the Bogalusa paper mill from 1947 to 1972, including a 16-year overlap period after the sill was constructed. Use of mercury was discontinued by the mill in 1972 but the fate of discharged mercury into the Pearl River is largely unknown. Mercury health advisories have been issued for the Pearl River and other nearby waterways. However, these advisories have been issued for most of the rivers on the north shore, which are not hydrologically connected to the Bogalusa paper mill discharge. Another source of mercury must be present, and is most likely atmospheric deposition related to power plants. Therefore the mercury advisory on the Pearl and Bogue Chitto Rivers may be related to simply regional mercury contamination and may not indicate a river sediment contamination source related to the paper mill in Bogalusa.

The Bogue Chitto sill was not explicitly evaluated in the Pearl River Fishway Project. In his conclusions Kohl (2003) suggests that fish bypasses could be utilized at both Poole Bluff and the Bogue Chitto sill. The Bogue Chitto sill should be less likely to have mercury contamination related to the paper mill in Bogalusa since the mill is located several miles upstream of the confluence with the Pearl River into which contaminated sediments may have been deposited. It appears the opportunity may be greater for sill removal on the Bogue Chitto River without risk of remobilizing potentially mercury-contaminated sediment.

Canebrake Habitat

One particular habitat that has been virtually eliminated from the Upland Sub-basin is the immense canebrakes (monotypic stands of giant cane, or switch cane, *Arundinaria gigantea*) described by Darby (1816) and occurred along the Amite, Comite Rivers. The canebrake habitat often had good soils and was generally cleared for agriculture (Platt and Brantley, 1997). This ecological community type has been considered critically endangered (Brantley and Platt, 2001; Platt and Brantley, 1997). Canebrakes have also been suggested as an important site for feeding of the apparently extinct Bachman's warbler (*Vermivora bachmanii*).

Summary of Upland Sub-basin Riverine Impairments:

1. Landscape denudation and altered hydrology from strip mining of the river beds and adjacent riverine deposits

2. Loss of riverine bank vegetation and significantly reduced potential to re-vegetate

3. Alteration of soils from strip mining to be more acidic and have reduced organic content

4. Increases in sediment load from denuded landscape

5. Dramatically reduced freshwater mussel populations due to combined effects of harvesting, water quality and decline in overall habitat quality.

6. Most north shore rivers were classified as “not supporting” their intended use for fish and wildlife in 2000 and 2002. In addition to the water quality problem already described, inadequate sewage treatment is also contributing to water quality degradation.

7. The Pearl and Bogue Chitto Rivers have had impairments due to the altered hydrology caused by the construction of two sills and a bypass canal. This has impacted natural migration of several species including the anadromous Gulf sturgeon, which is classified as threatened. Populations of sturgeon have declined due to habitat degradation, incidental by-catch of shrimp in shrimp trawls and illegal fishing. Other migratory species of fish have probably also been negatively impacted.

8. Possible water quality impairment due to use of abandoned pits for sewage sludge disposal

9. Loss of canebrake habitat along rivers and streams of the Upland Sub-basin

<u>Restoration Recommendations for Upland Riverine Habitats (See Figure 7 for a summary map)</u>

1. A complete assessment of active sand and gravel mining operations should be completed as soon as possible; including at least, vegetation surveys and studies of the hydrologic modification, soil chemistry and water quality effects.

2. Historical mining sites should be assessed within three years for their environmental impact such as water quality and fish and wildlife. A priority list of project sites should be selected for remediation including those sites which can best improve stream quality and restore indigenous flora and fauna.

3. Active mining operations and practices should be evaluated to develop BMP’s and, if necessary, additional regulations to protect natural habitats. Mitigation should be considered where impacts occur due to mining operations, especially if these impacts extend beyond the footprint of the mine.

4. Freshwater mussels should be inventoried on the Amite, Comite, and Tangipahoa Rivers. Louisiana Natural Heritage Program may have already initiated a survey.

5. A plan to re-establish mussels in the Amite, Tangipahoa, and Bogue Chitto Rivers should be developed as part of the state’s Wildlife Conservation Plan.

6. The need for regulations to protect freshwater mussels in the Pontchartrain Basin from recreational musseling should be evaluated.

7. A conservation area should be established on the Amite River where inflated heelsplitter mussels (*Potamilus inflatus)* are still present to protect this remaining mussel population for future public outreach and research.

8. Procedures should continue to de-authorize the Pearl River Navigation Project as quickly as possible. The Vicksburg District of the U.S. Army Corps of Engineers has recommended a reconnaissance study be initiated in FY06 to de-authorize the project.

9. The Poole Bluff sill on the Pearl River and the sill on the Bogue Chitto River should be removed, on the condition that the potential for remobilization of contaminated sediment is evaluated and deemed to have acceptably low risk. The goal of sill removal is to re-establish the natural hydrology and to improve fish migrations in the Pearl and Bogue Chitto Rivers. If the sills cannot be removed due to potential mercury (or methymercury) mobilization or other environmental hazards, fish ladders should be constructed. A rock fish ladder was proposed by Maygarden (2003) and Kohl (2003) for the Poole Bluff sill. The fish ladders should be designed to improve fish migration including Gulf sturgeon and other migratory fish.

10. Disposal of sewage sludge into abandoned pits or lakes should not generally be permitted, but where allowed, applicable permits for air, solid waste, hazardous waste and water quality must be approved (see Title 33, Part IX. Subpart 2, section 6901, November 2004 page 297).

11. Re-establishment of canebrake habitat along reaches of the Amite and Comite Rivers.

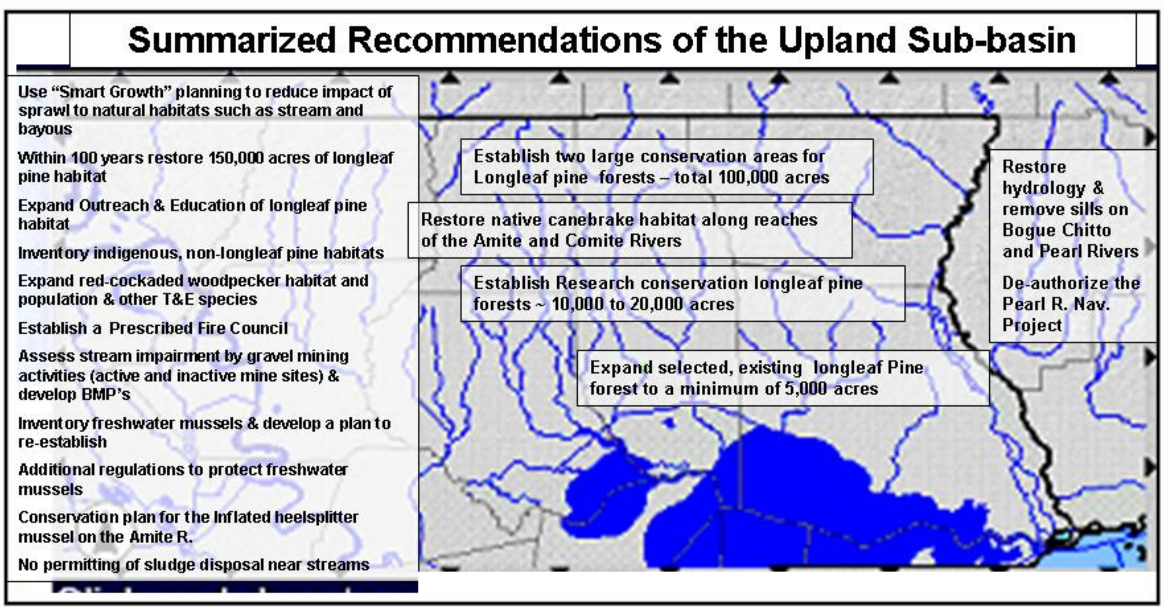


Figure 7: Map of General restoration recommendation in the Upland Sub-basin (North of Interstate 12). See text for detailed and complete recommendations.

Upper Sub-basin Analysis (Lake Maurepas and Adjacent Wetlands)

<u>Function Baseline of the Upper Sub-basin, circa pre-1800</u>

The pre-levee condition, circa 1800, of the Mississippi River was one dominated by overbank flow and small natural levee crevasses. The hydrology was dominated by the Mississippi River overbank flow, tidal flow through Pass Manchac from Lake Pontchartrain, Amite River discharge, and an average annual rainfall of 60 inches. Bayou Manchac was also originally connected to the Mississippi River and occasionally flowed river water into the Amite River. These and other smaller inputs of water kept the salinity range such that a mature (1,000-year+) cypress/tupelo (*Taxodium distichum – Nyssa aquatica*)swamp developed. The forested wetland extended as much as 26 miles north from the Mississippi River, to the Baton Rouge-Denham Springs fault line, which defines the edge of the Prairie Terrace just south of Ponchatoula. Lake Maurepas was enclosed by the swamps but by 1800 the lake was expanding by conversion of swamp to open water along its northern shoreline. This is evidenced by the capture of the former lower reach of the Tickfaw River, which is now North Pass. Davis (2000) reports significant 19th century crevasse breaches through artificial levees on this reach of the Mississippi. In general, rivers in an unaltered condition, may be expected to have overbank flooding on average once every 1 ½ years. Lopez (2003) reported from an incomplete record of the Mississippi River in the Pontchartrain Basin that flooding occurred once every 3.5 years. Cypress logging prior to mechanization (pre-1890) was accomplished by floating logs out of the swamps when swamp water elevation typically peaked in June (Mancil, 1972). This suggests that the pre-levee (circa 1800) flood baseline for spring flooding extended as late as June.

Rangia clams (*Rangia cuneata*) undoubtedly were significant to Lake Maurepas pre-1800 as evidenced by shallow cores, Indian middens, and shell banks. Poirrier and Franze (2001) suggested the Rangia clam could be considered the dominant species for Lake Pontchartrain, or at least an excellent indicator species. Rangia clams are thought to be volumetrically significant to the food web, and to be critical as a base component of the food web. The Rangia clams also play an important role in maintaining water clarity, thus supporting many other aspects of the Lake Maurepas ecology such as predation and maintenance of essential fish habitats. Blue crabs *(Callinectes sapidus),* which consumes Rangia clams, might also be considered a vital species due to it prevalence and its broad value in the lake’s food web as prey by mammals, birds, fish, and turtles.

<u>Form Baseline of the Upper Sub-basin circa 1900- 1920</u>

The Upper Sub-basin is dominantly a bald cypress-water tupelo swamp (see **Figure 17**). Commercial logging of the swamps in Upper Sub-basin started as early as 1800 but greatly accelerated after 1890, and by 1925 much of the cypress forests in the Upper sub-basin had been entirely clear-cut (Mancil, 1972). Commercial logging was occurring during the baseline period 1900-1932, and therefore the baseline condition is a partially logged habitat. The suggested baseline is 50% to 60% of the original virgin wetland forest area (pre-logging) in the Upper Sub-basin was in unimpaired condition, i.e. mature stands of cypress/tupelo swamps with a well developed canopy, understory, and ground cover with associated indigenous flora and fauna of a healthy cypress/tupelo swamp.

The map of wetland forest classification **(Figure 8),** provided by Dr. Gary Shaffer of Southeastern Louisiana University, depicts the current condition of the formerly extensive wetland forests around Lake Maurepas. Green areas are sustainable wetland forests representing 13.3% (12,547 acres) of the wetlands. Red areas are as degraded swamp which were formerly wetland forests (now mostly marsh), representing 16.1% (15,168 acres) of wetlands. Yellow areas are thinly forested wetlands that are not re-generative, i.e. “relic forest”, which represent 67.2% (63,247 acres) of the wetlands.

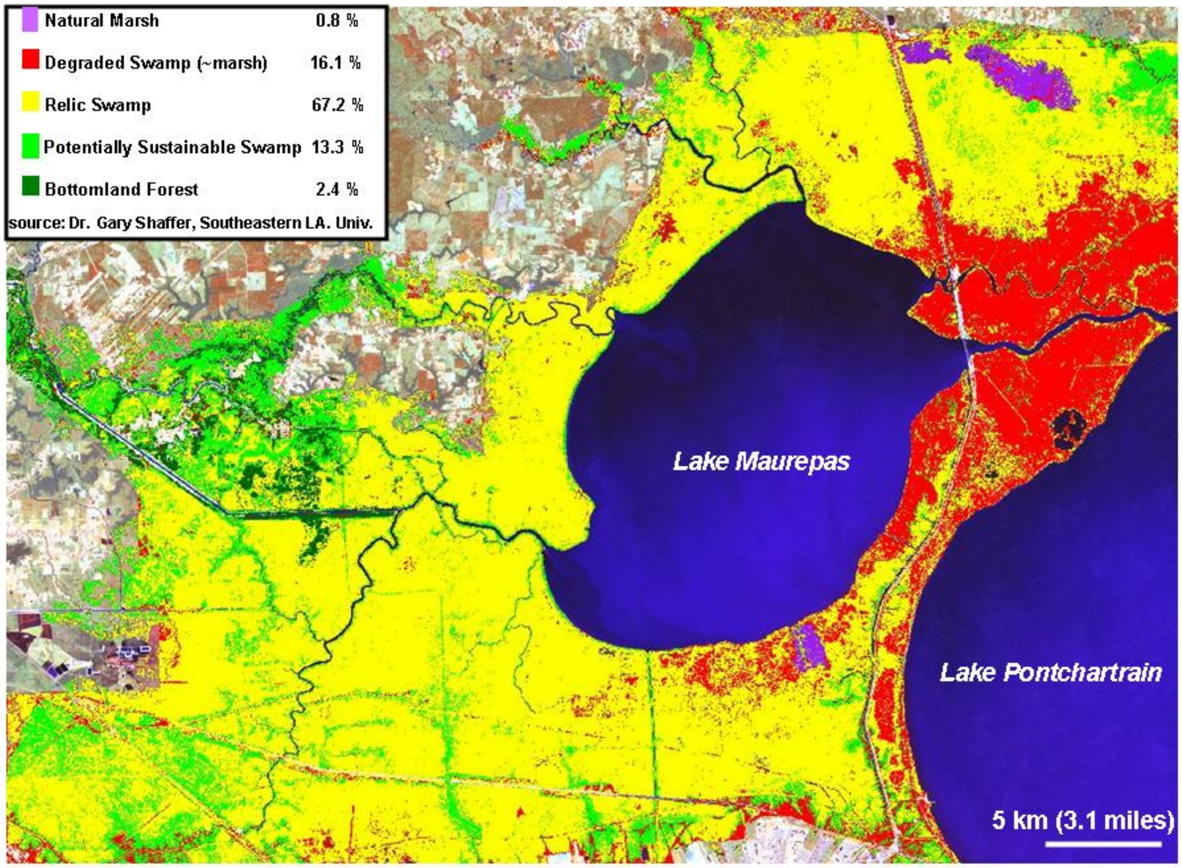


Figure 8: A 2002 Thematic Mapper scene (with "supervised classification" in the GIS Imagine) was used to extrapolate known classes of swamp (from forty 625 m^2 permanent plots) to the Maurepas/Manchac as a whole. Wetland areas include: (a) swamp that has converted to marsh or open water (red), as well as a few areas of stable marsh, (b) swamp that will not likely regenerate if logged (yellow), (c) and swamp that will likely regenerate if harvested (green). (source: Dr. Gary Shaffer, Southeastern Louisiana University)

Ranked Impairments and Restoration Strategies of the Upper Sub-basin

Impairments highly critical to the habitats of the Upper Sub-basin

Mississippi River levees Construction of flood protection levees along the Mississippi terminated the hydrologic connection of the Mississippi River to this portion of its deltaic plain, which directly resulted in several major chronic impairments to the Upper Sub-basin wetlands, including:

1. Loss of mineral sediment input reducing sediment accumulation in wetlands
2. Significant reduction in nutrient input, of which nitrogen is now highly limiting to productivity
3. Significant reduction of freshwater input, which allows occasional but significant short term salinity increases and severe salt stress of vegetation including the dominant species of bald cypress
4. Significant reduction of hydraulic head and therefore circulation of water leading to stagnant conditions such as low dissolved oxygen
5. Loss of regeneration potential of second growth cypress-tupelo forests, of which roughly 64% are now considered "relic forest" i.e. a chronic condition leading to eventual loss of the forest. Local impoundments have also contributed to this impairment.
6. Limits growth of the bald cypress, the dominant species in the Upper Sub-basin, and has prevented the natural succession to a habitat structure of a thick upper canopy with limited lower shrubs and grasses

Restoration Strategies:
1) Re-introduction of Mississippi River water to benefit wetlands
2) Gapping of channel banks or berms to increase freshwater circulation
3) Modify MRGO to reduce magnitude of high salinity events

Impoundments: The generally unintended, impoundment of wetlands in the Upper Sub-basin by canals, berms, logging ditches, roads, highways, railroads, etc., has severely altered the natural hydrology by proportionally increasing channelized flow volume while reducing overland flow volumes, which lead to the following detrimental habitat conditions:

- Interior swamp areas have very low water circulation contributing locally to further low nutrient and sediment deficit
- Disruption of the natural movement of organisms that are otherwise influenced by the unimpeded flow of water

Restoration Strategy:
Reduce impediments to overland flow by use of culverts or gapping of banks or berms

Cypress Logging: Historical cypress clear-cut logging of the entire stand of virgin wetland forest is the single greatest impairment to the Upper Sub-basin. Regeneration potential of second growth has been severely limited. Nevertheless active and potential future logging of the second growth forest is still possible under current regulatory environment including the "relic forests". The logging of the relic forest is unequivocally non-sustainable and potentially could result in permanent loss of the remaining forests under current habitat conditions.

- Historical logging resulted in near complete loss of tree cover, tree canopy, and severe alteration in the natural hydrology
- Current logging, even with BMP's, of "relic forests" is non-sustainable and is resulting in the loss of thin forest stands which under current conditions will not re-generate

Restoration Strategies:

1) Acquisition in-fee of wetland forests or of wetland areas, which have potential for re-forestation
2) Ban on logging of relic forests (**see Figure 8 and 9)** and in benefit areas of proposed restoration projects
3) Implementation of logging easements in which landowners are paid not to log their land
4) Use of BMP's for logging in sustainable wetland forests, so that forests are sustained by re-generation and also to protect stream water quality

Figure 9: Examples of deteriorated cypress-tupelo swamp in the region south of Lake Maurepas, taken along Potato Run in the vicinity of sampling site 6 (north of Tent Bayou, south of Alligator Island, west of Dutch Bayou). (source Lee Wilson & Associates, Inc., Gary Shaffer, Mark Hester, Paul Kemp, Hassan Mashriqui, John Day, and Robert Lane, 2001)

5) Education of the public to reduce demand for cypress wood products, especially mulch
6) Mitigate for adversely impacted swamp habitat by development of mitigation plans to benefit of similar habitat within the Pontchartrain Basin
7) Endorse the policies of the Science Working Group of Coastal Wetland Forestry
8) Pursue state legislation banning cypress logging within the relic forest in the Pontchartrain Basin. A moratorium should be placed on all other cypress logging in the Pontchartrain

Basin until credible BMP's are established and practiced so that logged cypress forests can be sustained.

Subsidence: Relative subsidence, as a result of combined absolute sea level rise and absolute sinking of the wetland soil platform, is a significant influence, which allows more frequent flooding from Lake Maurepas when water levels rise. This results in the following impairments:

- Changes in the natural hydroperiod causing stress on wetland vegetation, particularly cypress, which requires dry periods for re-generation
- Increased occasional inland movement of saltwater, which stresses freshwater wetland vegetation

Restoration Strategies:
1) Dedicated dredging to nourish drowning marsh and historic swamp areas (now permanently flooded) with sediment to maintain marsh and swamp platforms to sustain marsh or forest vegetation (alternative borrow sites evaluated should include the Mississippi River and the Bonnet Carre' Spillway)
2) Increase organic accumulation by increasing plant productivity by use of treated sewage effluent
3) Re-introduction of Mississippi River to benefit subsided wetland platforms

Urbanization: The Upper Sub-basin has significant historical and potential encroachment of urbanization along the southern and western regions. Urbanization of Upper Sub-basin contributes a myriad of impacts to habitats and water quality. Habitats are impacted by:

Direct loss of wetlands habitat by development footprints or by inclusion in flood protection areas

Indirect degradation of habitat may occur due to water quality degradation, increased hunting and fishing pressure and related effects.

Restoration Strategies:
1) Acquisition of critical habitats subject to loss due to potential development
2) Education of the public on the value of wetlands and methods for minimizing urban impacts, i.e. land use planning
3) Conservation easements to preserve critical ecosystem elements to sustain nearby wetland habitat
4) Creation of land trusts
5) Maximization of benefit to wetlands through the permitting process by submitting comments and creation of mitigation banks within the Upper Sub-basin

Impairments Moderately critical to the Habitats of the Upper Sub-basin

Shoreline Erosion along the rim of Lake Maurepas averages as much as 10 feet per year from 1960 to 1995 (Zganjar et al., 2001). The northern and northeast shorelines are most critical and warrant consideration of projects to reduce erosion and protect critical landforms such as the peninsula between North Pass and Pass Manchac.

Herbivory by insects and mammals are mostly due to invasive species, which have a major impact under the current stressed condition of wetland vegetation. It is possible that with restoration, such as freshwater reintroductions, that more robust vegetation may not be as vulnerable to herbivores. Examples are: nutria (*Myocastor coypus)* and fruit tree leafroller caterpillar, *(Archips argyrospila)*. Currently a CWPPRA bounty program exists to reduce nutria populations.

Invasive species of concern are mostly plants, which displace indigenous vegetation and are generally less beneficial or even detrimental to the ecosystem. Examples include: Water hyacinth (*Eichhornia crassipes*), Giant salvinia (*Salvinia molesta)*, Common salvinia (*Salvinia minima*), Chinese tallow *(Sapium sebiferum***)**, and Eurasian watermilfoil (*Myriophyllum spicatum***).**

Impairments Less Critical to the Habitats of the Upper Sub-basin
Current Oil and Gas Activities are low in the Upper Sub-basin, but there can be expected to be occasional increases in activities and potential impacts. Historical impacts include dredging of canals, land clearing, pipelines and other possible effects.

Methylmercury appears to be an emerging issue principally due to human health concerns. Study is ongoing and probably should continue.

Over-harvesting of wetland species is a complex issue resulting from commercial and recreational capture of various species. There are indications that a long term decline in certain species may be occurring such as alligator snapping turtle (*Macrochelys temminckii*), American bullfrog *(Rana catesbeiana*), blue crab (*Callinectes sapidus*), and blue catfish *(Ictalurus furcatus)***.** More data are necessary on the local populations to assess the status of these and other species.

Potential for oil/chemical spills or accidental releases of effluent leachate, etc. are relatively low. The largest industrialized area in the Upper Sub-basin is along the Mississippi River, in which most plants currently discharge into the Mississippi River. Historically spills have occurred such as a gasoline spill in 1996. The Marathon Pipeline ruptured on 05/24/96 releasing 11,308 barrels of gasoline just north of the intersection of Blind River and US 61 (Airline Hwy.). In addition, a network of pipelines servicing this industrial corridor crisscross the Upper Sub-basin and do represent a potential threat from accidental or even terrorist related leakage events.

Extinct/ Extirpated and Threatened/Endangered fish and wildlife

Due to the impacts described above and other compounding factors the following species are extinct in Upper and Middle Sub-basins: Louisiana parakeet *(Conuropsis carolinensis)* and the passenger pigeon *(Ectopistes migratorius).* In addition the following subspecies have been extirpated: Bachman's warbler (*Vermivora bachmanii*), American bison (*Bison bison*) and the ivory-billed woodpecker (*Campephilus principalis*). The following species are considered threatened or endangered Bachman's warbler, Bald Eagle (*Haliaeetus leucocephalus*), Louisiana black bear (*Ursus americanus luteolus)*, Gulf Sturgeon (*Acipenser oxyrinchus desotoi)*, Pallid Sturgeon *(Scaphirhynchus albus*), Peregrine falcon (*Falco peregrinus*).

<u>Restoration Recommendations in the Upper Sub-basin (See Figure 10 for a summary map)</u>
Mississippi River Re-introductions in the Upper Sub-basin - Although the ubiquitous, clear-cut logging of the Upper Sub-basin's virgin Bald cypress forests was the greatest historical impact to the Upper Sub-basin (Lopez, 2003), it is the construction of Mississippi River levees, which is primarily preventing recovery of the forests and therefore, defines the characterization these

wetlands as predominately a relic forest (Shaffer, 2003). The deficiency of nutrients, particularly nitrogen, and the lack of circulation are the primary limitations to regeneration of bald cypress, the dominant species (Shaffer, 2003). Lack of nutrients also results in a generally low productivity of the swamp ecosystem. An alteration in the hydroperiod including excessive elevated water events is also contributing to the lack of re-generation of bald cypress. Cypress seeds will not germinate under water, and once sprouted seedlings must grow fast enough to keep crowns above any rising water. Seedlings completely submerged become dormant and will eventually die. Reintroduction of Mississippi River water with outfall management and appropriate planning for flood abatement is the most effective and sustainable approach to restore these once magnificent forests. **Table 7** summarizes the goals of Mississippi River reintroductions into the Upper Sub-basin.

Four river reintroductions are supported. However the precise location of a diversion structure or conveyance canal is secondary to the goal of simply getting the river water to the benefit areas. It is recommended that diversion structures and their conveyance canals be designed toward the upper end of the discharge ranges proposed so that if larger discharges are warranted, the discharge will not be precluded by design-limitations. It is generally recommended that discharges be designed to maximize wetland productivity while minimizing the direct introduction of river water into Lake Maurepas. Management plans should consider discharges which emulate the circa 1800 (pre-levee) hydrologic function including reintroductions during the spring flood from April to June. The primary impact to Lake Maurepas should be reduced salinity stress by reintroduction of Mississippi River water through wetlands and an increase in the input of detritus.

An additional goal of reintroductions is enhanced fisheries within Lakes Maurepas and Pontchartrain without harmful cyanobacterial (blue-green) algal blooms. Discharges from various reintroduction sites should be sized proportionally to the area of wetland benefit. Within the Upper and Middle Sub-basins the benefit areas rank as follows (largest first): Blind River basin,

Table 7: Goals of Reintroductions of Mississippi River Water to the Upper Sub-basin

1) Convert a dominantly relic forest into a sustainable forest over the southern half of the upper basin - (see map with benefit areas)
2) Develop a mature swamp canopy over 50% of the benefit areas
3) Increase productivity of woody plants to at least 200% of current levels
4) Increase organic export (detritus) to Lakes Maurepas and Pontchartrain to 200 % of current levels.
5) In general, increase populations of indigenous species to sustainable levels, such as crawfish, alligator snapping turtles, bald eagles, blue crab, and channel catfish
6) Increase mineral and organic accumulation
7) Reduce net relative subsidence
8) Reduce stress to freshwater vegetation due to high salinity events related to seasonal hydrology, drought conditions, saltwater introduction by storm events and the Mississippi River Gulf Outlet.
9) Manage as a tidal freshwater system with salinities ranging from fresh (<0.5 ppt) to 1 ppt during most years. Occasional short–term increases up to 3 ppt are needed to allow recruitment of Rangia clams from larvae.
10) Enhance fisheries within Lake Maurepas and Pontchartrain without harmful cyanobacterial (blue-green) algal blooms.

Maurepas Reintroduction (Hope Canal), LaBranche wetlands, Frenier wetlands, Bayou Trepagnier, Bonnet Carre' Spillway wetlands, Bayou Fountain, Bayou Manchac. The combined discharge and the potential effects on Lake Pontchartrain and Maurepas should be considered for both fisheries benefit and the potential to cause harmful cyanbacterial algal blooms.

River Reintroduction into Maurepas Swamp - The "River Reintroduction into Maurepas Swamp" (Project # PO-29) is an approved CWPPRA project in Phase I (design phase) and is one of five coastal projects proposed under the 2004 draft LCA report. Both the CWPPRA and the LCA projects propose using the Hope Canal as a conveyance canal. The current CWPPRA project proposes a 2,000 cfs discharge conveyed through the Hope Canal toward a 36,000 acre benefit area extending from the Reserve Relief Canal (eastern boundary) to the Blind River (western boundary). The LCA report suggests a discharge from 1,000 to 5,000 cfs also through the Hope Canal for a similar benefit area. However the actual benefit area, in all proposals, would depend on the actual seasonal discharge and other design features. **Figure 15** depicts the proposed target benefit area for a reintroduction project in the vicinity of Hope Canal. Since productivity is currently very low, it appears high discharge rates may be justified by the potential to increase productivity.

River Reintroduction into Blind River Basin - The Blind River Basin is a natural dendritic drainage area which drains off the large crescent shaped topography from the former natural levee of the Mississippi River. This drainage converges into Blind River, which flows northeasterly into Lake Maurepas. This drainage have been altered by the construction of Mississippi River levees, which has reduced fresh water input and by un-elevated portions of Highway 61, the Kansas City Southern railroad, and by Interstate 10, which by crossing east-west has reduced the northward flow of water and impaired movement of local fauna. The proposed project is to restore the natural hydrology by construction of culverts underneath the Railroad, Highway, and Interstate; and by reintroduction of Mississippi River water. The diversion site may be located at one or several small sites between Lutcher and White Hall on the Mississippi River. Two or three small diversion structures may better emulate the overbank conditions than a single structure, however, one large structure with outfall management could still achieve the objective of dispersing river water over a large portion of the Blind River Basin.

Bayou Manchac and Fountain Bayou - Two small reintroductions are also recommended near Baton Rouge for Bayou Manchac and Fountain Bayou. The Bayou Manchac reintroduction will re-establish a small distributary of the Mississippi River and primarily benefit water quality of the bayou and adjacent swamp. Potential for flooding of homes, as with all reintroduction projects, needs to be evaluated and addressed. Fountain Bayou reintroduction is to primarily benefit Spanish Lake, which is currently in a highly stagnant condition. Water control structures should be evaluated to increase circulation within Spanish Lake.

Hydrologic Restoration in the Upper Sub-basin

Amite River Diversion Canal Bank Gapping Project - The "Amite River Diversion Canal Bank Gaping Project" is a U.S. Army Corps of Engineers restoration project under Section 1135. A Preliminary Restoration Plan is complete, but the project is currently unfunded. The same project is also listed in the 2004 LCA report. The Amite River Diversion was constructed by the U. S.

Army Corps of Engineers in 1964, which included a continuous spoil bank on both the north and south. The Amite diversion canal receives excess flow from the Amite River. This project is to gap the northern spoil banks to reintroduce Amite River water into the adjacent swamps. This project is supported and has the same goals as those listed for river reintroductions.

South Slough Hydrologic Restoration - The “South Slough Hydrologic Restoration” was proposed by the U.S. Army Corps of Engineers as a restoration project for the Pontchartrain Restoration Act in 2003. The project is located south of Ponchatoula where a drainage canal flows south and west into the Interstate 55 access canal. This project proposes gapping the spoil bank to allow assimilation of storm water in adjacent wetlands. This will improve the adjacent wetlands by improving circulation and introduction of nutrients. Water quality will also be improved by reducing storm water in channels and other open water conditions. Similar conditions exist just west of Interstate 55 from South Slough. Local landowners have indicated support for a similar gapping project on their land. Combining these two projects may be cost effective and generate a more integrated design.

Other Restoration Recommendations in the Upper Sub-basin

Shoreline protection in Lake Maurepas - The north and northeast shore of Lake Maurepas is undergoing the modest rates of shoreline retreat (generally 4’ to 10 ‘/year) (Zganjar et al., 2001). In 2004, a local resident proposed a CWPPRA shoreline protection project be constructed near Jones Island. The CHMP Committee supports shoreline protection in truly critical areas if this can be accomplished with low impact to the lake or shoreline. In particular aquatic access and hydrologic continuity need to be maintained from the lake to the channels and shoreline wetlands. Reef, beach restoration or vegetative type protection should be considered as alternatives for shoreline protection.

Alligator Snapping Turtle Protection – In 2003, state legislation was passed prohibiting the commercial harvest of alligator snapping turtles due to a depleted population throughout much of the state. The Upper Sub-basin is prime habitat for alligator snapping turtles and so this ban is supported until the population rises significantly to a sustainable level that would allow commercial harvesting.

Ivory-Billed Woodpecker Re-introduction -Develop a plan to re-introduce the ivory-billed woodpecker (*Campephilus principalis*) to its native range within the Pontchartrain Basin. The reported confirmation in 2005 of the ivory-billed woodpecker sightings represents a unique opportunity to re-establish a species of great interest, which was presumed to be extinct. The reported sightings are in Arkansas near the Louisiana state line. The Pearl River alluvial swamps and the swamps near Lake Maurepas should be targeted for re-introduction and/or protection.

Conservation Recommendations in the Upper Sub-basin
Four Wildlife Management Areas (WMA) are established in the Upper Sub-basin, including the Joyce WMA, Manchac WMA, Maurepas Swamp WMA and Maurepas Swamp WMA - eastern tract (near the Reserve Relief Canal). The southern WMA’s (Maurepas Swamp WMA and Maurepas Swamp WMA- eastern tract) are largely included in the benefit areas for river reintroductions. The primary goal of the river reintroductions is to re-establish a highly productive forested swamp. Therefore it is proposed that the WMA’a, which overlap with the benefit areas of

the river reintroductions, have management and restoration strategies which are consistent with the goals of these restoration projects. The river reintroduction projects will likely cost in excess of $200 million. A complete and permanent ban on commercial logging and prohibition of any other activity that significantly detracts from the goals of the restoration projects should be implemented.

The Joyce and Manchac WMA's have largely been converted to fresh marsh and these WMA's have little opportunity to benefit directly from a river reintroduction from the Mississippi River. At this time there is no restoration strategy known that can reestablish these fresh marshes into the former forest. Unless a restoration plan can be developed to restore the forests, it is best to simply preserve and optimize the function of these marshes to support secondary production in Lakes Pontchartrain and Maurepas. If these areas begin to have indicant conversion to open water, long-distance piping of sediment from the Mississippi River should be considered to re-build or sustain these marshes.

One critical habitat that has not been brought into conservation in the Upper Sub-basin is a riverine ecosystem. It is proposed that a conservation area be targeted including one or more of the small rivers draining into Lake Maurepas. Specifically the Tickfaw, Amite or Blind Rivers should be considered for conservation. This new conservation area should capture a segment of the river and the adjacent shoreline at its outfall in Lake Maurepas. Another riverine conservation opportunity would be to extend the Joyce WMA eastward to include a portion of the Tangipahoa River.

Beneficial use of treated sewage effluents – The increasing urbanization of rural areas and expansion of municipalities is placing an increasing burden on already generally inferior sewage treatment systems within the Upper Sub-basin. Numerous plans and projects are underway to expand or refurbish sewerage plants. Treated sewage effluent can be used beneficially in wetlands and stimulate productivity (Day, et al., 2004; and Mitsch and Gosselink, 2000). Residence time of discharges into wetlands must be sufficient to ensure nutrients and pathogens are reduced to safe levels before they reach streams or open water. Opportunities exist to better treat sewage and to improve nearby wetlands. Mandeville in St. Tammany Parish has developed a tertiary treatment system, which conveys effluent into recently acquired nearby wetlands. Hammond is developing similar plans. Beneficial use of treated sewage effluent may be especially critical to restoration for those areas of the Upper Sub-basin beyond the influence of Mississippi River reintroduction projects. It is recommended that municipalities near wetlands in the Upper Sub-basin evaluate the opportunity to beneficially use treated sewage effluent from their plants. This does not imply that adding wastewater will be beneficial to all types of wetlands. Certain types of wetlands (e.g. flatwoods, sawgrass, and sedge meadows) may be damaged by wastewater (Keddy and Fraser, 2002)

Restoration Position Statements on Various Issues in the Upper Sub-basin

1. The CHMP supports a permanent ban on commercial shell dredging in Lake Maurepas.

2. The CHMP supports protection and a restoration plan for re-establishment of the endangered small-tooth sawfish *(Pristis pectinata)* in Lake Pontchartrain and Lake Maurepas. Such a plan would need to consider impact to commercial fishing.

3. The CHMP supports the continued development of corridors for pipelines or powerlines to minimize habitat loss in and around Lakes Pontchartrain and Maurepas. An agreement was developed which defined preferred north-south and east-west pipeline corridors across Lake Pontchartrain to minimize habitat loss. (LA Department of Natural Resources, 2003)

4. The CHMP endorses a ban on commercial dredging of the water bottom in Lake Maurepas (similar to that passed in the state legislature in 2004 for Lake Pontchartrain (Senate Bill No. 767: Act N0. 716). (Dredging on a small scale, where deemed a net environmental benefit and for the construction of wetlands, is not opposed. These projects should consider possible negative impacts such as avoidance of sensitive habitats, such as SAV and other indirect effects such as wave refraction.)

5. The CHMP endorses the recommendations of the Science Working Group of Coastal Wetland Forestry (LA Coastal Wetland Forest Conservation and Use - Science working Group (2005).

6. State legislation should be developed to permanently ban cypress logging of "relic forests" (Category 3) and to place a moratorium on all other cypress logging within the coastal zone of the Pontchartrain Basin. A moratorium should be placed on all other cypress logging in the Pontchartrain Basin until credible BMP's are established and practiced so that logged cypress forests can be sustained.

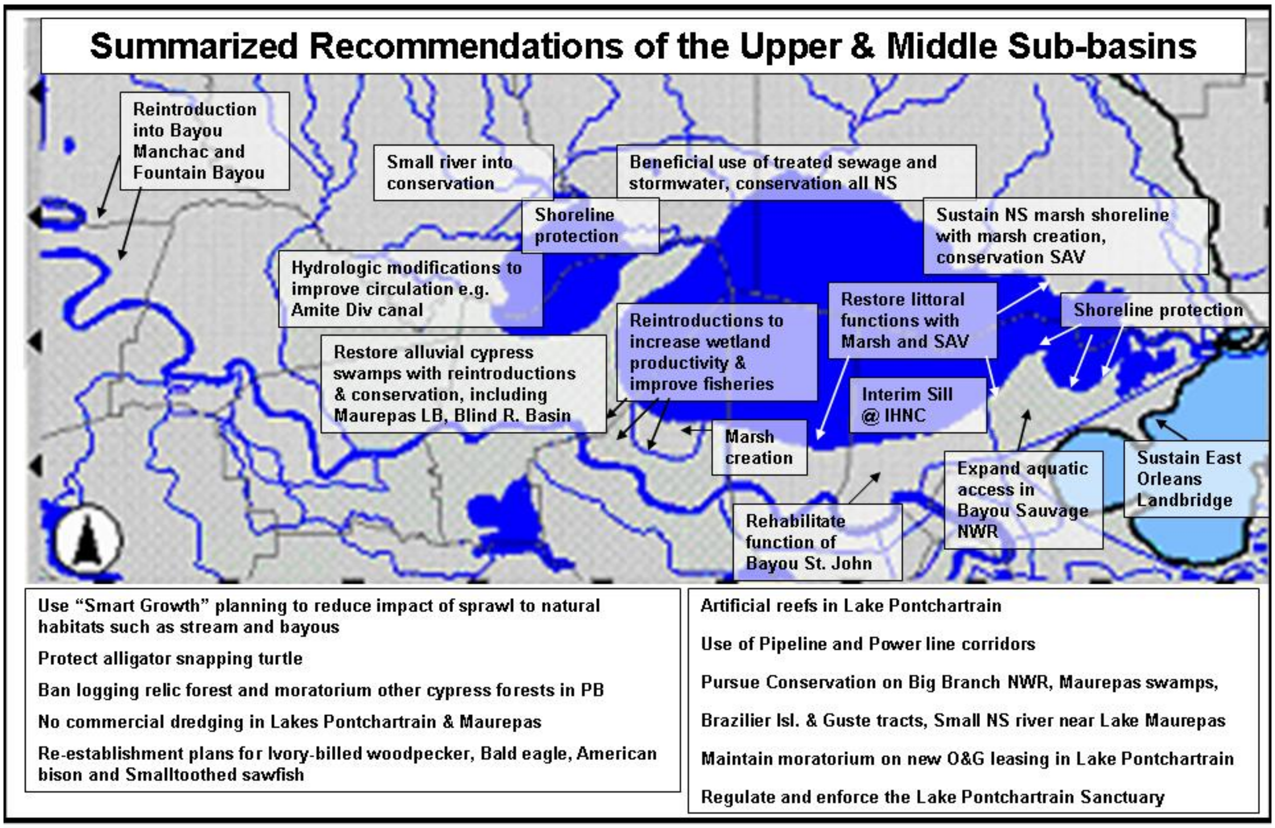


Figure 10: Map of general restoration recommendations in the Upper and Middle Sub-basins (Lakes Maurepas and Pontchartrain and adjacent wetlands). See text for detailed and more complete recommendations.

Middle Sub-basin Analysis (Lake Pontchartrain and Adjacent Wetlands)
Function Baseline of the Middle Sub-basin, circa pre-1800

Since most of the Middle Sub-basin is occupied by Lake Pontchartrain and its surrounding wetlands, Lake Pontchartrain is the defining feature of the Middle Sub-basin.

Lake Pontchartrain differs from other Louisiana estuaries in that it receives drainage from pinelands associated with upland Pleistocene terraces of the Florida Parishes. Water entering from Lake Maurepas and streams to the north is generally acidic, highly colored, low in alkalinity and relatively low in nutrients or suspended silts and clays. Pre-armoring, the eastern sector of Lake Pontchartrain had a sand shoreline with sand and shell beaches. Because of its shallow depths, bottom sediments are often temporarily re-suspended by strong winds of winter storms increasing turbidity. Runoff also causes locally highly turbid conditions. However, due to low phytoplankton concentrations and lack of introduction and re-supension of silts and clays, there are extended periods of relatively clear water during spring, summer, and fall. Water clarity generally correlates with higher salinity conditions of the summer or during extended drought conditions (Francis and Poirrier, 1999).

Although the south shore of Lake Pontchartrain had a deltaic origin and may have been more eutrophic prior to levee construction, Mississippi River water flowed through swamps and marshes, and was probably relatively clear and low in nutrients when it entered the Lake. At present, urban runoff from the developed flood plain is relatively low, in silts and clays and although it stimulates phytoplankton production does not lower water clarity from suspended silts and clays. Lake Pontchartrain also naturally has a relatively, low stable salinity regime because it is connected to higher salinity estuaries by narrow tidal passes, and not subject to large, daily lunar or wind-generated tidal changes. The number of animal species in an estuary increases as salinity increases, and by nature relatively few marine or freshwater species occur in Lake Pontchartrain.

A biological factor that contributes to the unique nature of Lake Pontchartrain is the abundance of Rangia clams (*Rangia cuneata*). Clams are filter feeders that remove phytoplankton, bacteria, suspended detrital particles, silt, and clay from the water column. These clams provide numerous ecological services for Lake Pontchartrain and their filtering activities contribute to the extended periods of relatively clear water. Another feature of Lake Pontchartrain is the presence of *Vallisneria* and *Ruppia* grassbeds that used to extend to depths of six feet and beyond. The abundance and distribution of these grassbeds is dependent upon clear water and low concentrations of plant nutrients. Turbid water shades the plants and limits growth. Nutrients may also induce shading from phytoplankton and algal growth on the plants. Lake Pontchartrain, as other estuarine systems, is dependent upon surrounding wetlands to provide organic matter (detritus) for secondary production (food for shrimp, fish, clams, crabs, etc.); essential habitat for invertebrate fish and wildlife; maintaining water quality; and other ecological services. However, it differs from other Louisiana estuaries in having high loss of wetlands and wetland functions through urbanization, shoreline modification, levees, roads, hydrologic changes, and other factors.

The low, stable salinities, grassbeds, and sandy bottoms provide diverse habitat for unique, aquatic communities. The relatively clear estuary water and a few beaches support recreational activities such as sunbathing, swimming, water skiing, snorkeling, SCUBA diving, and spearfishing for the New Orleans area that are difficult to find in other Louisiana estuaries.

Lake Pontchartrain's combined characteristics of being an estuarine lake with relatively clear water is what distinguishes it from most inland lakes in general, and from other more purely estuarine lakes and bays common in the Louisiana coast. Other estuarine lakes in Louisiana are more likely to be eutrophic or mesotrophic. It is the resulting balance in these physical and biological processes that are Lake Pontchartrain's central character, which is paramount to restore and preserve in the Middle Sub-basin. It is the consensus of the CHMP Draft Committee that Lake Pontchartrain as a whole should be considered an oligotrophic to mesotrophic in character, for both the present and past. The value of this is not just historic precedence, but it is this character, which in modern times allows Lake Pontchartrain to be a major fisheries and recreational resource simultaneously. These intrinsic values must be preserved and sustained.

Darnell's (1958) studies of Lake Pontchartrain were among the first to demonstrate that the estuarine food web was highly dependent on detritus. While some organisms directly consume detritus, most gain benefits from the digestion of the bacteria and fungi associated with the breakdown of detritus or by filtering dissolved organic matter. Day et al. (1989) emphasized the important role of detritus in estuaries in general, and in Louisiana estuaries in particular. O'Connell's recent studies of the food webs of Lake Pontchartrain indicate that organisms rely on multiple primary sources of energy (e.g., marine phytoplankton, freshwater phytoplankton, detritus, etc.). Of these, detritus remains one of the most important energy sources, especially in the western portions of the estuary. O'Connell (email Comm., 2004) suggests the following benefits of wetland derived detritus in Lake Pontchartrain:

- Providing Lake Pontchartrain with wetland derived detritus from local sources is more ecologically beneficial to Lake Pontchartrain than using unfiltered Mississippi River detritus because this delivery process is more like the original natural system of overbank flooding with longer retention time in the wetlands before entering the lake
- Though detritus may be directly consumed by organisms, it is usually not the dead plant material that confers energetic benefits but the bacteria and fungi associated with the decomposition of this material
- Therefore, the longer detritus stays in the ecosystem being digested by bacteria, fungi, and higher organisms, the greater its ecological benefits to local species

Detritus has probably been reduced by both loss of wetlands and by reduction in primary productivity of these wetlands. The benefits of a reintroduction are maximized when introduced organic matter and nutrients move slowly though the wetland system, rather than being delivered quickly as in a direct diversion of Mississippi River water to Lake Pontchartrain, which historically have caused harmful algal blooms

The salinity of at least the southeastern portion of Lake Pontchartrain was probably 20-30% fresher than current salinities but also with fewer severe salinity periods. Several studies report increases in salinity in Lake Pontchartrain after construction of the Mississippi River Gulf Outlet (Tate et al., 2002; USACE, 1995). Also absent was salt water stratification and related anoxia. The water column was generally well mixed and generally well oxygenated. Shallow cores of the Holocene sediments taken from Lake Pontchartrain, generally contain gray muds and silts and generally do not contain black, organic rich layers, which would indicate anoxic events in the Holocene (Flocks and Kindinger, 2001).

Rangia clams (*Rangia cuneata*) undoubtedly were significant to Lake Pontchartrain pre-1800 as evidenced by shallow cores, Indian middens, and shell banks. Poirrier and Franze (2001) suggested the Rangia clam could be considered the dominant species for Lake Pontchartrain, or at least an excellent indicator species. Rangia clams are thought to be volumetrically significant to the food web, and to be critical as a base component of the food web. The Rangia clams also play an important role in maintaining water clarity, thus supporting many other aspects of the Lake's ecology such as predation and maintenance of essential fish habitats such as SAV. Blue crabs*(Callinectes sapidus),* which consume Rangia clams, might also be considered a vital species due to its prevalence and its broad value in the lake's food web as prey for mammals, birds, fish, and turtles.

The wetlands adjacent to Lake Pontchartrain are co-dependent with the Lake. The wetlands provide detritus, cover, and diversity. Lake Pontchartrain allows tidal exchange and provides aquatic access to migrating species into the wetlands. The remaining south shore wetlands, such as the LaBranche wetlands, are vital because they allow the potential for river reintroduction through the wetlands to then benefit Lake Pontchartrain. The north shore wetlands are important because of their extent and their support to the streams and bayous of the north shore. The north shore wetlands also have some unique wetland characteristics for the Middle Sub-basin. In the coastal wetlands on the west side of the Tchefuncte River, cypress swamps intergrade with sawgrass (*Cladium jamaicense*) meadows, producing a landscape reminiscent of wetlands found much further east in the Everglades (**Figure 11).** Near Big Branch, wet pine flatwoods gently grade into coastal marshes, producing a highly diverse assemblage of wetland plants that is unique on the north shore.

Figure 11: Photograph from near the west bank of the Tchefuncte River on the north shore, where a cypress swamp intergrades with sawgrass (*Cladium jamaicense*) meadows, producing a landscape reminiscent of the Everglades. The sawgrass plants grow over 5 feet and are surrounded by wet meadows containing many other distinctive plant species.

Form Baseline of the Middle Sub-basin circa 1900- 1920

By 1920, the Middle Sub-basin had been impacted by loss of the natural levee by plantation farming and by the footprint of New Orleans. However, in spite of these impacts, Lake Pontchartrain and its adjacent wetlands were an extensive and healthy estuary. In 1932, there were 165,600 acres of wetlands with the freshest habitats being those along rivers, bayous, and along the western shore of Lake Pontchartrain. These areas were originally forested with cypress/tupelo, which were logged by 1940. Much of the remaining wetlands around Lake Pontchartrain were probably fresh to intermediate marshes (see **Figure 17**).

The current shoreline length in Lake Pontchartrain is 125 miles (Beall et al., 2001). In 1928, 97% of the shoreline (~120 miles) was unarmored, but by 2002, only 63% of the original lake shore (~78 miles) remained unarmored (Lopez, 2003). Unarmored shoreline allows a natural interchange with adjacent wetlands, and therefore, important hydrologic and aquatic functions occur. The lake's fringe wetlands provide nutrient/detritus exchange, biologic refuge, feeding areas, tidal flow, wildlife habitat, growth of shoreline plant communities, and other estuarine functions (Day et al., 1989 and Shafer et al., 2002). Approximately 8% of this armoring is located offshore and not directly on the shoreline. Armoring offshore, such as with an offshore breakwater, has negative effects, but does allow many important functions to occur. Armoring on the shoreline generally reduces or eliminates most functions. Over 92% of the armoring in Lake Pontchartrain (43 miles) is armoring directly on the shoreline where function is severely limited. Most of this direct shoreline armoring is located on the south shore in Orleans and Jefferson Parishes, utilizing rip-rap or seawall.

Due to a combination of armoring, turbidity increase and other impacts there was a dramatic loss in SAV associated with the armored sections of the littoral zone.

Key form baseline circa 1900-1920

1) Approximately 620 square miles of open water of Lake Pontchartrain
2) 165,600 acres of marsh and swamp reported in 1932 adjacent to Lake Pontchartrain*
   *Coast 2050 mapping units: Bonnet Carre' Spwy, LaBranche Wetlands, Bayou Sauvage, East Orleans Landbridge, Pearl R. Mouth, North Shore Marsh, Tchefuncte R. Mouth, Tangipahoa R. Mouth, East Orleans Landbridge
3) A minimum of 120 miles of littoral shoreline (unarmored)
4) Approximately 50 miles of shoreline with some SAV cover
5) 2000 acres of SAV in Lake Pontchartrain extending to a depth of six feet in most years (Poirrier, pers. comm.)
6) Two tidal passes introducing saltwater into Lake Pontchartrain
7) One tidal pass connecting to Lake Maurepas (Including both Pass Manchac and North Pass)

Ranked Impairments to the Middle Sub-basin

The areal extent of marsh and swamp adjacent to Lake Pontchartrain declined by 28,300 acres (17%) from 1932 to 1990 based on reported land extent in Coast 2050 for those periods. In 1990, 137,300 acres were reported to be present (see preceding description of baseline form for mapping units). Other major morphologic change includes the man-made creation of a new tidal pass into Lake Pontchartrain at the Inner Harbor Navigation Canal. The only area of creation of new wetland in the Middle Basin is at the site of the Bayou LaBranche Marsh Creation project (CWPPRA Project # PO-17), which created 300 acres of land.

The overall drivers for major anthropogenic environmental change in Lake Pontchartrain are well known but there is still much to be learned about their consequences, interactions, and relations to long-term natural cycles and changes.

Impairments Highly Critical Habitats in the Middle Sub-basin

Elevated Salinity - The salinity of the Middle Sub-basin is critical due to intolerance by indigenous species of higher salinity and to benthic mortality from poor water quality (low dissolved oxygen). The causes of elevated salinity are a long term rise in salinity from hydrologic modification, intrusion of stratified salt water from the MRGO/IHNC, and short term meteorological events, which overlap and compound during exceptionally high elevated salinity levels.

STATION	SIKORA & KJERFVE	USAENOD	Committee (Appendix A)
Rigolets	2.0	Not Published	Not Published
Chef Menteur	2.6	2.4	2.1
Little Woods	1.6	1.8	1.7
North Shore	1.3	1.3	1.1
Pass Manchac	0.2	0.4	0.3

Table 8: Comparison of published historical net salinity change at various locations within the Pontchartrain Basin before and after construction of the MRGO (Source: U.S. Army Corps of Engineers- Committee on Tidal Hydraulics, 1995). Sikora and Kjerfve (1985) considered the increases statistically insignificant compared to the seasonal variations, which dominate the record (see discussion).

In general, salinity has probably risen in the Middle basin due the construction of the MRGO (See **Tables 8 and 9**). The average rise in salinity pre and post-MRGO is 28% to 36% according to statistical analysis of measured salinity and modeling of the effect of the MRGO by several

USACE studies (1995, 1997, and 2001). The report "Bonnet Carre' Freshwater Diversion, Lake Pontchartrain, Lake Borgne, Biloxi Marshes, MRGO, and the IHNC" published by the Committee on Tidal Hydraulics of the U.S. Army Corps of Engineers concluded that after MRGO construction there was a net increase in salinity in the Middle Sub-basin. Specifically they found at Chef Menteur a 2.1 ppt increase, at Little Woods a 1.7 ppt increase, at North Shore a 1.3 ppt increase and at Pass Manchac a 0.3 ppt increase. These reported changes are similar to Sikora and Kjerfve (1985). Sikora and Kjerfve (1985) and Francis and Poirrier (1999) concluded the salinity increase in Lake Pontchartrain was "statistically insignificant". They noted that the pattern of annual and seasonal variation in salinity is much larger than the apparent change in salinity after MRGO construction. Therefore their conclusion does not indicate the change did not occur; rather that the change may be masked by the seasonal or other influences on the salinity record. The USACE study in 1995 reported a 95% confidence that the salinity increase at Little Woods was statistically valid. The average changes noted by all publications pre and post-MRGO is a significant potential change in regard to the salinity tolerance of the habitats impacted. Modeling of the post-MRGO hydrology by USACE (1997) supports the salinity shift post –MRGO as reported by most researchers, i.e. a 28% to 36% increase. In 2002, another report analyzed the potential salinity change after the MRGO and claimed to detect the most notable increase in salinity occurred in 1963. The year 1963 corresponds to the date of "partial completion" of the MRGO when a continuous (but narrower) canal was cut through the marshes of St. Bernard (Tate et al., 2002).

Month	Pass Manchac ppt		North Shore ppt		Little Woods ppt		Chef Menteur Pass ppt		Alluvial City ppt	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
January	1.1	1.5	3.0	4.0	3.9	5.0	3.8	5.7	6.8	9.8
February	1.0	1.5	2.5	3.0	3.0	6.5	2.9	4.8	6.4	9.7
March	1.0	1.2	1.9	2.6	2.3	4.4	2.2	4.3	6.3	10.4
April	0.8	1.3	1.9	2.6	2.4	4.0	2.2	4.0	7.0	10.0
May	1.0	1.1	2.4	2.7	2.2	3.9	2.6	4.0	9.5	10.2
June	1.0	1.5	3.6	3.0	2.2	3.8	3.3	4.2	9.0	12.3
July	1.0	1.6	3.0	4.6	2.1	4.4	3.2	6.3	7.9	16.0
August	1.2	1.7	4.6	5.6	2.5	4.8	4.8	7.5	8.6	16.1
September	1.7	2.0	5.4	7.5	4.5	6.2	6.0	8.5	8.2	12.9
October	1.8	2.2	4.7	7.3	4.9	6.8	5.2	8.4	7.6	13.8
November	1.8	2.1	4.6	6.7	4.8	6.8	5.2	8.0	8.0	13.1
December	1.2	1.8	4.5	5.4	4.7	6.2	4.2	7.0	8.0	12.5
Average	1.2	1.6	3.5	4.6	3.3	5.2	3.8	6.1	7.8	12.2
Salinity Increase		0.4		1.1		1.9		2.3		4.5

Table 9: Measured salinity changes in Mean monthly salinity pre- and post-MRGO (1951 to 1963 and 1963 to 1977) Source Carrillo et al. (2001)

A direct indicator of change in salinity is saltwater stratification occurring post-MRGO noted by Poirrier (1978), Junot et al. (1984), LA DEQ (1984), USACE (1995), Georgiou, 2000 and others. In addition, the post-MRGO increase in salinity in Lake Borgne is well documented and reported by USACE 1995, 1997, 2001, and 2004. Lake Borgne is the source of 30% of the tidal exchange with Lake Pontchartrain through Chef Menteur Pass. Indirect evidence of a salinity shift are habitat changes such as the anecdotal reporting of dramatic decline of Roseau cane (*Phragmites australis)* along the lake's southeast shoreline (Ibos, pers. Comm.) and the shift of SAV in the same area from *Vallisneria americana* to *Ruppia maritima* (Poirrier pers. Comm.). In sum, although some researchers have concluded that the measured salinity record alone cannot prove a salinity change post-MRGO in Lake Pontchartrain, others have concluded there was a valid shift based on the same record. Considering the modeling and habitat changes may corroborate the salinity shift and that the physical process may easily explain the sources for saline water, it is reasonable to conclude that salinity in Lake Pontchartrain probably did, in general, rise after and due to the construction of the MRGO. There is certainty that salinity did rise in the eastern half of Lake Pontchartrain after construction of the MRGO.

This background rise in salinity may be compounded by short term drought conditions. Rises in salinity in the Middle Sub-basin will stress vegetation, particularly the freshwater marshes and swamps of the western side of the Middle Sub-basin. Mortality of cypress has been observed in areas such as the eastern LaBranche wetlands since a drought, which began in the summer of 1998 and ended in 2000. A general rise in salinity may be due to one or more compounding events. The drought was preceded by Hurricane Georges (1998) which increased salinity just as the drought began (Cho and Poirrier, 2005). An extreme La Nina climatic event is reported to have caused the drought event, which elevated salinity even further (Cho and Poirrier, 2005). Elevated water levels during the drought may have exacerbated the stress on vegetation. Shaffer (2003) concluded that high salinity events contribute to the stress in Upper Sub-basin swamps where salinity in general is lower than the Middle Sub-basin.

Another highly significant impact related to salinity change is the creation of a benthic "dead zone" in Lake Pontchartrain by the introduction of saltwater through the Inner Harbor Navigation Canal (IHNC) and Mississippi River Gulf Outlet (MRGO). Introduction of highly saline water at the IHNC was first reported in 1978 by Dr. Michael Poirrier at University Of New Orleans (Poirrier, 1978). The MRGO allows water in excess of 20 ppt to enter the IHNC just a mile from Lake Pontchartrain (Poirrier, 1978; McCorquodale and Georgiou, 2002). From the INHC the denser water becomes stratified upon entering the fresher water of Lake Pontchartrain (average salinity post-MRGO 4.9 ppt).

The introduction of water 400% more saline than the ambient lake water, allows the development of a dense underflow of water that continuously enters the lake during the flood cycle, which quickly becomes hypoxic or anoxic (Georgiou and McCorquodale, 2002). The radial spreading of this plume is slow and persistent in the presence of density gradients, and typically moves into the lake until it reaches equilibrium. Georgiou and McCorquodale (2002) reported that this plume typically moves with the bottom lake currents, which do not always follow the wind direction. The interface of this layer is sharp (i.e. the changing salinity can be detected within 1 foot across this interface) and it therefore inhibits oxygenation and mixing, typically leading to hypoxic or anoxic conditions near the bed **(Figure 12).** Tidal currents are not sufficient to disturb and mix this layer with the ambient water, and in the absence of wind waves, the mixing mechanism is very slow. Georgiou (2002) determined that winds with northerly components in excess of 22 mph (10 m/s) can generally produce waves with sufficient energy to completely mix this layer.

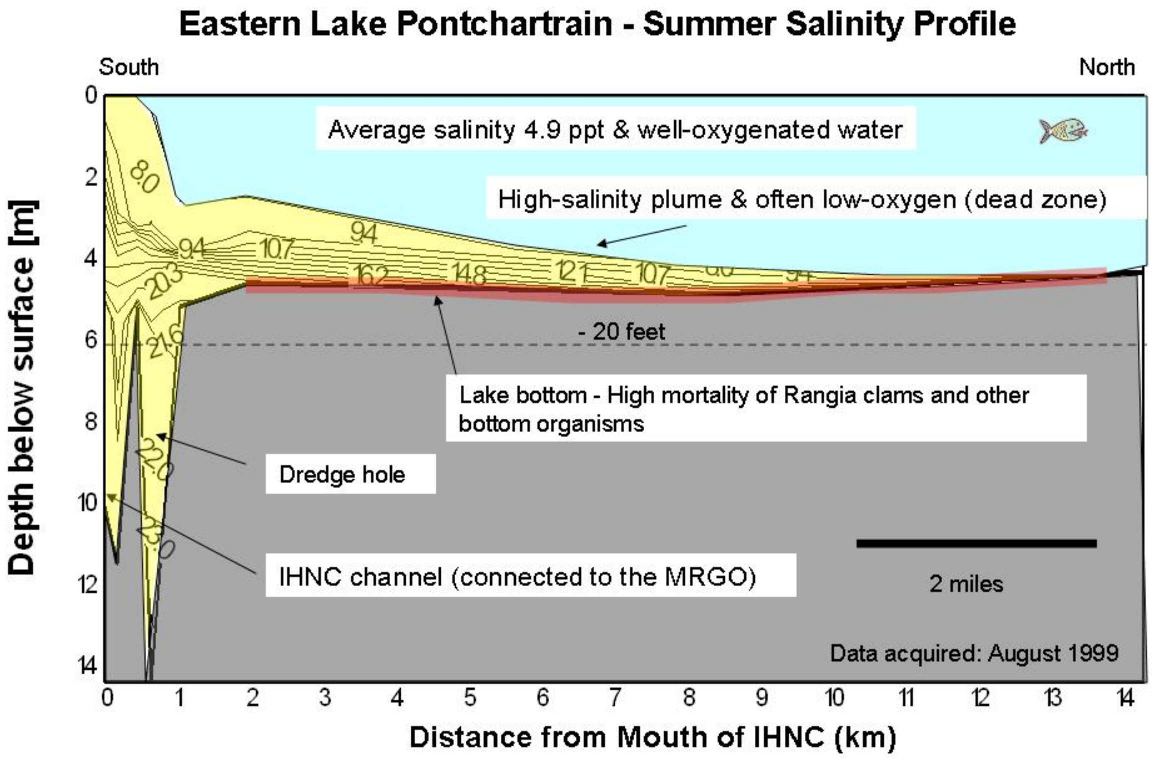


Figure 12: Typical profile in meters through the plume of stratified high-salinity water introduced through the IHNC (left side of profile) and the MRGO into Lake Pontchartrain. Salinity contours (8-23 ppt) define a distinct wedge of water extending several miles into Lake Pontchartrain, which averages 4.9 ppt. This plume typically covers at least 1/6 of the lake's areal extent with a low-oxygen benthic "dead zone". (**Figure 12** is modified from Georgiou and McCorquodale, 2002)

The occurrence and seasonal pattern of stratification and anoxia in Lake Pontchartrain was also documented by Junot et al. (1984) and a LA Department of Environmental Quality study released in 1984 (Schurtz and St. Pe', 1984). LA DEQ conducted exceptionally intense sampling of top and bottom salinity, and DO (dissolved oxygen) at 148 stations across the entire lake in just a two day period. This data clearly define the origin and nature of the plume. Data were collected in 1980 and twice in 1982. **Figure 13** is a composite of the August 1980 data. The contours are of the net difference in top and bottom salinity and clearly depict a plume's shape with its apex located at the point to origin at the mouth of the IHNC. This plume extends nearly to the north shore and covers at least 1/6 of the lake's bottom. The yellow pattern indicates hypoxic bottom conditions and red indicates anoxia recorded at the same time as the salinity data. LA DEQ also reported black surface sediment as indication of anoxic conditions.

The plume maps reported by DEQ suggest the axis of the plume shifts swings like a pendulum pivoted around the IHNC mouth. The plume at times swings completely west (counter clockwise) and may be attached to the New Orleans lakefront seawall where locals commonly fish and crab. Conversely it may swing all the way eastward (clockwise) against the southeast shoreline (near

Hayne Blvd). This oscillatory movement is probably driven by wind-driven and astronomical tides, which greatly expands the area of potential impact of anoxia in Lake Pontchartrain. Seasonally the stratification and anoxia appear to develop most commonly in the spring and summer when gulf tides are higher, and wind speeds are lower and more southerly. Georgiou (2000, 2002, and 2003) documented and modeled the introduction of high salinity water entering Lake Pontchartrain from the IHNC and demonstrated that that stratified denser and anoxic water is still entering Lake Pontchartrain from the IHNC. Modeling by McCorquodale and Georgiou (2002) suggests the low-oxygen plume may be entrained in the two gyres that develop in the lake from typical wind and tidal conditions.

Many benthic lake species are sessile and the impact on the benthos will depend on the residence time of the anoxic plume. Longer residence time results in defauniating the benthic community. LA DEQ reported anecdotal reports of dead crabs that may have been related to the anoxia, but the biological impact of this anoxia did not become apparent until after cessation of shell dredging in Lake Pontchartrain in 1990, which previously had removed or prevented a mature population of Rangia clams throughout Lake Pontchartrain (Abadie and Poirrier, 2001). Post-dredging, large clam populations had generally rebounded to 1950 density by 1997, but only for areas not chronically impacted by the anoxic plume. The salinity stratification from the IHNC has led to low oxygen events within Lake Pontchartrain leading to clam mortality near the IHNC extending across 1/6 of the lake area (100 square miles or 64,000 acres)(Abadie and Poirrier, 2000; and Poirrier et al., 2000). Occasional lake-wide clam mortality may occur and is presumed to be due to an expanded anoxic event (Spalding and Poirrier, 2004). The impacted clam is the Rangia clam, which is a dominant species of Lake Pontchartrain. Its mortality probably indicates mortality or stress on other sessile, benthic organisms within Lake Pontchartrain during the low-oxygen events. **Figure 14** is a map of large clam densities and it depicts a region nearly devoid of large clams which has a plume-shaped outline centered on the IHNC.

The post-1990 mapped benthic impairment and the post-MRGO mapped low-water quality in Lake Pontchartrain is a compelling data set documenting that since the construction of the MRGO high salinity water is introduced into Lake Pontchartrain via the IHNC and causes major chronic impairment to Lake Pontchartrain. Additional negative impacts from the anoxia may occur to the lake's food web. Blue crabs are typical benthic dwellers of the lake, which feeds upon Rangia clams. Blue crab harvest is the most significant commercial fishery in Lake Pontchartrain and has strong local traditional aspects of recreational fishing and local consumption. The magnitude of impact to blue crabs by anoxia in Lake Pontchartrain is unknown.

Figure 13: Anoxic and Hypoxic (dead zone) Areas in Lake Pontchartrain.

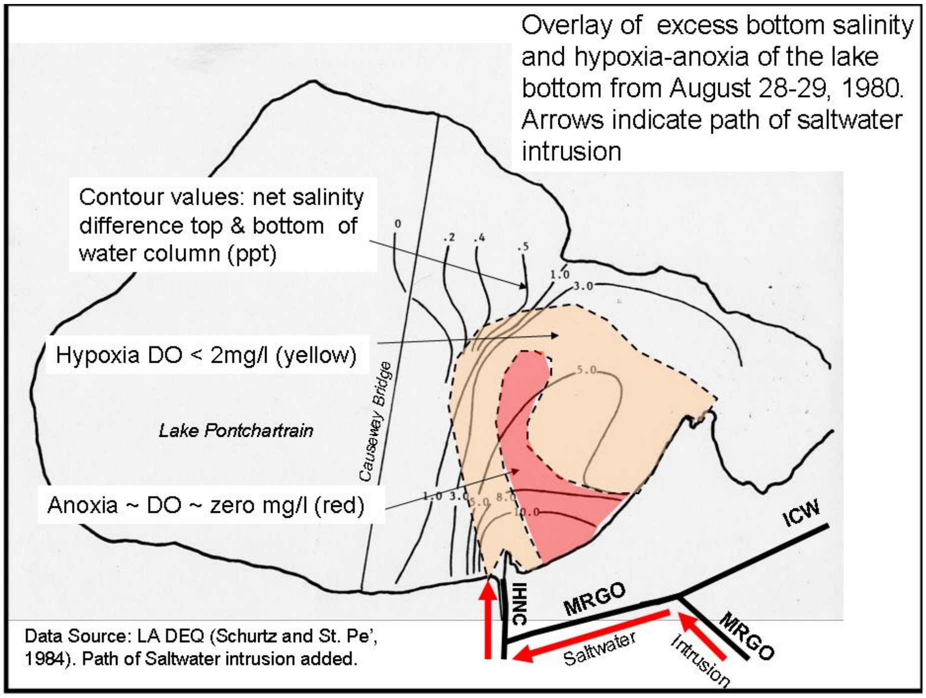
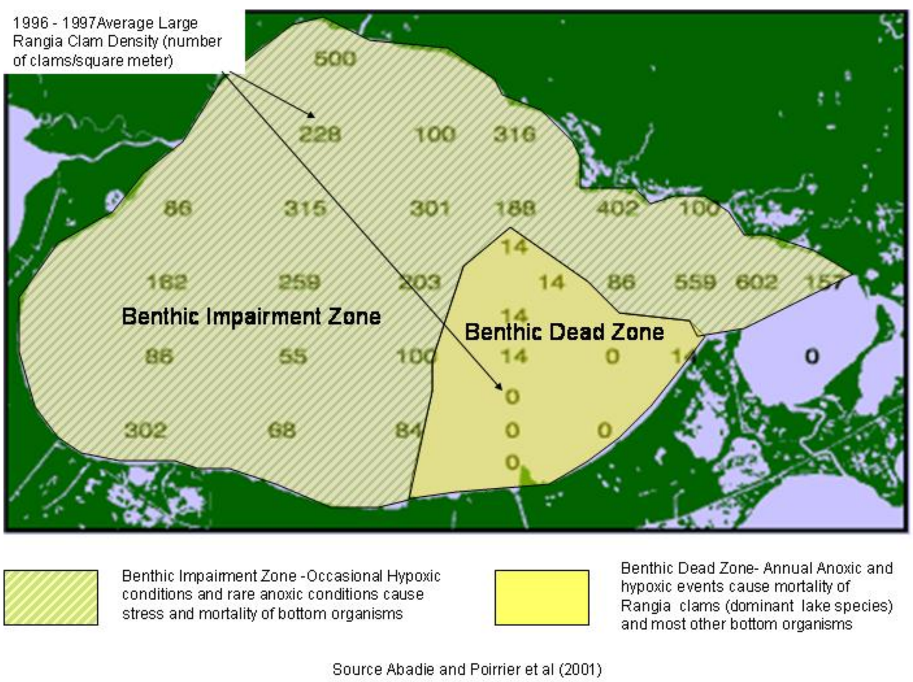


Figure 14: Map the density distribution of large Rangia clams (*Rangia cuneata*) in Lake Pontchartrain in 1996/1997 (numbers). Areal extent of impact shown in color (see legend).



Summary of the causes of high Salinity in the Middle Basin:

1) Lack of riverine fresh water inflow from north shore rivers due to local drought conditions
2) Lack of riverine fresh water inflow due to flood protection levees on Mississippi River
3) Inner Harbor Navigation Canal/MRGO tidal introduction of salt water
4) Inner Harbor Navigation Canal/MRGO density flow of stratified salt layer
5) Tropical storm or hurricane storm surge
6) Elevated water levels due to many causes exacerbates the effect of salinity

Summary of the impairments in Middle Sub-basin due to salinity:

1) Mortality of freshwater vegetation such as bald cypress (swamp dominant species)
2) Reduced productivity of fresh water marsh and swamps
3) Mortality of Rangia clams (lake dominant species) and other sessile benthic organisms
4) Disruption of the food web in Lake Pontchartrain by impacts to the benthic habitat
5) Probably affects the seasonal movement of shrimp

Reduction in submersed aquatic vegetation (SAV) within Lake Pontchartrain littoral zone - SAV occupies an important niche in both the littoral zone of Lake Pontchartrain and in the adjacent wetlands. SAV in interior wetlands are impacted by introduced species and are discussed elsewhere. The SAV within the littoral zone of Lake Pontchartrain has been reduced by 75% areal extent during a dramatic decline from 1955 to 1990. Although the SAV, even prior to 1950, represented a small percent of the area of Lake Pontchartrain, the habitat has a very high value to the lake ecosystem by providing structure for small fish and invertebrates such as shrimp and crab. SAV is classified as an “Essential Fish Habitat” by National Marine Fisheries Service and is given priority for protection and restoration.

In 1950, Lake Pontchartrain contained SAV in its littoral zone for nearly the entire eastern half of Lake Pontchartrain (from roughly the Causeway Bridge eastward). At their 1950 extent, they probably provided important migration routes for small fish entering Lake Pontchartrain from The Rigolets and Chef Menteur Passes.

Fish Assemblage change in Lake Pontchartrain - O’Connell et al. (2004) describe shifts in fish assemblages between 1954 and 2000. One of the main factors in the assemblage change was a decrease in the proportion of Atlantic croaker in trawl collections and an increase in the proportion of bay anchovies during the same period. These and other shifts were tested for a correlation to wet and dry periods. They concluded that the shift in fish assemblage was most likely not related to natural wet and dry periods and rather more likely related to anthropogenic stressors, which have degraded Lake Pontchartrain.

Summary of the primary causes for historical SAV loss:

1. Hard armoring of the shoreline
2. Reduced water clarity from shell dredging (currently prohibited) and other causes
3. Increased water depth in littoral zone by dredging and armoring
4. Excess nutrients in the water column stimulating excessive algae overgrowth on SAV, which inhibits SAV growth
5. Shrimp trawling in shallow areas

Summary of secondary effects of reduction in SAV areal extent:

1) Reduced structural cover for small fish
2) Reduced area for feeding for larger fish such as bass, trout, and redfish
3) Reduced area for crab molting
4) Reduced food source for fish, turtles, and manatee
5) Potential interruption in migration routes within Lake Pontchartrain
6) Reduced detritus
7) Reduced productivity
8) Reduced shoreline stability
9) Reduced habitat for species entirely dependent on SAV in Lake Pontchartrain such as pipefish

Shoreline modification (Hard armoring) - Armoring of Lake Pontchartrain covers approximately 61 miles (40%) of the Lake Pontchartrain shoreline (Beall et al., 2001). Armoring has led to the direct loss to the shoreline edge (fringing marsh) which is considered the most biologically significant zone in estuarine systems. The change in the shoreface is significant both biologically and physically. SAV are typically lost under these conditions. Wave energy is concentrated near the armoring and typically deepens the adjacent water bottom. The shoreface and adjacent marsh is altered significantly, so that movement of small fish and small crabs is reduced by the loss of structure.

Armoring in most areas was to halt shoreline erosion to protect social infrastructure such as the lakefront in New Orleans but has also been a part of environmental restoration such as the Bayou Chevee Project (CWPPRA) in eastern Lake Pontchartrain. Bayou Chevee armoring was placed just slightly offshore and has preserved the natural shoreline. There is evidence of increased SAV between the armoring and the shoreline. In all cases in which armoring is placed directly on the lake shoreline the connection to the fringe marsh is lost.

Summary of the effects of hard armoring of shorelines in Lake Pontchartrain

1) Loss of natural shoreline, i.e. direct juxtaposition on wetlands and lake
2) Reduced or complete loss of SAV
3) Modified beach profile
4) Higher energy shoreline, which suppresses development of lower energy benthic species
5) Reduced shoreline erosion of the adjacent estuary
6) Occasional focus of floating organic material into concentrated mats that may cause locally high BOD.
7) Properly designed offshore breakwaters, generally, will stimulate SAV development on the protected side

Urbanization - The Middle Sub-basin is home to New Orleans and several major urban communities. Urban sprawl is a major issue being driven by attraction of new developments and the migration of residents from the south shore to the north shore. St. Tammany Parish is one of the fastest growing parishes in the state. 48,000 acres of wetlands are estimated to have been lost from 1982-2000 due to urbanization (Beall, 2001). St. Charles Parish is also expanding and there is discussion of a new flood protection levee which may enclose wetlands leading to their eventual loss. Another major potential impact is related to the possible development of a cargo airport within the LaBranche wetlands. The development footprint of the proposed airport would cover more than 5,000 acres of wetlands in the LaBranche area along the shore of Lake Pontchartrain.

Direct loss of habitat is just one issue of urbanization. Inadequate sewage treatment is still common in St. Tammany and Tangipahoa Parish (and elsewhere in the Pontchartrain Basin). Aside from human health issues, habitat degradation also occurs, such as low DO or high BOD. The aging infrastructure of the urbanized south shore of Lake Pontchartrain (Orleans and Jefferson Parishes) limits or reduces habitat quality in Lake Pontchartrain (Houck et al, 1989). The antiquated sewerage and stormwater drainage systems together introduce sewage effluents and other waterborne pollutants (both liquid and solid) into Lake Pontchartrain (LPBF, 1995). Extensive programs are underway to improve these systems and reduce the negative impact to Lake Pontchartrain.

Effects of Urbanization in the Middle Sub-basin:

1) Direct loss of wetlands habitat by development footprints or by inclusion in flood protection areas
2) Loss of wetland support functions including fisheries production from nursery and detrital input
3) Indirect degradation of habitat may occur due to poor water quality
4) Increased hunting and fishing pressure and related effects
5) Increased flooding events and flood water elevation altering the natural flood cycle

Impairments Moderately Critical to Habitats in the Middle Sub-basin

Mississippi River levees - Currently within the Middle Sub-basin is the estuarine transition from fresh to brackish marsh. The adjacent wetlands of the western half of Lake Pontchartrain were historically fresh marsh and swamp. In the easternmost area of the Middle Sub-basin brackish marsh has been present since at least 1949, but there are few data pre-Intracoastal Waterway (circa 1944), which may have altered salinity and habitats post-construction. Construction of flood protection levees along the Mississippi terminated the hydrologic connection of the Mississippi River to adjacent marsh and swamps of the southern rim of Lake Pontchartrain, which directly resulted in several major chronic impairments to the Middle Sub-basin wetlands.

Summary of chronic impairments by lack of natural overbank flow into Middle-Sub-basin wetlands:

1) Loss of mineral sediment input reducing sediment accumulation in wetlands
2) Significant reduction in nutrient input, of which nitrogen is now highly limiting to productivity

3) Significant reduction of fresh water input, which allows occasional but significant short term salinity increases and severe salt stress of vegetation including the dominant species of bald cypress
4) Significant reduction of hydraulic head and therefore circulation of water leading to stagnant conditions such as low dissolved oxygen
5) Loss of regeneration potential of second growth bald cypress

Active Opportunistic Cypress Logging - Although not as extensive as the forested wetlands in the Maurepas swamps, Middle Sub-basin swamps were also completely clear-cut by commercial logging from 1890 to 1930. Nevertheless active and potential future logging of the second growth forest including the "relic forests", is still possible under current regulations. The logging of the relic forest is non-sustainable and will result in a permanent loss of forests under current habitat conditions. Historical logging resulted in near complete loss of tree cover and tree canopy and to severe alteration of the natural hydrology. Current logging, even with BMP's, of "relic forests" is non-sustainable and is resulting in the loss of thin forest stands, which under current conditions will not re-generate.

Impoundments - The largest area of impounded wetlands in the Middle Sub-basin are those associated with the Bayou Sauvage National Wildlife Refuge in Eastern New Orleans. Impoundments there are the result of a long history as a transportation corridor on the landbridge between Lakes Pontchartrain and Borgne, including railroads, highways, canals, and Interstate Highway 10. These historical impoundments were eventually enclosed by a hurricane protection levee constructed in the 1970's. In 1990, the Bayou Sauvage Refuge was created and most of the impounded wetlands were then in conservation. In 1996 and 1997, two CWPPRA projects were constructed to allow better hydrologic control of two sub-areas of the refuge, which had subsided to a point that vegetation was being severely lost due to near continuous flooding. Since the creation of the refuge and with "marsh management" these marshes have become more productive and become a significant bird rookery. However, the hydrologic connection and aquatic access to Lake Pontchartrain has been lost.

The LaBranche wetlands are in-part a failed agricultural impoundment. Similar to Eastern New Orleans, the area has several railroad and highway foundations which have segmented the wetlands into partial impoundments. Several water control structures were built near the railroad to attempt to limit saltwater intrusion. Some of these have failed and now limit aquatic access. The lack of fresh water introduction and overland flow probably reduces the productivity and quality of these wetlands. In spite of these impairments these wetlands still remain exceptionally significant as a nursery since they are the last significant marsh on the entire south shore still connected to Lake Pontchartrain.

Impairments Less Critical to Habitats in the Middle Sub-basin

Bonnet Carre' Spillway impacts related to operation for flood control - The Bonnet Carre' Spillway was constructed for the purposes of flood control of the Mississippi River and reducing the threat of flooding of New Orleans. Since its construction in 1931 it has been operated for flood control eight times in which an average of 13 million acre-feet discharge per event occurs typically over roughly a one month period. Typically during such an event the volume is several times that of the volume of Lake Pontchartrain (~4,000,000 ac-ft) and nearly all lake water is displaced. Within two weeks of the opening Lake Pontchartrain is entirely fresh. Typical discharge ranges between 100,000 to 230,000 cfs, which is roughly 10% to 25% of the typical spring peak discharge of the entire lower Mississippi River. The average historical spillway discharge is 154,000 cfs with the maximum historical discharge of 318,000 cfs in 1945 (Lopez, 2003). In spite of this massive hydrologic change, the abrupt shift in salinity and the displacement of species intolerant to fresh water these flood spillway openings may not have a major, detrimental long-term environmental impact. In 1997, salinity returned to normal lake levels within six months of the opening (McCorquodale, 2000). However, algal blooms did occur in 1997 and algal blooms also occurred for much smaller controlled releases (Normandy, 1998 and Poirrier, 1996).

Water quality in the Mississippi has improved for most regulated contaminants. However while heavy metals and hydrocarbon-based contaminants have declined post-1980, there has been a steady rise in fertilizers, particularly nitrogen. Any introduction of river water through the Bonnet Carre' spillway must consider the current water character of the Mississippi River, especially into a shallow open water body such as Lake Pontchartrain, which is prone to have algal blooms.

Considering that the lake is essentially estuarine and will inevitably have fluctuations in salinity and nutrient levels, it may seem reasonable to assume that Lake Pontchartrain estuary may benefit from an influx of Mississippi River water. However, an inherent conflict with restoration is that the criteria to open the Bonnet Carre' Spillway are based on stages of the Mississippi River, which is controlled by its drainage basin far removed from the Pontchartrain system, and criteria are not based on local ecologic conditions. There is simply no assurance or expectation that a spillway opening for flood control will necessarily correspond to a point in time when Lake Pontchartrain may benefit from the introduction of a large volume of fresh water. In fact, it may accentuate conditions already less than optimum. **Table 10** summarizes some of the potential positive and negative effects of a Bonnet Carre' Spillway opening for flood events.

Table 10: Summary of some suspected effects of Bonnet Carre Spillway Openings on the Middle Basin Habitats

Potential Benefits of a Bonnet Carre Spillway opening:

1) Long-term increase in productivity
2) Possible long-term increase in shrimp populations
3) Reduces salt induced stress on freshwater vegetation
4) Re-introduces nutrient to adjacent wetlands

Potential Negative Impacts of a Bonnet Carre Spillway opening:

1) Mortality of oysters
2) Short-term displacement of brown shrimp
3) Short-term displacement of speckled trout and redfish
4) Short-term displacement of Blue crab
5) Excessive nutrient introduction in Lake Pontchartrain
6) Cyanobacterial algal blooms
7) Hypoxia and fish kills

Water body Impairments - Lopez (2003) reported that the 2000 and 2002 water quality data published by LA DEQ indicates continued and increasing impairment for “fish and wildlife” for most of the waterbodies in the Pontchartrain Basin. Most of this impairment is within the Middle Sub-basin. The classification of "not supporting" fish and wildlife is based on several parameters including DO and contaminants. The contaminant that is commonly reported by LA DEQ that contributes to the impairment classification is copper. Very little is known regarding the origin or relative significance of copper to Middle Sub-basin habitats. A suspected contributor to copper levels is anti-fouling paints used as surface treatment on boat hulls to reduce fowling organisms such as barnacles.

Methylmercury in fish has also been discovered and several rivers and bayous have had fish consumption advisories. Fish advisories include: Pearl R., Bogue Chitto R., Bayou Boniface, Bayou Liberty, Tchefuncte R., Bogue Malaya R., and Tangipahoa R. (also the Tickfaw , Blind, and Amite Rivers in the Upper Sub-basin) (Source LA DEQ website 1-2005).

It also should be noted that at least two prior creosote plants and a ship-building plant in the Middle Sub-basin had soil and water bottom contamination and were designated Superfund sites under CERCAL (one in Madisonville and two in Slidell). These sites are closed and have undergone remediation programs and continue to be monitored. Prior to remediation, benthic habitats near the Bayou Boniface site were severely degraded. The headwaters of Bayou Trepagnier near Norco have sediment and spoil bank contamination with chromium and lead from several years of discharge by the Norco refinery.

Historical Shell Dredging - Dredging for the Rangia clams (*Rangia cuneata*) in and around Lake Pontchartrain was practiced by early European settlers, but it was the introduction around 1930 of mechanical methods, the suction dredge, which greatly increased the volume of clam material being removed from Lake Pontchartrain. Due to a general lack of foundation material in the region this industry flourished as New Orleans’ population grew after 1950. The volume of material being removed probably climaxed around 1975 (Lopez, 2003). The environmental problems associated with this dredging activity have been well documented by Sikora et al. (1981); Houck et al. (1989); and Poirrier and Franze (2000). The primary impact was a near complete loss of mature Rangia clams for nearly all of Lake Pontchartrain bottom. The population of large Rangia clams was severely depressed continuously for nearly 60 years. Shell dredging was prohibited in 1990 and since then there has been some recovery. Abadie and Poirrier (2000) reported that in 1998, the large clam population had rebounded to pre-1930 level except for an area near the Inner Harbor Navigation Canal. Poirrier (2004) reported that large clam populations had severely declined presumably due to an anoxic event related to saltwater intrusion from the Inner Harbor Navigation Canal. The prohibition of shell dredging has allowed clams to begin a significant long-term recovery, however, other limiting factors such as annual anoxic events continue to impact clam populations.

Rangia clams are a significant component of the base of Lake Pontchartrain food web and may account for the greatest biomass volume of macro-vertebrates or invertebrates of the lake. The Rangia clams are preyed upon by blue crab, ducks and black drum and others. Blue crabs have been even more significant in the food web than Rangia in respect to the number and variety of species which consume them, including sea turtles, redfish, speckled trout, alligator gar, otters, flounder, herons and others. In addition, blue crab is the largest commercial fishery in Lake

Pontchartrain. Lake Pontchartrain "Lake Crabs" once again are becoming coveted by locals due to their size and quality. Recent landing in 2003 of unusually large crabs have led some local elderly crab fishermen to say that this is not truly anomalous, rather "this is the way it's supposed to be." Whether these large crabs have any relation to the recovery of Rangia clams is unknown. It is well known that blue crabs prey on live Rangia clams. However, it is less documented how dependent blue crabs are on Rangia clams for their diet.

Shoreline erosion - Approximately 60% of the Lake Pontchartrain shoreline does not have hard armoring (Beall et al., 2001). The unarmored shorelines continue to erode. Lake Pontchartrain is currently in a general state of its geologic evolution in which lakes enlarge by natural shoreline erosion. As described previously the wetland/lake interface is extremely important to the estuarine ecology. However there are some areas of concern where higher rates of shoreline retreat are converting wetlands to open water and threaten to accelerate. Zganjar et al. (2001) have shoreline erosion rates for Lake Pontchartrain from 1960 to 1995 and the area of highest shoreline retreat is in the northwest region of the Lake extending from the Tangipahoa River to Ruddock. In this reach shoreline retreat averaged 6 to 17 ft per year from 1960 to 1995.

Rio Grande cichlid – The Rio Grande cichlid *(Cichlasoma cyanoguttatum)* has been discovered in Lake Pontchartrain and there is concern its population will increase there (O'Connell, et al., 2002). The Rio Grande cichlid feeds on plants, insects and small fishes. The species would probably compete directly or indirectly with native sunfish. The cichlid reproduces very quickly, and produce abundant surviving offspring. The cichlid may impact native species by harboring parasites that can spread to native species of fish.

Extinct/ Extirpated and Threatened/Endangered fish and wildlife

Due to the impacts described above and other compounding factors the following species are extinct in Upper and Middle Sub-basins: Louisiana parakeet *(Conuropsis carolinensis)* and the passenger pigeon *(Ectopistes migratorius).* In addition the following subspecies have been extirpated: Bachman's warbler (*Vermivora bachmanii*), American bison (*Bison bison*) and the ivory-billed woodpecker (*Campephilus principalis*). The following species are considered threatened or endangered Bachman's warbler, Bald Eagle (*Haliaeetus leucocephalus*), Louisiana black bear (*Ursus americanus luteolus)*, Gulf Sturgeon (*Acipenser oxyrinchus desotoi)*, Pallid Sturgeon *(Scaphirhynchus albus*), Peregrine falcon (*Falco peregrinus*).

<u>Restoration Recommendations in the Middle Sub-basin (See Figure 16 for a summary map)</u>

Mississippi River Re-introductions in the Middle Sub-basin

The Middle Sub-basin receives significant fresh water from north shore rivers and is occasionally completely flushed with fresh water by opening of the Bonnet Carre' Spillway for Mississippi River flood control. However the wetlands located between the lake and the Mississippi River do not get sufficient regular introduction of fresh river water. The goal of Mississippi River re-introduction in the Middle Sub-basin is to maintain lower salinity and increase productivity of these marshes and swamps.

Four river reintroductions are recommended for the Middle Sub-basin **(Figure 15).** However the precise location of a diversion structure or conveyance canal is secondary to the goal of simply delivering of Mississippi River water to the benefit areas described here. It is recommend that diversion structures and their conveyance canals be designed toward the upper end of the discharge ranges proposed so that future adaptive management that may desire larger discharges will not be precluded by design-limitations. Proposed discharges are just “best professional judgment”. The overriding determination of discharge rate is the rate optimum for the benefit of the targeted wetland. Reintroductions should emulate the pre-levee condition of overbank flooding during the spring from April to June. The goals of these diversions are to increase wetland productivity not to reduce salinity of Lake Pontchartrain although slight incidental reduction may be expected. An additional goal is to enhance fisheries within Lake Pontchartrain without harmful cyanobacterial (blue-green) algal blooms.

Discharges from various reintroduction sites should be sized proportionally to the area of wetland benefit. Within the Upper and Middle Sub-basins the benefit areas rank as follows (largest first): Blind River basin, Maurepas Reintroduction (Hope Canal), Frenier Wetlands, LaBranche wetlands, Bayou Trepagnier, Bonnet Carre' Spillway wetlands, Bayou Fountain, Bayou Manchac. The combined discharge and the potential effects on Lake Pontchartrain and Maurepas should be considered for both fisheries benefit and the potential to cause harmful cyanbacterial algal blooms.

River Reintroduction Frenier wetlands (west of Bonnet Carre’ Spillway)* - The target benefit area is the wetlands extending 5 – 10 miles northwest from the Bonnet Carre’ Spillway west guide levee (within south end of the “East Manchac Landbridge Mapping unit). These wetlands are thinly forested with second growth cypress and are probably a relic forest as has been described in the adjacent swamps to the west (Shaffer, 2003). The target habitat is cypress-tupelo swamp. Conveyance of Mississippi River water is probably best accomplished through the Bonnet Carre’ Spillway within the borrow canal of the west guide levee. A water control structure would probably be needed through the guide levee.

River Reintroduction into the Bayou Trepagnier wetlands (east of Bonnet Carre’ Spillway)* - The target benefit area is the wetlands extending 5 miles southeast of the Bonnet Carre’ Spillway east guide levee (the northwest half of the “LaBranche wetlands Mapping unit). These wetlands are very thinly forested with second growth cypress with an undergrowth of marsh plants. The target habitat is swamp and fresh marsh. Conveyance of Mississippi River water is probably best accomplished through the Bonnet Carre’ Spillway within the borrow canal of the east guide levee. A water control structure would probably be needed through the guide levee.

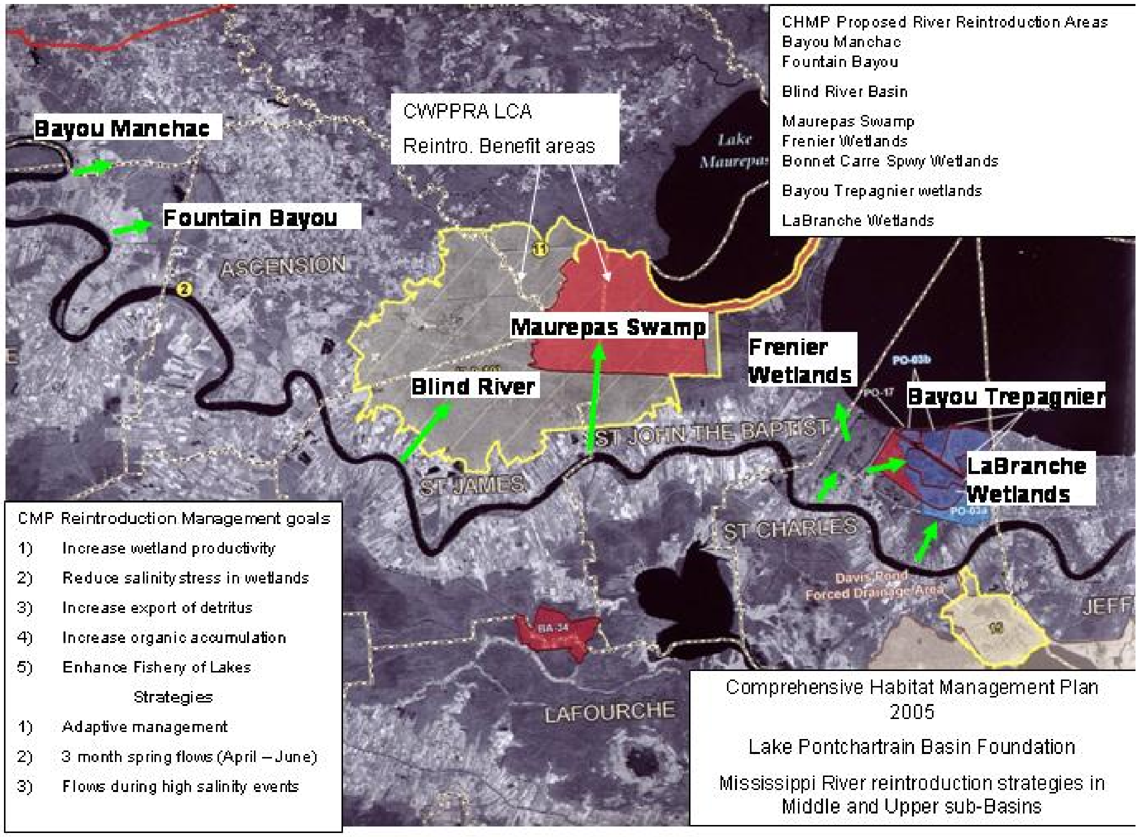


Figure 15: Map of proposed Mississippi River Reintroductions in the Upper and Middle Sub-basins

River Reintroduction into the Bonnet Carre' Spillway wetlands* - The target benefit area is the forested wetlands within the Bonnet Carre' Spillway northeast of Highway 61. (The northeast half of the "Bonnet Carre' Spillway Mapping unit). These wetlands have a dense cover of second growth cypress but with very low growth rates (Brantley pers. communication). The target habitat is cypress-tupelo swamp. Conveyance of Mississippi River water is probably best accomplished through the Bonnet Carre' Spillway redirecting flow from the spillway structure into the wetlands via the borrow canal of the east guide levee.

**Note regarding the use of the Bonnet Carre' Spillway for proposed restoration projects – Three reintroduction projects are proposed by the CHMP, which could use the Bonnet Carre' Spillway for conveyance. The previously approved CWPPRA project (Opportunistic Use of the Bonnet Carre' Spillway, project # PO-26) is under Phase I design. The Phase I budget has been exhausted and there is no approved Phase II (construction) budget within the authorized project. To meet the objectives of any of the proposed projects by the CHMP, which would utilize the spillway for conveyance, would require construction and operational and maintenance funds. Therefore under current authorization the CWPPRA project cannot meet the requirements of any of target benefit areas proposed in the CHMP. Therefore it is recommended that the CWPPRA project be re-authorized with a request for Phase II funds for design to benefit wetlands within the Bonnet Carre' 'Spillway (as proposed above in River Reintroduction into the Bonnet Carre' Spillway wetlands). This project should require the least construction and is most aligned with the* *original opportunistic use concept under CWPPRA. The other two benefit areas outside of the Bonnet Carre' Spillway (Frenier wetlands and Bayou Trepagnier wetlands) should be proposed as separate projects since this will require significantly more engineering and cost. These projects could be handled as one project but in two phases for the two benefit areas. This could be done as new project authorizations in either CWPPRA or LCA programs.*

River Reintroduction into the Bayou LaBranche wetlands (east of Bonnet Carre' Spillway)* - The target benefit area is the wetlands extending southeast of Bayou LaBranche to the Jefferson Parish line. These wetlands are mostly marsh but are forested in part. The cypress mortality is significant and is probably due to salinity. The target habitat is fresh swamp and intermediate marsh. Access of Mississippi River water would be through a siphon through the levee and possibly an existing pipeline located along the river. Conveyance would be either by pipeline or through existing canals. A gas company has offered to allow use of an existing pipeline to convey river water. Another alternative would be to divert storm water from the Jefferson Parish drainage canals into these wetlands. This volume would probably be insufficient for the target benefit area but should be given strong consideration due to the additional water quality benefit to these wetlands.

Littoral Shoreline Restoration in the Middle Sub-basin

Restoration of the Littoral shoreline – Orleans Parish - The shoreline from South Point to the Jefferson Parish line is almost entirely armored and the littoral functions have been drastically reduced. Littoral restoration should focus on developing a fringing shoreline marsh and adjacent SAV habitat. The Orleans parish shoreline restoration should be considered in three segments due to the nature of adjacent land use.

1) The shoreline adjacent to the Bayou Sauvage National Wildlife Refuge (~ 5 miles) is proposed to have near continuous restoration by placement of a breakwater just offshore. Armoring material to be considered would be rock dike or pre-fabricated material such as reefballs. The protected open water would be utilized for marsh creation and SAV restoration.

2) The shoreline along Hayne Boulevard would be partially restored with marsh restoration generally being located near outfalls of stormwater pumps and canals. Offshore breakwaters may be necessary to protect created marsh near outfalls. Created wetlands will increase habitat and improve water quality. In recent years significant Rangia clam shell bars have developed along the lake shoreline. These may be suitable protection for created marsh and should be investigated for this purpose. It may be possible to re-vegetate marsh grasses on emergent shell bars. This concept is being tested through UNO's Department of Biological Science with support from a NOAA Community-Based Restoration grant.

3) The shoreline along the New Orleans Lakefront would have small pockets of marsh restoration near outfall canals and at Bayou St. John. Water depth in front of the seawall may preclude more extensive restoration.

Restoration of the Littoral shoreline – Jefferson Parish - The shoreline in Jefferson Parish is entirely armored with rip rap and the littoral functions have been drastically reduced. Littoral restoration should focus on developing a fringing shoreline marsh, SAV habitat and improving water quality. The Jefferson Parish shoreline restoration should be concentrated first near, but not limited to, stormwater outfalls and areas accessible for recreational fishing (e.g. fishing piers and boat launches). A design consideration is to provide fringe marsh restoration and some additional protection to the Jefferson Parish levee. This may be provided by placement of offshore breakwaters to protect the created marsh along the lake's shorelines. Levee protection is enhanced by the rock breakwater and the wetland habitat. Modeling and empirical observation suggest that stormwater plumes under current conditions tend to attach themselves to the shoreline near the outfall canal. This has the negative effect of delaying mixing of the stormwater with lake water and to place water of poorer quality adjacent to the shoreline where locals are likely to recreate (swimming, fishing, crabbing, water skiing, etc). It may be possible that the marsh creation will afford an opportunity to address the problem of plume migration at the outfall canals. Stormwater that is pushed south back into the shore would flow into the created marsh. The effect should improve water quality and may actually benefit the marsh. Another consideration related to outfall canals is that grass cutting might be reduced at the bank of the outfall canals. A vegetated bank will enhance the habitat and may improve water quality.

Restoration of the Littoral shoreline – St. Tammany - The armored shoreline in St. Tammany is generally private residential homes located along the shore with varying types and degrees of hard armoring such as bulkhead and concrete rip rap. It is unlikely marsh creation is acceptable to the landowners. It is also different from the south shore in that over much of this shoreline healthy marsh is present landward of these developments. However, the shoreline has had limited recovery of SAV. A demonstration project should be conducted utilizing wave dampening engineering to promote a lower energy shoreface and depositional area with the goal of re-vegetating the shoreface with SAV. Reefballs or other engineered material may be suitable for a demonstration project. There are numerous recreational piers along the shore here and materials would be placed parallel to the shore but within the length of pier. This may partially address issues related to safe navigation. It is also necessary for the water to be sufficiently shallow to be effective.

Other Restoration Projects in the Middle Sub-basin

Bayou St. John Restoration - Historically Bayou St. John was a naturally flowing, tidally influenced stream flowing northward from the natural levee of the Mississippi River to its entrance into Lake Pontchartrain. The Bayou was not connected to the Mississippi River. Bayou St. John is now entirely in urbanized New Orleans Parish and is adjacent to a fine municipal park containing lagoons and a golf course. This bayou is designated as "Historic and Scenic" by the state of Louisiana but has been ecologically and hydrologically degraded by numerous impacts including a navigation gate and water control structure constructed on the bayou by the Orleans Levee District. The navigation structure remains closed since the bayou is not navigable more than ¼ mile upstream from the lake. The navigation gate has sluice gates which may allow water to pass through the structure from Lake Pontchartrain to Bayou St. John. In general, the lake level is approximately 1 foot higher than Bayou St. John.

The current condition of Bayou St. John is a virtually landlocked linear body of water (a four-mile lagoon) with little of its historic estuarine influence. The habitat value of this historic bayou has been severely degraded. The existing water control structures were designed and managed simply to control the water level in the bayou and not for ecologic benefit. The water control structure at Robert E. Lee Blvd. is non-functional. The navigation gate is operable but is not managed for ecologic benefit. Bayou St. John also has hydrologic connection to the lagoons within City Park. In the past two pumps and a gravity-driven flow through a culvert allowed water from Bayou St. John to flow into the park's lagoons. An engineering study completed in 1996 by Burk-Kleinpeter, Inc. for the Orleans Levee District recommended rehabilitation of hydraulic controls of Bayou St. John and related lagoons within City Park emphasizing their ecologic restoration.

The recommendation is to identify sustainable methods to benefit Bayou St. John water quality, habitat management, recreational access and educational opportunities. The general goal of restoration is to restore some estuarine function to Bayou St. John including altering the hydrology and increasing habitats of marsh, forested wetlands, and SAV. A related restoration feature is to increase water circulation in the City Park lagoons.
Proposed restoration goals include:

1. Manage Bayou St. John water circulation and water quality.

2. Along shoreline and at the mouth of Bayou St. John prepare and establish an estuarine plant and animal community that represents fringe marsh near the south shore of Lake Pontchartrain.

3. Promote native SAV growth within Bayou St. John

4. Enhance recruitment and aquatic access of marine organisms into Bayou St. John

5. Create public awareness and educational opportunities related to the cultural and historical links between Bayou St. John and the development of New Orleans.

6. Identify and create public awareness and educational opportunities related to bayou and estuarine ecology along Bayou St. John.

Some key steps to implement should include:

1) Survey water depths throughout Bayou St. John and the City Park lagoons.
2) Creation of marsh and SAV habitat on the west bank south of Robert E. Lee Blvd
3) Rehabilitate or replace the water control structure at Robert E. Lee Blvd so that regular water interchange occurs resulting in regular water level changes within design parameters.
4) Plant Bald cypress and Red maple trees along Bayou St. John
5) Habitat enhancement in Bayou St. John north of the navigation gate where it is open to Lake Pontchartrain
6) Rehabilitate or replace pumps or culvert between Bayou St. John and City Park lagoons.

The Bayou St. John Ecosystem Restoration Project in Orleans Parish was proposed for Section 1135 with the U.S. Army Corps of Engineers in 2003. This project is currently waiting on funding to develop a project restoration plan. Other funding options are being evaluated or pursued.

LaBranche Marsh Creation - A CWPPRA marsh creation project (Project # PO-17) was completed in 1994 in the LaBranche wetlands. This project created approximately 300 acres of marsh in formerly open water ponds induced by a combination of canals, subsidence, agricultural management and saltwater intrusion. Similar open water area is adjacent to the original project. This area is the reference area for the original CWPPRA project. The CHMP supports a second marsh creation project within the adjacent open water ponds, including the reference area. After ten years of monitoring the reference area, there has been essentially no change. If this trend continues, there is no point in avoiding restoration to a reference area that is clearly in a chronic state of impairment. The marsh creation project would be similar in design to the original project. It may be possible to use the original permitted borrow site. The elevation (subsidence) history of the original placement area should be evaluated closely to determine the appropriate design elevation for the marsh creation area. The goal of this project is to restore marsh along the south shore of Lake Pontchartrain where aquatic access is likely to continue.

Goose Point/Pointe Platte Marsh Creation (Project # PO-33) - The Goose Point/Pointe Platte Marsh Creation (PO-33) is a CWPPRA project approved in 2003 and is currently being designed. The project would utilize a borrow site within Lake Pontchartrain and create marsh within open ponds just north of the Lake Pontchartrain shoreline. These benefit areas are within the Big Branch Marsh National Wildlife Refuge. The goal of the project is to expand the areal extent of emergent marsh and prevent the breaching of the lake into large interior ponds. The CHMP endorses this project as long as the borrow site is placed to minimize negative impacts including possible wave refraction that might accelerate shoreline erosion and negatively impact SAV.

Preliminary estimates indicate that Hurricane Katrina may have caused significant additional loss to the north shore marsh between Mandeville and Slidell (See addendum E). As much as 2300 acres of mostly interior marsh may have been lost by this event. Due to this impact the Goose Point/Pointe Platte project should be expanded to create additional marsh in critical areas of need along the north shore.

Artificial Reefs - Through a cooperative effort of environmental organizations, fishing associations, and government agencies, five new artificial reef sites were created in Lake Pontchartrain from 2001 to 2004 (Lopez, 2004). The Lake Pontchartrain Artificial Reef Working Group (LPARWG), was organized in June 2000, and built its first reef near Lakefront Airport in August 2001. Four additional artificial reef sites were developed from August of 2003 to January 2004. One site was created with limestone rubble in Orleans Parish. Four sites utilizing Reefballs^{TM} are located in Jefferson and St. Tammany Parishes. These Reefballs are the first Reefballs to be deployed in Louisiana. All five sites have been donated by the Lake Pontchartrain Basin Foundation to the LA Department of Wildlife and Fisheries. Reef sites are about an acre in size and have been marked with yellow, crash-proof buoys. Coordinates can be found on-line at SAVEOURLAKE.ORG. The purpose of these reef sites is to create additional hard-bottom and structured habitat for Lake Pontchartrain. The goal is to create new habitat and enhance recreational fishing opportunities near major residential areas. Monitoring is being conducted by the University of New Orleans, Department of Biological Sciences (Poirrier and Whitmore, 2005). Additional opportunities exist to expand this program elsewhere within Lake Pontchartrain or within the Pontchartrain Basin.

East Orleans Landbridge – The east Orleans landbridge is considered the area between Lakes Pontchartrain and Borgne and between the passes of The Rigolets and Chef Menteur. This region has extensive wetlands and significant natural waterbodies such as Lake Catherine and Unknown Pass. It is a landbridge which defines major estuarine landforms and is a major barrier to storm surges into Lake Pontchartrain. The landform also provides an important transportation corridor with significant cultural resources. It is recommended that this landbridge be evaluated for long-term sustainability of the estuarine ecology and as a critical landform. Restoration planning might include marsh creation, shoreline protection or other projects warranted to maintain the habitats and landform. Conservation of marsh is also recommended to offset the rapid growth of camps sites in the area.

Highway 90 Cutoff Impoundment - On the east side of Highway 90 between Chef Menteur Pass and The Rigolets (pass) is an impoundment created by re-routing of Highway 90 to avoid a large and dangerous curve in the road. The old highway bed was left in place and so with the new highway alignment creates a large crescent-shaped impoundment. This impoundment was originally healthy marsh but is now open water that has indications of stress such as lack of fresh vegetation and a large amount of decaying material on the bank. The water is dark and appears stagnant. Although not monitored it is likely water quality is poor such as low DO. A proposed solution is to breach the existing abandoned roadbed on the east and south flank. This should increase water exchange and improve water quality. Aquatic access will be re-established. It should be noted that the old roadbed could well serve as a small nature/bird watching trail. With minor improvements and a place to park along the highway this amenity could be cost effectively developed.

Lake Pontchartrain Shoreline Protection Irish Bayou to Chef Menteur Pass - The CWPPRA Bayou Chevee Shoreline Protection Project (Project # PO-22) was constructed in 2002 to protect the shoreline near Bayou Chevee in eastern Lake Pontchartrain. Breakwaters were constructed offshore of the shoreline in 2002 and previously by U.S. Fish and Wildlife Service. Initial monitoring indicates the project is stabilizing the shoreline and has created SAV habitat in the protected littoral zone. Expansion of this project was considered as a candidate project for PPL 14 CWPPRA program. This would expand shoreline protection from Point aux Herbes to Chef Menteur Pass. This project is recommended as long as breakwaters are placed offshore and similar results might be expected as seen in the original Bayou Chevee Shoreline protection project.

Inner Harbor Navigation Canal Sill - Modification of the Mississippi River Gulf Outlet (MRGO) is discussed in the Lower Sub-basin section. A related interim project to modification of the MRGO, is to construct a sill in Lake Pontchartrain near the Inner Harbor Navigation Canal (IHNC). As discussed previously, the IHNC-MRGO connection to Breton Sound allows salt water intrusion into Lake Pontchartrain. This can be in the form of a salt water wedge, which upon entering Lake Pontchartrain creates a stratified water column with denser salt water lying on the lake bottom. This salt water layer causes hypoxia/anoxia in the absence of mixing under strong wind conditions, and is the cause for clam mortality in the vicinity of the IHNC (Poirrier et al, 2004). This hypoxia/anoxia may adversely impact the entire lake benthic habitat. A sill is proposed near the IHNC to block the movement of a salt water layer into Lake Pontchartrain. The sill would be several feet from the bottom. It may be possible to construct an effective barrier and maintain 15 feet draft clearance for navigation.

Bayou Sauvage National Wildlife Refuge - The Bayou Sauvage National Wildlife Refuge (NWR) has several large impoundments. Most of the refuge is impounded and is under marsh management. Two CWPPRA projects were constructed in 1996 and 1997 to improve this marsh management. The marsh management appears to be successful in that the marsh appears to be healthier. However, the drawback to this restoration is the lack of aquatic access to the surrounding estuary. The historical impounding of the refuge is complex being related to highways, interstates, railroads, etc. The latest and most significant impounding was the construction of the hurricane projection levee around much of the area now included in the refuge in the early 1970's prior to creation of the refuge in 1990. It is recommended that the potential to restore some level of aquatic access between Lake Pontchartrain and the western, impounded side of the refuge be evaluated.

Conservation Proposals in the Middle Sub-basin

Big Branch Marsh National Wildlife Refuge - The Big Branch Marsh National Wildlife Refuge (NWR) was created in 1994 as a grass-roots conservation initiative to preserve some of the most pristine, and un-impacted habitat of the Pontchartrain Basin. This effort has led to fee title acquisition of 15,000 acres by 2004 placed in federal conservation. Additionally 1,300 acres in state conservation are co-managed by the state and U.S. Fish and Wildlife Service. Nine thousand acres remain in the target acquisition area boundary. This present boundary includes a near contiguous area extending from Fontainebleau State Park to Highway 11. The CHMP strongly endorses the acquisition of undeveloped wetlands and ridges within the acquisition boundary. Further it endorses expansion of the boundary eastward to the Pearl River to make a refuge corridor to the state-managed Pearl River Wildlife Management Area (WMA). Critical areas are the marsh and upland mounds within the marsh north of Highway 433 (Fritchie Marsh), and the marsh and swale topography south of Highway 90 (Weeks Island) abutting the Pearl River WMA. These two areas would conserve a vital wetland link from the established Big Branch Marsh NWR to the Pearl River Wildlife Management Area.

A non-contiguous acquisition area to the west should also be targeted for conservation. This area is commonly referred to as the Guste Tract and is located along the northwest shore of Lake Pontchartrain. This property was recently purchased by a developer from liquidated property assets. The developer has indicated an interest in placing the wetlands in conservation. Acquisition here would establish a new conservation area in this quadrant of the lake shoreline. The general vicinity of this tract contains some wetland habitat of unique character including the sawgrass meadows described previously (see **Figure 10**). The Guste tract and the wetland complex west of Madisonville should be targeted for conservation. Acquisition of the Guste tract and wetland complex for conservation is strongly endorsed. The area should also be continued to targeted for mitigation banking.

The goal of these acquisitions is to sustain and preserve these productive habitats and their support for Lake Pontchartrain as a nursery and fisheries for both recreational and commercial interests.

Lake Pontchartrain Sanctuary – In 1928, the Louisiana Department of Conservation Act 264 was passed by the state legislature, which granted the department authority to create sanctuaries for "protection and propagation of fish for maintaining supply." Just one year later, the Department of Conservation acted on that authority by creation of the "Lake Pontchartrain-Lake

Borgne and Bayou Biloxi Fish Preserve" (Gowanloch, 1965). This was a major sanctuary with significant restrictions. Including the marshes, it was roughly equal to 1/3 of Lake Pontchartrain (approximately 230 square miles or 150,000 acres). The 1929 sanctuary was centered around the eastern lobe of Lake Pontchartrain – east of the Norfolk-Southern Railroad - and included Lake Catherine and both Chef Menteur and The Rigolets passes all the way to the western shore of Lake Borgne. It also included a large portion of the north shore from Slidell to Pearlington, Mississippi following the east Pearl River. One non-contiguous area also included was across Lake Borgne along Bayou Biloxi. Except for some minor exceptions like small bait seine nets the sanctuary prohibited all commercial netting including seines, trawls, trammel nets, and gill nets. Commercial crab traps did not exist at that time and therefore, were not addressed. Although the Department of Conservation was empowered to enforce this sanctuary, it is unclear how strongly the protection was enforced.

Since the inception of the Lake Pontchartrain sanctuary in 1929 the areal extent and species protection has been dramatically reduced. At this time the sanctuary is a 1 ¼ mile strip from the Lake Pontchartrain shoreline for roughly half of the lake's perimeter.

2004 Louisiana Commercial Fishing Regulations state:

"Trawling is prohibited in Lake Maurepas and that portion of Lake Pontchartrain from the shoreline 1 ¼ miles out from the Jefferson Orleans Parish line west to South Point, from South Point along the railroad bridge west from the railroad bridge to Goose Point.

Trawling is prohibited between the railroad bridge and the I-10 in Lake Pontchartrain."

However it is suspected enforcement of the prohibition of trawling within the designated area has been lax. Protection inside the refuge in Lake Pontchartrain is almost no different from that outside the sanctuary. In short, the sanctuary in Lake Pontchartrain provides little if any actual protection to any species or habitat.

Recommendations for the Lake Pontchartrain Sanctuary:

1. Within the existing sanctuary the ban on trawling should continue but in addition all other commercial net fishing should be prohibited. Commercial crabbing would generally be allowed but only in water depth greater than 5 feet and greater than 300 feet from the shoreline. The goals are to promote SAV habitat and optimize areas as a nursery for the entire Lake Pontchartrain estuary. Additional goals are to minimize user conflicts and optimize recreational fishing along the metropolitan shorelines of Orleans and Jefferson Parish.

2. The sanctuary should be expanded to include some of the wetland perimeter around Lake Pontchartrain, which would include a ban on commercial crabbing.

3. A derelict crab trap removal program would be implemented within the sanctuary.

4. Lake St. Catherine would also be included as part of the sanctuary and commercial trawling (except for live bait) would be prohibited. The goal is to protect extensive SAV that develop within this shallow lake.

5. SAV habitat should be delineated on signs at boat launches and power boaters would be discouraged from navigating across SAV beds. Habitat friendly recommendations should include avoidance of unnecessary boat crossings across grassbeds wherever it is possible to navigate around them. For example, SAV crossing should be north–south rather than east-west. The goal is to promote SAV habitat and minimize propeller strikes to manatee. If low-cost, suitable Coast Guard approved signage can be developed, the grassbed habitat areas should be delineated in Lake Pontchartrain.

6. Recreational fishing would be allowed in the sanctuary as allowed elsewhere in inland salt water designated areas. However within the sanctuary, tarpon fishing would be encouraged as catch-and-release only. The goals are to protect traditional recreational fishing areas and major game fish.

Brazilier Island (near Chef Menteur Pass) Conservation Opportunity - In 2002, a tract of land was purchased along Highway 90 near Chef Menteur Pass known as Brazalier Island. The "island" is not truly an island but is surrounded to the north by Chef Menteur Pass, to the east by the Highway 90 (and borrow canal) and to the west by Lake Pontchartrain. The tract is approximately 2,200 acres. The new owner, Ken Carter of New Orleans, is apparently interested in developing a portion of the developable property along the Highway or a canal but may also be interested in selling the remaining wetlands for conservation. Conservation of Brazilier Island would be the first conservation area on the landbridge between Lake Pontchartrain and Lake Catherine. The marshes in this region are generally in good condition. The Big Cedar and Little Cedar Bayous run through this marsh to Lake Pontchartrain and are completely undeveloped and unaltered. Acquisition of this property into the nearby Bayou Sauvage National Wildlife Refuge or establishment of a state- run wildlife management area should be considered. The Tally Ho hunting club is one of the oldest hunting clubs in the nation and is located nearby on Chef Menteur Pass and might be willing to support a conservation initiative.

<u>Restoration Position Statements on Various Issues in the Middle Sub-basin</u>

1. The CHMP supports a permanent ban on commercial shell dredging in Lake Pontchartrain (and Lake Maurepas in the Upper Sub-basin).

2. The CHMP endorses the continued ban on commercial dredging of the water bottom in Lake Pontchartrain as passed in the state legislature in 2004 (Senate Bill No. 767: Act N0. 716).

3. The CHMP supports a continued ban on new oil and gas leases in Lake Pontchartrain.

4. The CHMP supports the ban on gill nets in Lake Pontchartrain except for that allowed by strike netting during limited seasons as determined by the LA Department of Wildlife and Fisheries.

5. The CHMP supports existing protection for the Gulf sturgeon (*Acipenser oxyrinchus desotoi).* In 2003,U.S. Fish and Wildlife Service and National Marine Fisheries Service

established Critical Habitat areas in eastern Lake Pontchartrain, all of Lake Borgne, and on the Bogue Chitto and Pearl Rivers. These areas and sturgeon habitat extending beyond the designated Critical Habitat should be recognized and given appropriate protection.

6. The CHMP supports protection and a restoration plan for re-establishment of the smalltooth sawfish *(Pristis pectinata)* in Lake Pontchartrain. NMFS (2000) began a review of smalltooth sawfish as a candidate to be listed as an endangered species and in 2003 the smalltooth sawfish was listed as endangered. Local reports by biologists suggest the smalltooth sawfish is extirpated from Louisiana. Since 1999, the sawfish has been protected in Louisiana. However no plan to re-establish sawfish in Louisiana is developed or implemented. Such a plan would need to consider impact to commercial fishing.

7. The CHMP supports the continued development of corridors for pipelines or powerlines to minimize habitat loss in and around Lake Pontchartrain (and Lake Maurepas in the Upper Sub-basin). An agreement was developed which defined preferred north south and east west pipeline corridors across Lake Pontchartrain to minimize habitat loss. (LA Department of Natural Resources, 2003)

8. The CHMP endorses a program to re-establish nesting of Bald Eagles (*Haliaeetus leucocephalus*) around the perimeter of Lake Pontchartrain by use of nesting platforms. Bald eagle population in south Louisiana has increased since the severe decline in the 1970's due to the use of DDT. Bald eagles are protected by the Endangered Species Act and the Bald Eagle Protection Act of 1940. Re-establishment of bald eagles around the shoreline of Lake Pontchartrain is within an appropriate eagle habitat and would greatly enhance opportunity for the public to observe Bald Eagle nesting and behavior

9. The CHMP endorses the re-establishment of bison (American Buffalo – *Bison bison*) within the Middle Sub-basin. The recommended site for re-introduction and management of bison is within the hydrologically managed area of the Bayou Sauvage National Wildlife Refuge. Bison were widely reported in south Louisiana by early European settlers. The last bison in Louisiana was killed in 1803. The reestablishment of this indigenous, mammal in south Louisiana is a unique opportunity to return this species to a coastal wetland habitat.

10. The CHMP endorses the continued improvement in sewerage and stormwater systems of along both the north and south shores of Lake Pontchartrain. Compliance with EPA mandates are considered minimum goals that should be met. Disposal of treated sewage or stormwater into wetlands is encouraged where this would be expected to enhance habitat and improve water quality of Lake Pontchartrain. Specific sites that should be considered are: Schneider pumping station in south Slidell, and the West Esplanade drainage canal in Kenner. This does not imply that adding wastewater will be beneficial to all types of wetlands. Certain types of wetlands (e.g. flatwoods, sawgrass, and sedge meadows) may be damaged by wastewater (Keddy and Fraser, 2002)

11. The CHMP endorses programs to reduce nutria (*Myocastor coypus)* populations such as the CWPPRA program of bounties on nutria.

12. The CHMP recommends accelerated and sustained programs to reduce the invasive Chinese tallow *(Sapium sebiferum*) trees from all refuges or wildlife management areas.

13. The CHMP does not support the restoration plan as proposed in conjunction with development of an airport facility within the La Branche wetlands.

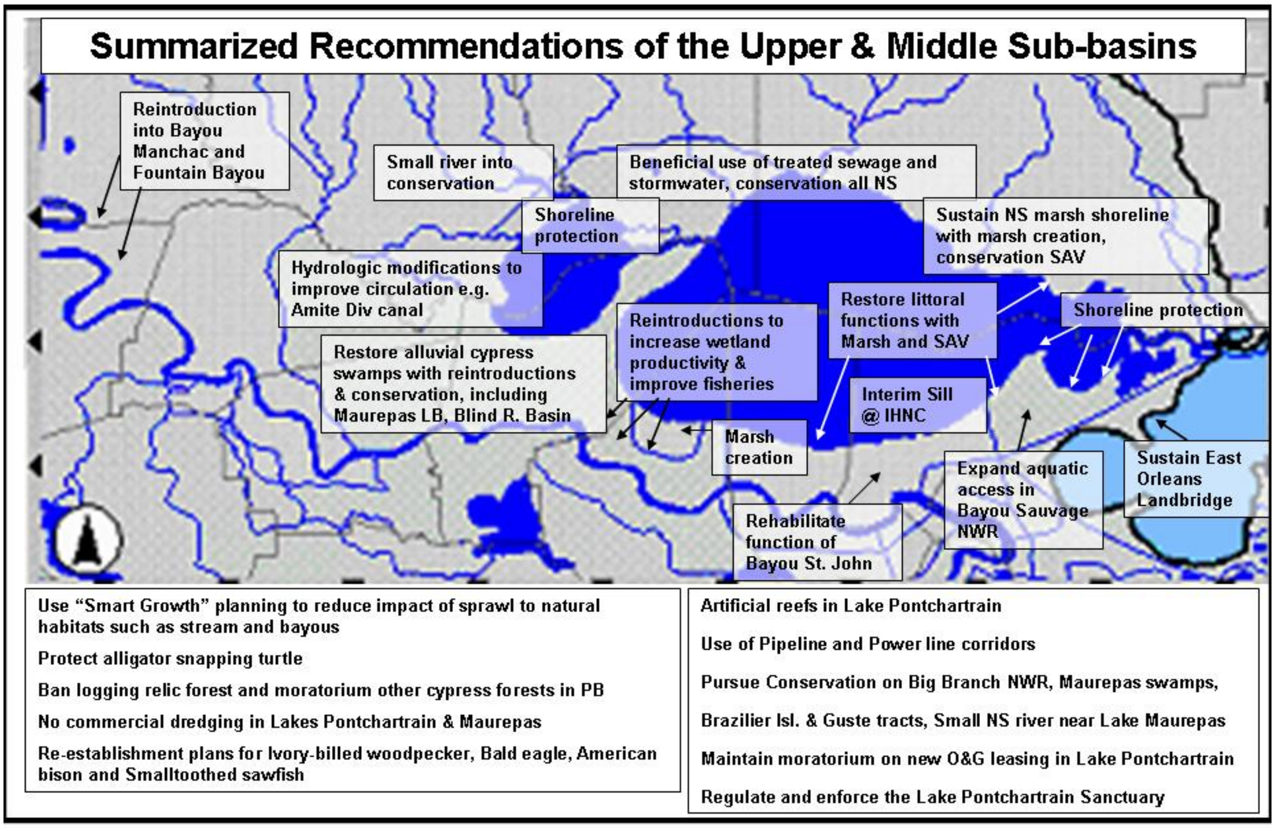


Figure 16: Map of general restoration recommendations in the Upper and Middle Sub-basin (Lakes Maurepas and Pontchartrain and adjacent wetlands). See text for detailed and more complete recommendations.

Lower Sub-basin Analysis (St. Bernard and Plaquemines Parishes)
The entire Lower Sub-basin owes its origin to deltaic processes of the Mississippi River and for purposes of the following analysis the Lower Sub-basin must be spatially divided into two regions representing two distinct and temporally separate delta-building events. The earlier event is the St. Bernard delta lobe which peaked in extent 2000-4000 years ago when it created a large delta which extended east beyond the current position of the Chandeleur Islands. After the St. Bernard delta development the Mississippi River moved west of its current position and created the Lafourche delta, which is outside of the Pontchartrain Basin. After the Lafourche delta event, the Mississippi River switched to its current course and approximately 800 years ago began creating the modern delta known as the Plaquemines/Balize delta. Since the current position of the Mississippi River is a hydrologic barrier, it is the western boundary of the Pontchartrain Basin. Consequently only the eastern half of the modern Plaquemines/Balize delta is considered within the Pontchartrain Basin. These distinctions are important in discussing both the form and function of the Lower Sub-basin. The Coast 2050 report (1999) mapping units which are utilized here to quantify aspects of form and function are divided as shown below.

Coast 2050 mapping units of the Plaquemines/Balize delta (within the Lower-sub-basin):
Pass a Loutre
Cubit's Gap
Baptiste Collette
American Bay
River aux Chenes
*Caernarvon (50%)
*Lake Lery (50%)
*Central Wetlands (50%)

Coast 2050 mapping units of the St. Bernard delta (within the Lower-sub-basin):
Chandeleur Island
Breton Sound
Chandeleur Sound
Jean Louis Robin
Eloi Bay
Biloxi Marshes
South Lake Borgne
Lake Borgne
*Caernarvon (50%)
*Lake Lery (50%)
*Central Wetlands (50%)
*(50% in St. Bernard and 50% in the Plaquemines/Balize deltas)

<u>Form Baseline of the Lower Sub-basin circa 1900- 1932</u>
Geomorphically the Lower Sub-basin is composed of extensive flat-lying marsh, meandering natural ridges, estuarine bays (lakes), marine sounds, barrier islands, active Mississippi River distributaries and crevasses.

Significant change in form to the lower basin since 1932 has been the dramatic loss of deltaic wetlands. The Coast 2050 report includes information on the 1932 extent of land (dominantly wetlands) and is considered the most accurate estimate of wetlands within the target baseline of the CHMP. Coast 2050 does not give sufficiently specific information of the wetland habitat types for 1932, and so additional information was used to make these estimates. Therefore the habitats distribution for the Lower Sub-basin was reconstructed based on available information. Oyster (*Crassostrea virginica*) distribution was based on a 1912 survey by Frank Payne of the distribution oyster reef density distribution within St. Bernard Parish (LA board of Commissioners, 1912) and additional early descriptions of oyster distribution such as Churchill (1920)(see also Wicker, 1979). The freshwater forested habitat was largely taken from Rosson (1988) who mapped forest types indicating the possible extent of cypress/tupelo forests in 1934. Other consideration was the estimated 1949 habitat regime map by O'Neil provided by the U.S. Geological Survey, and the general fresh and saltwater sources functioning during the baseline period. The overall wetland distribution is the 1932 maps from Britsch and Dunbar for the Black Bay and Mississippi River maps (1996). **Figure 17** is the estimated distribution of habitat types for the 1900-1932 baselines for the CHMP. It depicts freshwater swamp, freshwater marsh, mixed upland/swamp, intermediate marsh, brackish marsh and saline marsh.

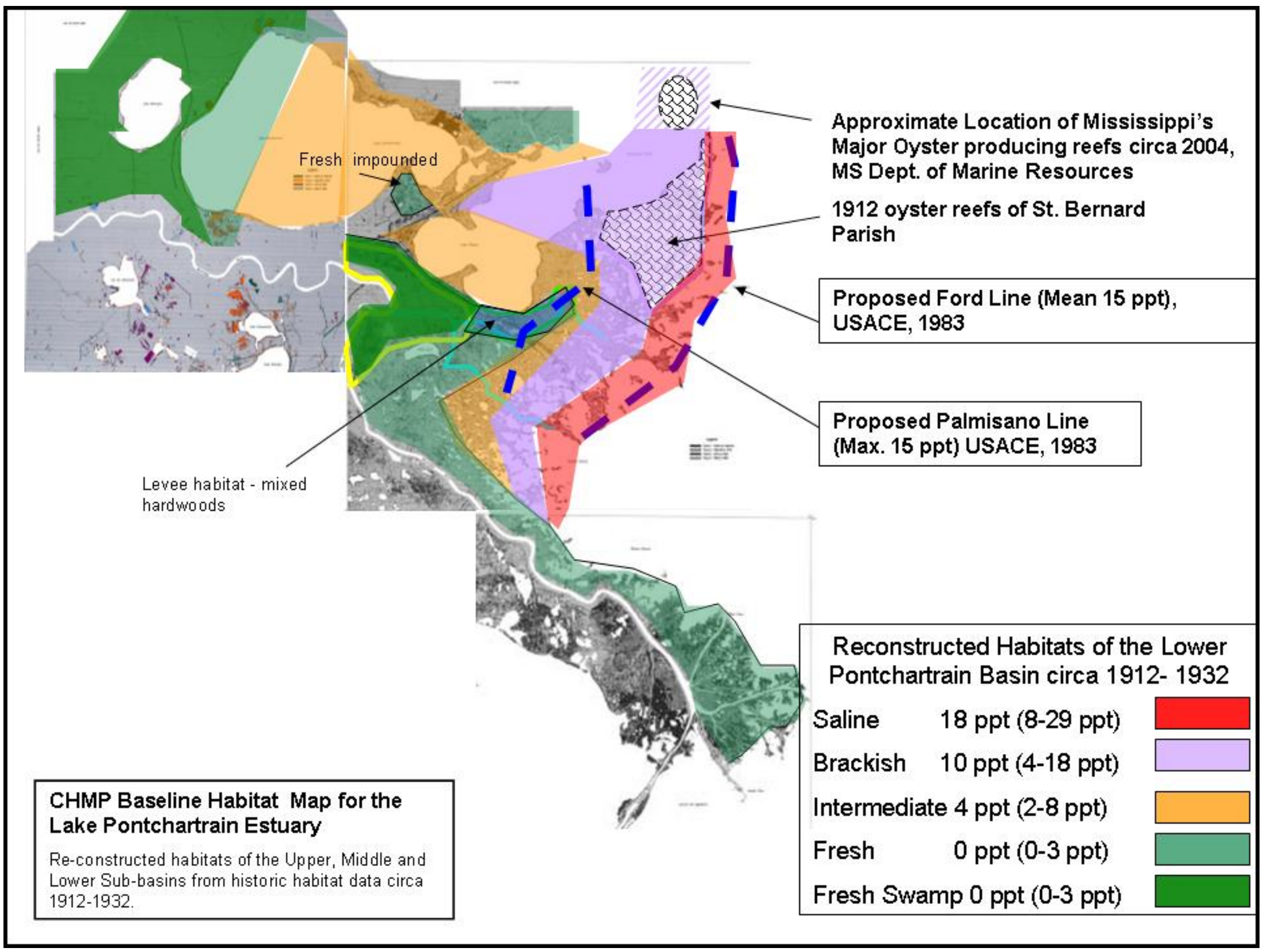


Figure 17: Map of Re-constructed habitats for the Lake Pontchartrain Basin Estuary. Historic maps of oyster reefs (*Crassostrea virginica*), forests, and other information were utilized (see text).

Two abandoned distributaries (Bayou la Loutre and Bayou Terre aux Boeufs) formed internal ridges, which were vegetated over a significant extent by oak and cypress. Bayou La Loutre probably sustained adjacent freshwater habitat at least as far east as the split with Bayou Terre aux Boeufs (Rosson, 1988). Freshwater habitat along Bayou La Loutre may have extended even further east to the vicinity of the Bakers Canal and Engineers Canal where the presence of logging canals suggests cypress trees were removed. It is certain that the Bayou La Loutre ridge and its channel were continuous without major alteration in the baseline period. The same is true for Bayou Terre aux Boeufs. Bayou la Loutre's connection to the Mississippi River prior to levee construction is unclear. The bayou probably received intermittent seasonal flow from the Mississippi River. By the late 1800's the river's connection was generally severed by primitive flood control levees. There was a crevasse-breach through the levee in 1922 (Poydras Crevasse see Davis, 1993) and the infamous intentional breach of the levee at Caernarvon in 1927 (Barry, 1997). River aux Chene is a smaller distributary, which was cut from the Mississippi River by artificial flood control levees.

Due to the geologic abandonment process, the Bayou la Loutre channel received little Mississippi River discharge. Consequently, the natural levees were primarily a hydrologic barrier from north to south. The Bayou la Loutre ridge extended eastward continuously from the Mississippi River for 25 miles (Pre-MRGO). It is this natural ridge which divided the Lower basin into two primary hydrologic basins. North of Bayou la Loutre ridge is herein referred to as the Borgne-Biloxi Estuary. South of the ridge is referred to as the Caernarvon-Terre aux Boeufs Estuary **(See Figure 26)**. The western margin of both these basins is the eastern bank of the Mississippi River where they once received overbank flow from the Mississippi River.

Lake Borgne is a large estuarine bay in the Lower Sub-basin located north of the Bayou la Loutre ridge. Lake Borgne is open to the north into Mississippi Sound but on all other sides has extensive marsh. Lake Borgne is the coalescence of three "round lakes" creating three circular lobes separated by two prominent peninsulas of marsh (and natural ridge) into the lake (Alligator and Proctor Point). The lake has two major natural tidal passes to Lake Pontchartrain (Chef Menteur Pass and The Rigolets) and is open to exchange with Mississippi Sound. Armoring of the lake shoreline in 1996 was minimal (Beall et al., 2001), and so most of the shoreline is a naturally eroding shoreline into the adjacent marsh, typical of "round lake" morphology (Price, 1947)

The barrier islands include Chandeleur and Breton Island chain and are the remnant of the eroded headland of the St. Bernard delta. These islands have a gulfward (~east) facing shoreface of beach and dune habitat, and lagoonal shoreline facing bayward (~west) toward Breton Sound. The gulf shoreline is higher energy and generally composed of sand and shell. The bayside is composed of sand overwash marshes and muddy lagoons. This 72 km barrier island arc trend is constantly altered by tropical storms, wind, and tidal action. Breton, the most southerly island, is about 15 km north of Main Pass in the Mississippi River's birdfoot delta. The north end of the island chain, near the lighthouse, is about 42 km south of Biloxi, Mississippi. Most of the islands are protected under the National Wilderness Preservation System, and called the Breton National Wildlife Refuge (Stake, Curlew, Grand Gossier and North Breton Islands are not included in the refuge).

In 1862, a manmade breach in the natural levee at Cubit's Gap developed into continuously flowing crevasses which by 1932 was a region of extensive small distributaries fanning into approximately 50,000 acres of wetlands. It is reported that this habitat was dominated by Roseau cane (*Phragmites australis*) with some floating marsh. The primary distributary was Main Pass. A similar pattern of sub-delta growth was also extensively developed between Pass a Loutre and South Pass east of Head of Passes in the Mississippi River. The wetlands here were also extensive. In 1932, it included 50,000 acres of wetlands, which also may have been dominated by Roseau cane and floating marsh. A less extensive crevasse was also developed at Baptiste Collette where in 1932 there were 15,000 acres of wetlands.

The Bohemia Spillway in Plaquemines Parish is a natural levee without flood protection levees along the bank of the Mississippi River. With sufficient river stage, the spillway allows Mississippi River water to flow into the adjacent wetlands. This spillway emulates the natural overbank flow process generally associated with the river prior to construction of levees.

Rangia clams habitat may have been extensive and potentially critical within the Lower Sub-basin. Rangia clams occur throughout estuarine habitats and are abundant at salinities ranging from fresh to 10 ppt. Their range may have been reduced by salinity increases. Their total extent in the marsh, bays or lakes of the Lower Sub-basin in 1932 is not known. Rangia clams can tolerate salinity in the lower range of that acceptable to oysters. It is possible that Rangia clam habitat extended from the Mississippi River gulfward to oyster habitat which overlapped with other bivalve habitat. Altogether these habitats could have provided important bivalve function over the entire estuary of the Lower Sub-basin (discussed in the next section).

Function Baseline of the Lower Sub-basin, circa 1800 (pre-levee)

Geologic function- The geologic function of the Plaquemines/Balize portion of the Lower Sub-basin was the functions associated with an active river delta. The Mississippi River delivered water, sediments and nutrients to this portion of the sub-basin and thereby continued to expand the deltaic wetlands. Based on the abandoned Lafourche and St. Bernard deltas, Lopez (2003) estimated the apparent rates of growth of wetlands while these deltas were in their growth phase (2.8 sq mile per year). Accounting for actual wetland extent (assumed 80%) and that only half of the active delta is within the Pontchartrain Basin suggests that the delta building function for the Plaquemines/Balize delta within the Pontchartrain Basin should be expected to have had a net growth of 1.1 square mile per year.

In contrast, the St. Bernard delta was in a state of abandonment and would be expected to have a net loss in areal extent of deltaic wetlands. Lopez (2003) also reports apparent loss rates for the Lafourche and St. Bernard deltas (0.8 square mile per year). Accounting for the actual wetland extent (assumed 80%) suggests that the net expected loss of wetlands in the St. Bernard delta is 0.6 square miles per year. This is close to the actual mapped land loss from 1932 to 1956 in the Biloxi marsh, where man-induced impacts are low. The apparent rate of growth and loss of the two different delta lobes are offsetting, but indicate there would be expected a slight net gain in wetlands (~ 0.5 square mile per year) over the entire Lower Sub-basin during the baseline period.

Mississippi River overbank flow: The pre-levee condition, circa 1800, of the Mississippi River in the Plaquemines/Balize of the Lower Sub-basin was one dominated by overbank flow and crevasses. The hydrology was controlled by river discharge of fresh water, tidal flow of gulf water, and an average annual rainfall of 60 inches. The resulting salinity gradient maintained the estuarine character. The effect of the Mississippi River eastward into the remnant of the St.

Bernard delta is less certain. The overbank discharge, unfettered by manmade levees or other alterations, is not known. Based on the apparent habitats as reconstructed for the form baseline (see previous discussion), the influence of the combined fresh water input of the river and rainfall was apparently sufficient to maintain these habitats even though the Mississippi had already been leveed by that period. It is reasonable to assume that habitats prior to levee construction, if any different from the reconstructed baseline, would be fresher. Therefore we can conclude that the riverine influence for the function baseline must be at least as great as that to sustain the habitats reconstructed in the form baseline. This applies to both the St. Bernard and the Plaquemines/Balize deltas. Salinity gradients appropriate to maintain the form baseline should be maximum values when considering the functional aspect of the Mississippi River's freshwater influence.

The Bayou la Loutre ridge had a primary function of restricting flow north or south from the two hydrologic basins. The Lake Borgne basin received overbank flow in the vicinity of the Central Wetlands mapping unit in a pre-levee condition. This eastward flow of fresher water should have played a significant role in controlling salinity of this basin. The Caernarvon basin, south of the Bayou la Loutre ridge, would have received some river discharge along a significant length of the Mississippi River. Flow across this basin was probably southeast toward Breton Sound.

Marsh platform: Because of the poorly consolidated soils and vulnerability to wave erosion, a critical function of the marsh vegetation is to resist wave erosion and therefore help maintain the marsh platform. Organic accumulation generated in situ also contributes to soil volume and to vertical accretion reducing the effect of subsidence.

Estuarine functions: The salinity gradient and related wetland habitats define an extensive estuary which then performs critical estuarine functions. Typical of estuaries, the Lower Sub-basin provides refuge and extensive nursery for numerous species, which migrate into the basin. The estuary can be regarded as a transition zone between highly evolved marine species and freshwater communities. Most estuarine organisms spawn offshore or in the lower estuary. Resident estuarine species such as clams and oysters proliferate. Species diversity is relatively low compared to adjacent marine habitat of the gulf but productivity is high. Salt marshes are one of the most productive habitats known. The Lower Sub-basin contains rare communities, habitats and species. These include true seagrasses, pink shrimp (*Farfantepenaeus duorarum)*, Atlantic bay scallop (*Argopecten irradians*) and hard clam *(Mercenaria campechiensis)* fisheries and essential fish habitat for rare and endangered fish and wildlife.

The barrier islands provide habitat for sea turtles, sea and shore birds (23 species) and nesting birds (13 species), including brown pelicans *(Pelecanus occidentalis)*, laughing gulls, and royal, Caspian and sandwich terns ***(Sterna sandvicensis)***. Waterfowl, especially redheads and lesser scaup *(Aythya affinis)*, take advantage of abundant food and protection during the winter. Endangered or threatened species that spend at least part of their life cycle on the islands include brown pelican (*Pelecanus occidentalis)*, piping plover (*Charadrius melodus)*, and green, hawksbill *(Eretmochelys imbricate*), Kemp's ridley *(Lepidochelys kempii),* leatherback *(Dermochelys coriacea),* loggerhead (*Caretta caretta)* sea turtles *(Caretta caretta),* and the Gulf sturgeon (*Acipenser oxyrinchus desotoi)*. During periods unaffected by storms and hurricanes, the shallow bay waters of the islands support about 6,000 ha of seagrass meadows, containing turtle grass, manatee grass and shoal grass, and smaller populations of star and widgeon grass *(Ruppia* *maritime).* These meadows are the only true seagrass beds in Louisiana, and serve as an important nursery ground for shellfish and finfish. They also support numerous invertebrates that are rare or only occur here, including Atlantic bay scallop (*Argopecten irradians*) and hard clam *(Mercenaria campechiensis)* fisheries.

It has been suggested that abandoned deltas such as the St. Bernard have higher biologic productivity than an active delta such as the pre-levee Plaquemines/Balize delta. Although, it is possible this assertion is biased toward commercial fisheries rather than overall productivity including primary production. A large volume of detritus generated by the marsh grasses is generally consumed locally. The estuary is dependent upon surrounding wetlands for organic matter (detritus) for secondary production (food for shrimp, fish, clams, crabs, etc.), essential habitat for invertebrates, fish and wildlife, maintaining water quality and other ecological services.

The high productivity and sub-tropical climate also attract many species of birds. It should be stated however, the many biological aspects of the Lower Sub-basin are understudied. Traditional research has focused on commercial fisheries and some threatened or endangered species. Non-commercial species and the biologic interaction need additional study. The biogeochemical aspects are beginning to be studied in regard to riverine reintroductions.

Oyster and Rangia clams' function: Oysters are a significant commercial fishery and considerable research and resources have been dedicated to oyster productivity in the Lower Sub-basin. A significant portion of oyster production is from cultivated oyster reefs. Historically, natural oyster reefs were harvested. Oysters and Rangia clams are filter feeders that remove phytoplankton, bacteria, suspended detrital particles and silts and clays from the water column. Oysters and clams provide numerous ecological services and their filtering activities contribute to periods of relatively clear water. In general, they filter water and provide benefit by improving water quality and contributing to an important trophic level. Numerous species of fish prey on oysters and clams. Commercial harvesting of oysters may preclude additional functions that a dense, natural oyster reef structure may have provided. These reefs had more vertical structure and may have had sufficient density to enhance local water clarity. The 1912 oyster reef map demonstrates there were a few large reefs of high density. The largest (5 square miles) was located north of the Biloxi Marsh within Mississippi Sound. This reef may have provided some barrier protection to the marsh. A similar function is provided by excess shell material that may generate a shell hash along shorelines or in shoals. Reefs and shell material will help reduce shoreline erosion of the surrounding marsh. Rangia clams do not attach themselves and so do not create reefs, however they can contribute to stabilizing sediment within bays and lakes. The full extent and significance of Rangia clams in the Lower Sub-basin under current conditions or under prior conditions is largely unknown.

<u>Impairments in the Lower Sub-basin (St. Bernard and Plaquemines Parishes)</u>

The greatest impairment to the Lower Sub-basin is the estimated conversion of 215,049 acres of wetlands to open water (82%) or to uplands or low quality wetlands on spoil banks (18%) from 1932 to 2001 **(Table 11).** This loss occurred in part to natural processes but was largely directly caused or induced by human activity. The majority of this loss occurred from 1932 to 1983 in what could be termed the "Coastal Industrialization Period" (CIP) **(Figure 18)**. Industrialization activities generally occurred at a time of little regulatory protection for the environment. The near ubiquitous wetland landscape of the Lower Sub-basin were severely impacted. Data from Penland et al. (2001) suggest for the entire Pontchartrain Basin, that 2/3 of the wetland loss (converting to water) was directly caused or induced by human activity.

Table 11: Lower Sub-basin Estimated Wetland Loss 1932- 2001
(all types & does not include growth)

1932 – 1990 wetlands to open water (source- USACE 2005 Estimated of loss in 12 mapping units 1932-1990, This data was ~10,000 acres less than previously reported in Coast 2050 for the same mapping units)	143,291 acres
1922- 1989 Chandeleur and Breton Islands (Source, Williams et al, 1992)	2,430 acres
1932-1990 wetlands to spoil bank Estimate 200% of estimated direct canal impact Penland (2001) for Pontchartrain Basin & estimate of loss due to MRGO spoil bank (MRGO Re-evaluation, 2001)	39,412 acres
1990 -2001 Lower Sub-basin only (source- USACE 2001 estimated of loss in 12 mapping units (1990-2001)	29,916 acres
Total Estimated loss 1932- 2001	**215,049 acres**

The CIP generally included activities related to oil and gas extraction, railroad and motor vehicular road building, flood protection, and navigation projects. Wetland loss from these activities was often related to direct or indirect effects of canals (described below) or man made ridges (such as, spoil banks, levees, road foundations, etc.) constructed for industrialization. Aside from the independent effects of each, canals and man-made ridges together fragment previously continuous wetlands, which may have caused further indirect loss of wetlands. Navigation projects tend to have greater impact than typical canals and may include stratified saltwater intrusion. Land reclamation occurred prior to the CIP, but latent effect of impoundments and drainage canals probably contributed to the loss during the CIP. Lopez (2003) estimated that the direct effect of Mississippi River flood control levees in the Pontchartrain Basin accounts for only 5,600 acres of the loss from 1932 to 1990, but may have prevented the expansion 30,000 to 40,000 acres of wetlands in the active Plaquemines /Balize delta in the same time period. Natural processes causing wetland loss are natural shore line erosion, and the amount of relative sea level rise as driven by natural processes. Man-induced causes of wetland loss are herbivory (introduction of nutria - *Myocastor coypus*), and possibly man-induced increases to relative sea-level rise. **Figure 19** is the percent wetland loss for each mapping unit from 1932 to 2001.

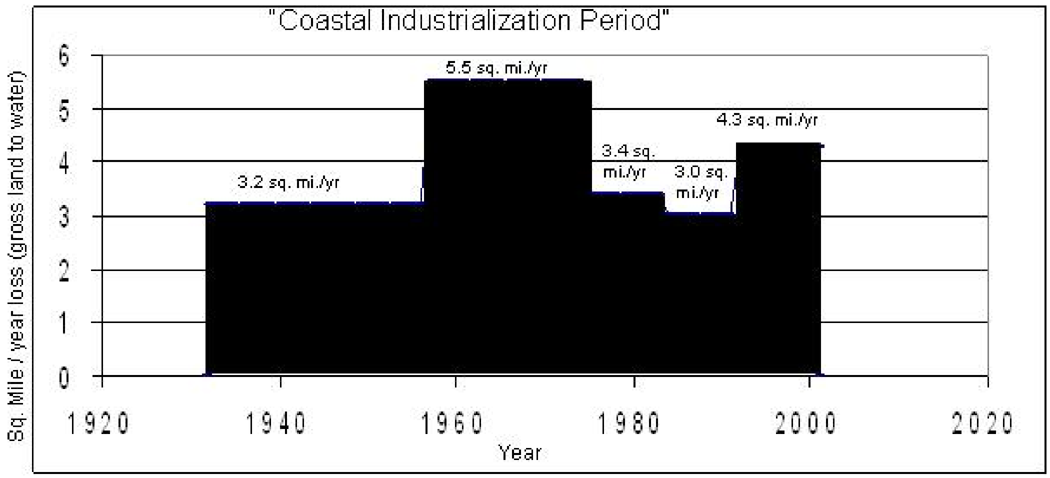


Figure 18: Graph of the land loss rates in Lower Sub-basin from 1932 to 2001. (Source: USACE, 2001; land to water conversion in the 12 mapping units of the Lower Sub-basin for 1932-1956,, 1956-1974, 1974-1983, 1983–1990, 1990-2001). The Coastal Industrialization Period included primarily the damaging effects from oil and gas activities, navigation projects, and rail and roadway projects, in addition to other longer term impacts such as Mississippi River flood protection levees, natural shoreline erosion, herbivory, brown marsh, and tectonic subsidence. The 1990 -2001 increase in wetland loss may indicate a new period of higher wetland loss post-CIP.

Figure 18 is the overall loss rates for the Lower Sub-basin for the five time periods. It depicts a distinct increase in overall rates of loss for the most current period (4.3 square miles per year). This is second only to the peak seen during the CIP of 5.5 square miles per year. **Figures 20 and 21** show the increase in the individual mapping units in which ten of the twelve mapping units increase in the 1990 to 2001 for both square miles lost and % lost per year. There is uncertainty in the degree of reliability in all of the land loss data and caution is warranted. It should be noted however that the final LCA report of November 2004, reported USGS land loss data indicating that the Pontchartrain Basin (Sub-province 1), is the only Sub-province in the coast to have had an apparent increase in the rate of loss in the 1990 to 2000 period. These increases in loss rates elevate concern for future loss of habitat in the Lower Sub-basin.

Figures 20 and 21 depict histograms of the twelve, mapping units within the Lower Sub-basin for the five time periods of mapped land loss provided by the USACE. **Figure 20** is square miles per year lost for each time period and **Figure 21** is the percent land lost from the beginning of each time period. All except American Bay and Biloxi Marsh mapping units have a peak of land loss during the CIP, but also show another peak in the last time period (1990-2001). The three mapping units of the Lower delta show the highest overall rates of loss, which combined have an average loss rate of 1.5% per year. This is more than three times as great as the average for all other mapping units (0.45% per year). These lower delta mapping units also have the highest overall percent loss (63% to 82%), which is exceptionally high compared to the other mapping units. Also anomalously higher than most other mapping units is the South Lake Borgne mapping unit, which has a weighted average loss rate of all time periods of 0.67%/year.

Without further analysis, it is not evident what the underlying causes are for this recent increase in wetland loss. However, it is interesting to note that American Bay and Cubit's Gap are not restricted from riverine discharge by flood protection levees. Cubit's Gap, Baptiste Collette and Pass a Loutre have some wetland growth in the 1990s and this is not reflected in these data (Britsch and Dunbar, Pers. Comm., 2005). One other area receiving river discharge is the outfall area of Caernarvon Freshwater Diversion structure. The nearby mapping units (Lake Lery and Caernarvon) indicate a significant rate in wetland loss in the 1990 to 2001 period during which Caernarvon was operative. More detailed analysis of this area by ongoing monitoring indicates a possible net wetland growth within 3 to 4 miles of the Caernarvon structure, where benefit may be greatest. It may be inferred that riverine introduction may be locally offsetting wetland loss which has otherwise increased in the past decade for unknown reasons. However the reason for the general increase in loss in 1990 to 2001 is unknown.

Impact of Canals

Quantification of wetland loss from canals in Louisiana is generally based on USACE mapping of land to water conversion from 1932 to 1990. As acknowledged by the USACE interpreters, their mapping technique has resolution limits. Generally the technique does detect canals of at least typical oil and gas canal dimensions (~70' width). However there are many other narrower canals, such as early navigation arpent canals, drainage canals, or logging canals, that often are smaller than the mapped resolution by the USACE data set. In addition canals constructed pre- and post-the period investigated from 1932 to 1990 are not included. A comparison of the USACE wetland loss maps to recent high altitude infrared imagery (circa 1998) in some areas shows that less than half of the linear open water areas (canals) may be mapped in the 1932 to 1990 wetland loss maps by the USACE.

Based on the USACE data, Penland et al. (2001) estimated 20,847 acres are due directly to oil and gas; navigation and access canals for all of the Pontchartrain Basin. Because of the limitations of this data this is an underestimate of direct loss (land to water) due to canals. However, the additional impact of spoil banks resulting from canal construction should also be considered. The footprint of spoil bank and berm is estimated to be 200% of the excavation footprint for typical oil and gas access canals. Including the MRGO spoil bank, it is estimated the total loss due to conversion of marshes to low quality scrub wetlands is 39,412 acres. Therefore the estimate for the total direct impact (i.e. spoil banks, berms, and wetland to water conversion) of all canals in all

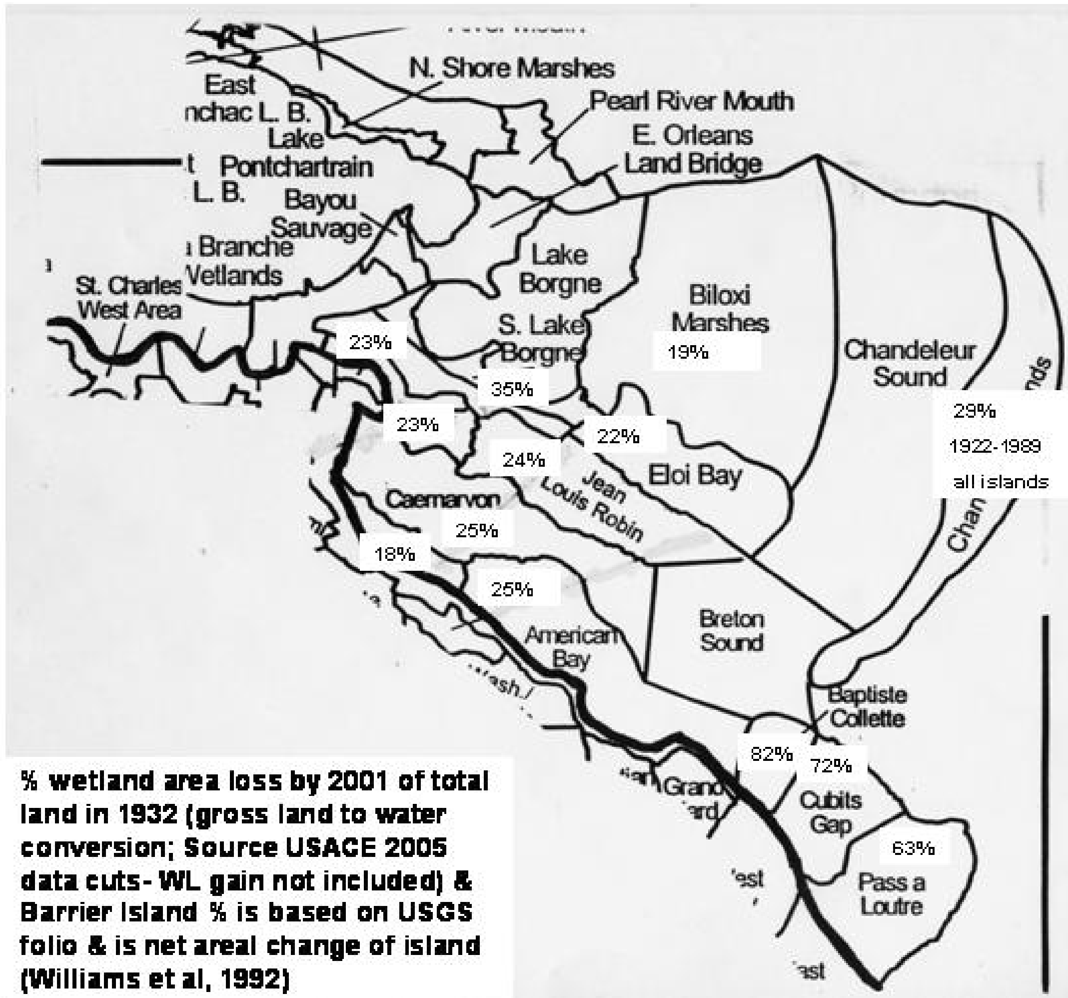


Figure 19: Percent land loss from 1932 to 2001 for each mapping unit within the Lower Sub-basin (Data source, marsh data are USACE landloss data released in 2005 to the CHMP draft committee and barrier island loss is from Williams et al., 1992)

of the Pontchartrain Basin is 60,259 acres for the period 1932 to 1990. Since 80% the overall loss in the Pontchartrain Basin occurred in the Lower Sub-basin and since canals are more common in the Lower Sub-basin, it is reasonable to assume that more than 80% of the direct losses in the Pontchartrain Basin are attributable to the Lower Sub-basin.

The indirect impact of canals is significant but difficult to quantify. For the entire Pontchartrain Basin, Penland et al. (2001) estimated 16,714 acres of wetlands were converted to open water due to the altered hydrology attributable to oil and gas canals, which is 30% greater than the loss attributed directly to these canals. In addition, Penland et al. (2001) included 54,513 acres of loss due to altered hydrology from multiple causes, which would include some contribution from oil and gas canals. Lopez (2003) estimated the indirect impact of all canals in the Pontchartrain Basin was 21,000 acres. Boesch et al. (1994) estimated that the overall impact by canals (direct and indirect) in Louisiana is between 30% and 50% of the overall losses in wetlands in south

Louisiana. This suggests in the Pontchartrain Basin with an overall loss of 266,157 acres that 80,000 to 133,000 acres may be attributed to canals. The combined direct impact loss (60,259 acres) and indirect estimates (16,714 to 21,000 acres) is up to 81,259 acres, suggesting that this estimate should be considered a minimum estimate of the overall impact of canals in the Pontchartrain Basin. The portion attributed to just the Lower Sub-basin should be at least 80% (65,000 acres).

It is important to note that the impact due to new canals since 1990 is apparently drastically less than historic impacts. The intent of federal and state regulatory processes, that regulate canal construction in wetlands, is that canal construction is an option of last resort from activities such as oil and gas access (Rives, Pers. Comm.). Directional drilling and other engineering technology create greater flexibility by the industry to minimize new impacts. This appears to be supported by the USACE land loss data provided for the period 1990 to 2001. For this data set, USACE interpreters attempted to distinguish obvious man-made feature from other forms of wetland loss. The obvious man-made loss features are linear loss patterns, which are canals of some unidentified cause. In the 1990 to 2001 period, “man-made” losses for the Lower Sub-basin are 270 acres (0.8% of the total loss), which are probably due to new canals. It is encouraging that the regulatory process appears to be reducing the direct impact from new canal construction. This does not imply that other man-made impacts are not occurring since any non-linear impact would not be identified as “manmade”.

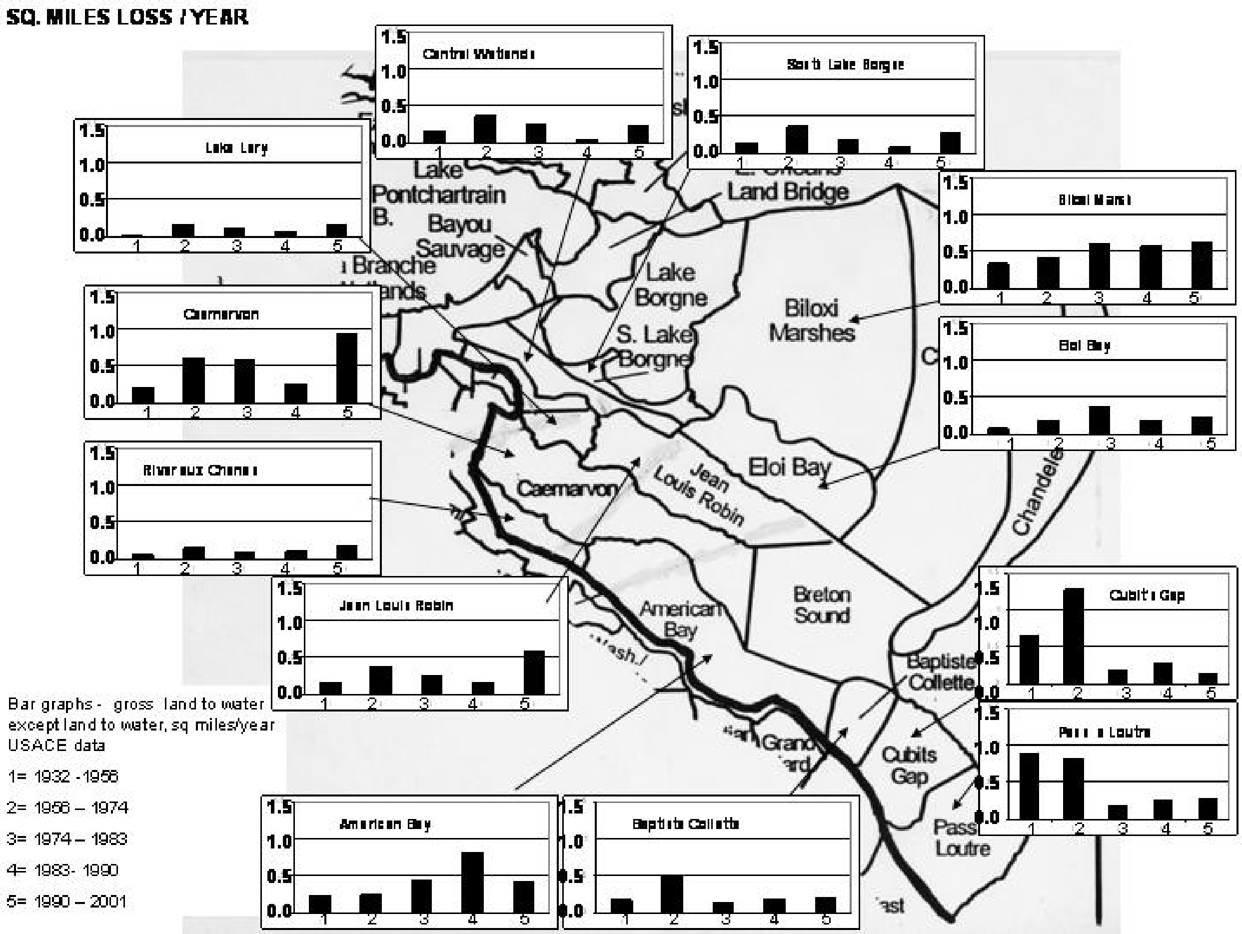


Figure 20: Historical landloss graphs (sq. miles landloss /year/period) for each mapping unit within the Lower Sub-basin (Data source, USACE landloss data released in 2005 to the CHMP draft committee)

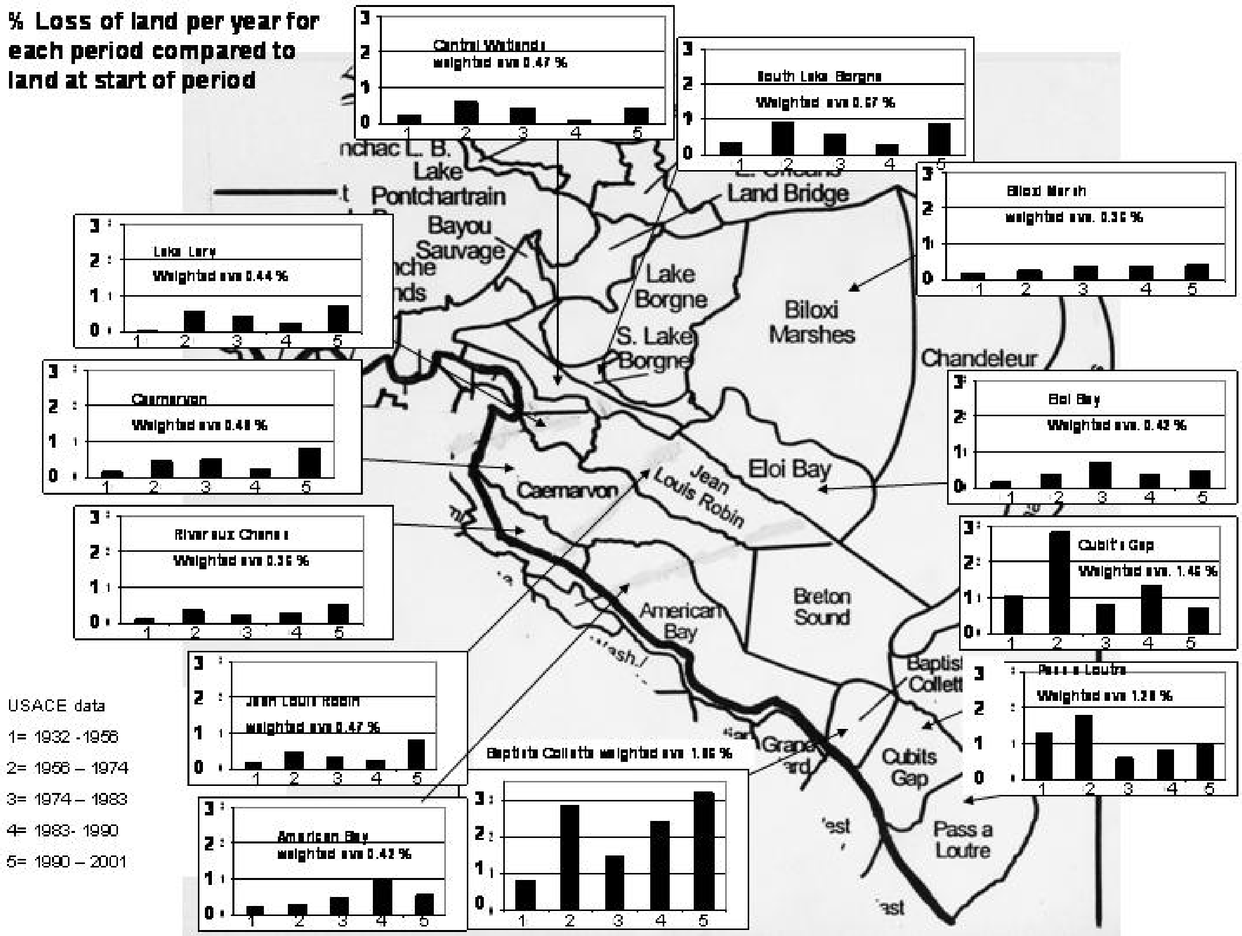


Figure 21: Historical landloss graphs (% of landloss /year/period) for each mapping unit within the Lower Sub-basin (Data source, USACE landloss data released in 2005 to the CHMP draft committee)

Mississippi River Gulf Outlet (MRGO) Impact

The completion in 1968 of the MRGO as a deep draft navigation channel and canal with an authorized depth of 36 feet, resulted in major hydrologic and habitat changes detrimental to much of the Pontchartrain Basin. The channel was dredged across 10 miles of the shelf edge of Gulf of Mexico, 20 miles of Breton Sound and 35 miles of St. Bernard Parish marshes. Within the MRGO reach through marsh, the dredged material was placed, as much as 15 feet high, on an adjacent 4,000 foot wide marsh to the south of the channel. Approximately 5 miles of retention dike (rock breakwater) were placed along the south bank of the channel in the open water of Breton Sound. Maintenance dredging is needed annually and emergency dredging is routinely needed after major storm events silt the channel. Most maintenance dredging is needed within the MRGO reach through Breton Sound. Maintenance dredge material has generally been placed on the approved Ocean Dredged Material Disposal Site in the Gulf of Mexico, but also more recently been used beneficially for marsh creation adjacent to inland portions of the channel or for restoration of Breton Island. However these restoration efforts have only been a minor offset to the overall environmental impact of the MRGO (1,000 acres of marsh and 180 acres of barrier island have been created from 1985 to 2004 – Ed Creef pers. Comm., 2005). The total habitat area affected by the MRGO is 618,000 acres or nearly 1000 square miles **(Table 12)**.

Hydrologically the MRGO created a new pathway for astronomical and storm-driven tides allowing saline water, for the first time, to flow directly from Breton Sound to Lakes Borgne and Pontchartrain. Overall gulf tidal flow in Lake Borgne was fundamentally altered from a Lake Borgne/Mississippi Sound system to a Lake Borgne/Mississippi Sound/Breton Sound system. This alteration is acknowledged by the USACE.

> *"Prior to construction of the MRGO, tidal flow into Lake Borgne was dominantly by flow from Mississippi Sound because the tidal flow from Breton Sound was reduced as it moved northwest across the marshes and wetlands through bayous and ponds toward Lake Borgne. Construction of the MRGO caused a reversal of the former circulation pattern, with the dominant tidal flow into Lake Borgne now coming from Breton Sound area directly via the MRGO".*
>
> U.S. Army Corps of Engineers, 2004

Construction of the MRGO is reported to also influence movement of storm surges. The LSU Hurricane Center's models of storm surge indicate that during hurricanes, water is deflected northwestward along the southern spoil bank and protection levee of St. Bernard Parish. A similar effect by the levee of Eastern New Orleans near the Intracoastal Waterway creates what has been referred to as a funneling effect of water westward toward Chalmette, New Orleans and Lake Pontchartrain (Pers. Comm., Dr. Hassan Mashriqui). This funnel effect may have been a significant contributor to the impact of Hurricane Katrina and may have also contributed to the re-flooding of New Orleans during Hurricane Rita (See Appendix E for further discussion).

From daily lunar tides to extreme storm surge events, the MRGO has fundamentally changed the hydrology of the Pontchartrain Basin and is recognized for its profound impact to the estuary and the region.

The hydraulic imbalance has continued to increase due to enlargement of the channel by bank erosion and advance maintenance dredging as deep as 42 feet. A typical profile of the MRGO has a cross-sectional area of 29,000 ft^2, which is 20-30 times larger than a typical bayou and is equivalent in cross-sectional area to 17% of the Mississippi River. Unlike the Mississippi River the MRGO carries water of near ocean sea-water salinity concentration and has been referred to as an "anti-diversion" implying its generally contrary effect to the restorative effect of freshwater diversions of Mississippi River water (Schexnayder and Caffey, 2002).

The MRGO slightly affected salinity as far inland as Lake Maurepas region (Upper Sub-basin). Elevated salinity has been well documented by actual pre and post measurements and supported by hydrologic modeling by the U.S. Army Corps of Engineers (Carillo et al, 2001 and USACE Committee on Tidal Hydraulics, 1995). In the Louisiana Coastal Area, Ecosystem Restoration Study, the "Problems and Needs" section describes elevated salinity and includes the table shown here as **Table 9**. This table documents that at the Alluvial City site (near Shell Beach) within the Lower Sub-basin, the average annual salinity increased from 7.8 ppt to 12.2 ppt, which is a dramatic 57% increase in salinity. The area influenced by increased salinity probably includes at a minimum all of Lakes Pontchartrain, Borgne, and most of the adjacent marsh and swamp habitats. The effected area of the lakes is 552,400 acres (390,400 acres + 162,000 acres).

The depth of the channel is a key aspect of the MRGO's negative environmental impact. With a minimum depth of 36 feet and depth as great as 50 feet in local borrow sites within the channel, the depth is at least 30 feet greater than the general water bottom depths of the adjacent marshes. Salt water moves northward through the channel and enters Lakes Borgne and Pontchartrain. Salinity stratification occurs in Lake Pontchartrain as a result of the MRGO and has been described in the impairment section for the Middle Sub-basin of this report (Poirrier, 1978; Poirrier et al. 2000 and 2004; Georgiou et al, 2000 and Schurtz and St. Pe', 1984). Salinity stratification in Lake Pontchartrain causes a benthic dead zone as evidenced by impact to the Rangia clams (dominant species) in Lake Pontchartrain covering at least 1/6 of Lake Pontchartrain (64,000 acres). The "Final Report- Environmental Resources Documentation Mississippi River-Gulf Outlet Re-Evaluation Study Southeast Louisiana" completed in 2002, indicates that salinity stratification is also present in the MRGO channel.

A concise summary of habitat impacts due to the MRGO is given in the Report of the Environmental Sub-committee to the MRGO Technical Committee completed March 16, 2000. This study included a team of wetland specialists reporting to the Technical Committee composed of representatives of the U.S. Army Corps of Engineers, National Marine Fisheries Service, U.S. Fish and Wildlife Service, U.S. Geological Survey, Louisiana Department of Natural Resources, Louisiana Department of Wildlife and Fisheries, University of New Orleans, Louisiana State University, Nichols State University and the Lake Pontchartrain Basin Foundation. The relevant text of the Executive summary is given below:

In regard to lost habitat due to the MRGO:

"Construction of the MRGO and subsequent erosion has caused extensive loss of land in St. Bernard Parish. Nearly 3,400 acres of fresh/intermediate marsh, over 10,300 acres of brackish marsh and over 4,200 acres of saline marsh have been converted to open water or disposal area. Over 1,500 acres of cypress swamp and levee forest have become disposal areas. A total of nearly

20,000 acres of wetlands have been lost and nearly 4,800 acres of shallow open water have been converted into deep water and disposal area".

Total Estuarine Wetland and Lagoon Habitat Loss (to deep water or spoil)

3,400 + 10,300 + 4,200 + 1,500 + 4,800 + 3,400 (see below)= 27,600 acres

In regard to habitat shifts due to the MRGO:

"Habitat shifts caused by saline waters brought in by the MRGO have caused 3,350 acres of fresh/intermediate marsh and 8,000 of cypress swamp to shift to brackish marsh. Approximately 7,500 acres of swamp have converted to intermediate marsh. Also 19,170 acres of brackish marsh have converted to saline marsh. If the roughly estimated amount of increased loss is considered, the area influenced by the MRGO could have lost over 3,400 acres of wetlands due to increased tides and salinity."

Total Estuarine Wetland Habitat Conversion (to higher salinity habitat):

3,350 + 8,000 + 7,500 + 19,170 = 38,020 acres

The distribution of these habitat changes may also be relevant to the overall function of the Lower Sub-basin estuary. **Figure 20** is a map of 1949 (Pre-MRGO) habitat types of the Lower Sub-basin. Note that there is a continuum of more saline habitats moving from Breton Sound across the Biloxi marsh and across Lake Borgne. **Figure 22** is a 2001 (post–MRGO) habitat map of the Lower Sub-basin. It illustrates the increased saline marsh around the Biloxi marsh along the MRGO and Lake Borgne shoreline. The 2001 map shows that saline marsh nearly encloses the entire Biloxi marsh. An increasingly small remnant of brackish marsh is being converted around the brackish perimeter to saline marsh. With a complete perimeter of saline marsh and no source of fresh water other than rainfall, it is possible the marsh may precipitously convert entirely to saline marsh. Although 1999 and 2000 were drought years, this brackish island is seen as early as 1988.

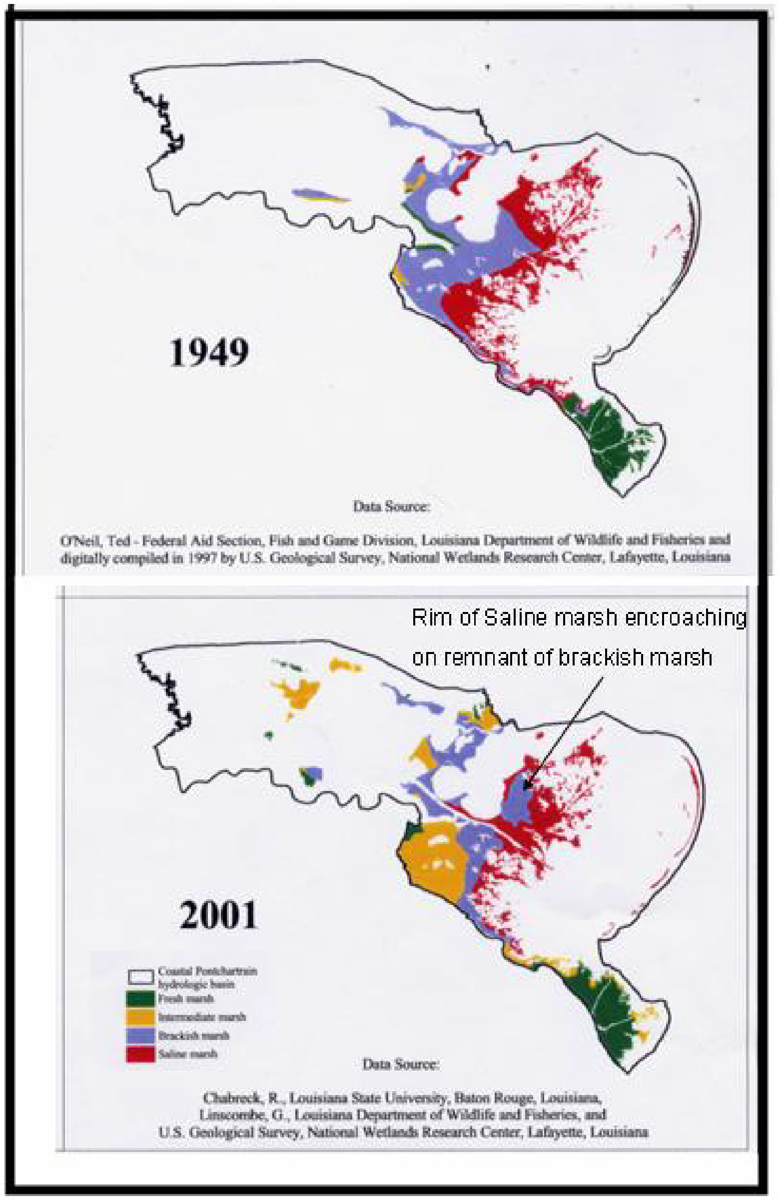


Figure 22: Habitat maps of the Lower Sub-basin from 1949 and 2001 (source USGS)

Perhaps most profound is the resulting or potential landscape changes from the MRGO. Bayou la Loutre and its natural ridge were the defining hydrologic element between the two dominant estuarine basins of the Lower Sub-basin. This defining landscape feature was critically compromised when the 500 foot X 36 foot channel was dredged northward through the east/west oriented ridge of Bayou la Loutre **(Figure 23)**. The authorized top width is 750 feet, but has enlarged to as great as 2,000 feet since construction. The Bayou la Loutre ridge extended 25 miles east from the Mississippi River as an upland ridge centered on a bayou of relatively fresh water. The MRGO altered the landscape by converting the ridge east of the MRGO into an isolated upland "island" now surrounded by brackish marsh habitat with a bayou carrying much more saline water. Bayou la Loutre has become an extension of the "anti-diversion" introducing saltwater to the heart of the St. Bernard delta such as Stump Lagoon. Due to these impacts and other factors the ridge habitat has dramatically declined.

Figure 23: Location of the MRGO breach across the Bayou la Loutre Ridge (1998 High altitude color infrared imagery).

Another landscape feature of concern is the southwest shore of Lake Borgne where the narrow band of wetlands separating the MRGO channel from Lake Borgne is rapidly eroding on both the channel and lake side (**Figure 24**). In 2005, we find Lake Borgne precariously close to transgressing to the MRGO channel pass this unnatural landbridge. If Lake Borgne and the MRGO coalesce, the environmental impacts include at least the following: increase in salinity, disruption of natural littoral transport, creation of a sediment sink, loss of fringing marsh, increase in the tidal prism, and an increase in hydraulic flushing.

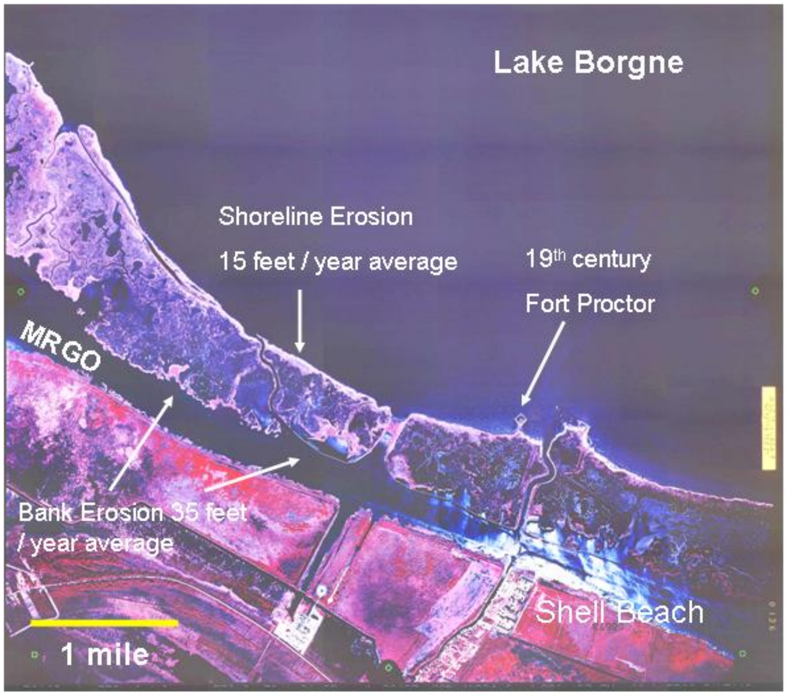


Figure 24: Unnatural landbridge between Lake Borgne and MRGO. High erosion rates on either side of landbridge threaten the integrity of Lake Borgne (1998 High altitude color infrared imagery).
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Large ships that use the MRGO on average twice a day cause unusually significant surges and waves. As a ship travels through the channel, a significant amount of water is first drawn toward the vessel and as the vessel passes the water is pushed back in the opposite direction. The action of surge is actually a hazard for small boats that may be within small channels where water may suddenly surge through. Scouring action of the water erodes the marsh soils. Ship waves break along the natural marsh bank, which has very weak soils (Coastal Environments, Inc., 1984). Average wave erosion of the north bank is 35 feet per year (USACE, 2004). A report on modeling of waves in the MRGO was completed in 2004 by the USACE and described wave dynamics of ships with draft as great as 41 feet (Demirbilek, 2004). A PowerPoint presentation is available online at http://chl.wes.army.mil/research/navigation/GulfportWorkshop/ZekiDemirbilek.pdf. A copy of the report was requested but never received.

The marsh on the north bank of the MRGO is also being lost from shoreline erosion in Lake Borgne. The average shoreline erosion in Lake Borgne here is 15 feet per year (USACE, 2004, see also Zganjar et al, 2001). The remaining marsh between the MRGO and the lake is now a narrow landbridge critical to maintaining the integrity of Lake Borgne and the MRGO. St. Bernard residents have grave concerns of this threat.

Table 12: Summary of Quantified Habitat Impacts of the MRGO (Including the Middle and Lower Sub-basins)

Estuarine Wetland & Lagoon Habitat Loss (to deep water or spoil)	27,600 acres
Estuarine Wetland Habitat Conversion (to higher salinity habitats)	38,000 acres
Dead Zone of Lake Pontchartrain (1/6 lake area benthic mortality)	64,000 acres
Estuarine (Lacustrine) salinity shift: Lakes Pontchartrain (5/6 area) and Borgne	488,400 acres
Total	618,000 acres

Fisheries have also been affected as reflected in the habitat shifts. Generally all species have shifted inland with the salinity shift inland. A comprehensive review and investigation of MRGO impacts in 2002 reported that of 22 species of freshwater fishes documented previously in the Biloxi marsh complex near the MRGO, ten species had disappeared after the completion of the MRGO, including shovelnose sturgeon *(Scaphirhynchus platorynchus*), chain pickerel *(Esox niger*), yellow bass *(Morone mississippiensis*), five species of sunfish *(Lepomis gulosus, Lepomis humilis, Lepomis macrochirus, Lepomis microlophus, Lepomis miniatus*), largemouth bass *(Micropterus salmoides*), and sauger *(Sander canadense*) (Final Report- Environmental Resources Documentation Mississippi River- Gulf Outlet Re-Evaluation Study Southeast Louisiana, 2002). This study also reports oyster-producing areas once restricted to being east of Lake Borgne are now found in the southwest quadrant of the Lake as was also reported by Dugas (1977). Also affected have been shrimp, which have shifted from a predominance of white shrimp (*Litopenaeus setiferus*), to being dominated by brown shrimp (*Farfantepenaeus aztecus*) in the commercial inland fishery (Schexnayder and Caffey, 2000).

<u>Restoration Recommendations in the Lower Sub-basin (St. Bernard and Plaquemines Parishes) - (See Figure 27 for a summary map)</u>

The restoration recommendations for the Lower Sub-basin are generally of two types. One set of recommendations is to essentially restore and sustain the regional habitat baseline **(Figure 15)**. The other set are more local and possibly interim projects that are discussed after the habitat restoration plan. The crux of the overall restoration for most of the Lower Sub-basin hinges on modification of the MRGO channel at Bayou la Loutre. Constriction of the MRGO is necessary to re-establish of the Bayou la Loutre ridge and the hydrologic integrity of the "Borgne-Biloxi Estuary" and the "Caernarvon-Terre aux Boeufs Estuary" **(Figure 26).**

Re-establishment of Bayou la Loutre ridge

Re-establishing and then managing the salinity gradient and the associated habitats is the central goal of the Lower Sub-basin restoration. The greatest impediment to achievement of this goal is the MRGO, because the MRGO breaches through the former hydrologic barrier of the Bayou la Loutre ridge. Ideally modification of the MRGO would be the complete re-establishment of the same effectiveness of the ridge prior to construction of the MRGO, i.e. an effective hydrologic boundary between the Borgne-Biloxi Estuary and the Caernarvon-Boeufs Estuary **(Figure 27).**

Because of the overriding need for some navigation north to south , the primary recommended modification to the MRGO is to redesign the channel at Bayou la Loutre to Intracoastal Waterway (ICW) dimensions, which are 125 foot width and 12 foot depth. It may be possible to achieve these dimension and the environmental goals without any type of gate. Modifying the channel to these dimensions reduces the cross-sectional area 96% **(Figure 25).**

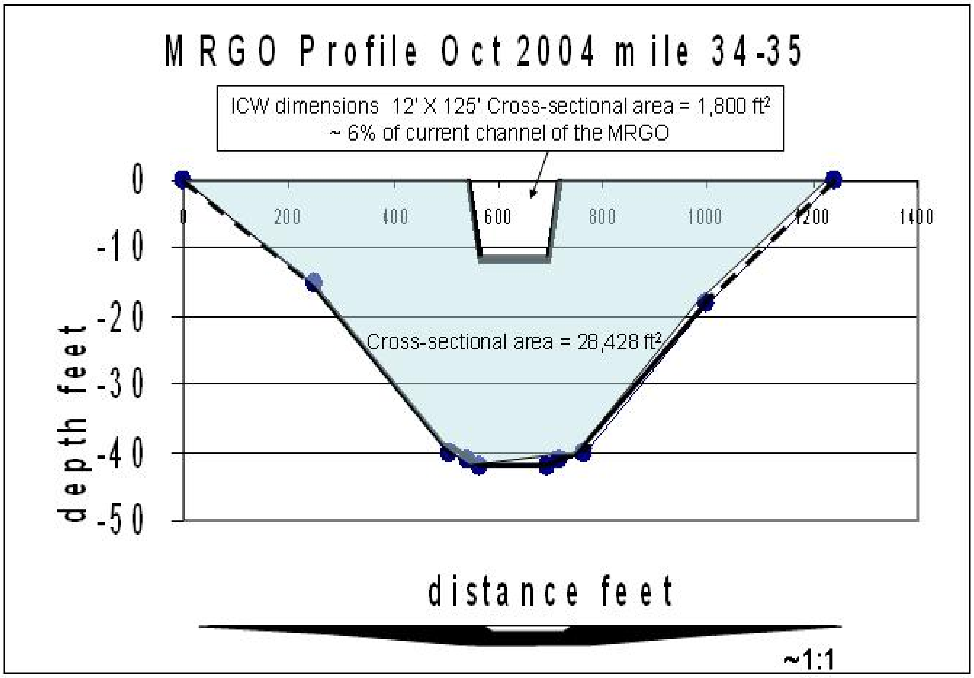

Figure 25: Transverse depth profile of the MRGO (source USACE website) and the superposition of a proposed channel of Intracoastal Waterway dimensions (12 feet by 125 feet).

The USACE modeled various closures scenarios for both depth and width (Tate et al., 2002). They found that significant salinity reduction can be achieved by reducing the channel dimension to ICW dimensions (125' X 12'). At Little Woods salinity reduction was estimated to range from 1.4 ppt to 2.4 ppt, which roughly offsets 100% of the increase in salinity due to the MRGO. Significant reduction would also be expected in southwest Lake Borgne, with an anticipated 5.4 ppt to 7.2 ppt decrease at Martello Castle. However, very little reduction would be expected in eastern Lake Borgne and adjacent marsh. Even with complete closure of the MRGO at Bayou la Loutre, the salinity reduction at Pointe Aux Marchettes was just 0.2 ppt to 0.5 ppt. This modeling suggests contraction of the MRGO channel to ICW dimensions will have significant effect on Lake Pontchartrain and the freshest wetland habitats and further upward in the estuary, but it also demonstrates that to reduce salinity in the outer Biloxi marshes requires fresh water introduction. The modeling therefore supports the validity of the proposal for as partial contraction (ICW dimensions) and freshwater introductions. It can reasonably be assumed that the volume of water necessary to affect habitats in the Biloxi marshes will be much less and more manageable with the proposed channel modification.

In addition, the natural levee ridge south of Bayou la Loutre would be re-built east of the MRGO to an elevation of approximately six feet as far east as the area of Long Lagoon. The objective is to maintain the integrity of the ridge as far east as possible and to re-establish ridge habitat along Bayou la Loutre.

A navigation channel of ICW dimensions at Bayou la Loutre will allow continued passage of more than 90% of all traffic, including commercial fishing vessels, recreation fishing vessels, offshore supply vessels, and commercial barge traffic. Access to the MRGO from Breton Sound by deeper draft vessels would be eliminated; however, all but the largest, deepest draft vessels would still have access to the MRGO through the IHNC locks. Commercial vessels able to pass through the existing IHNC lock dimensions (75 feet wide, 640 feet long and 31.5 feet deep) would still have access to the MRGO and docking facilities.

Engineering of the MRGO to ICW dimensions will have challenges but is achievable. A flood gate also of ICW dimensions located at Bayou la Loutre should be considered as an additional feature, but may not be needed for the environmental restoration. One engineering issue is potential water velocities through the constriction that would be created by re-building the channel at Bayou la Loutre. Tate et al. (2002) modeled the expected velocities through various channel reductions of the MRGO at Bayou la Loutre. In all cases, reduction of the channel increased velocities. Generally, the greater the constriction, the greater the increase in velocities with one significant exception. The smallest channel modeled was ICW dimensions and it was found to have less of an increase in velocities than larger channels. The velocity was greatest for a channel 125 feet x 20 feet. The reason is that the “jet effect” works to some smaller size then below which frictional forces outweigh the increase in head forces, i.e. the channel begins to be choked off. Velocities at the ICW dimensions are still a potential problem and would require additional engineering. Extension of the eastern rock dike into Breton Sound is just one option to consider reducing the head differential in the MRGO and therefore potential water velocities. Another factor is that without maintenance dredging south of Bayou la Loutre the channel will slowly shoal after storms and reduce flow. Constructed sills may have similar impeding effects on flow and velocities.

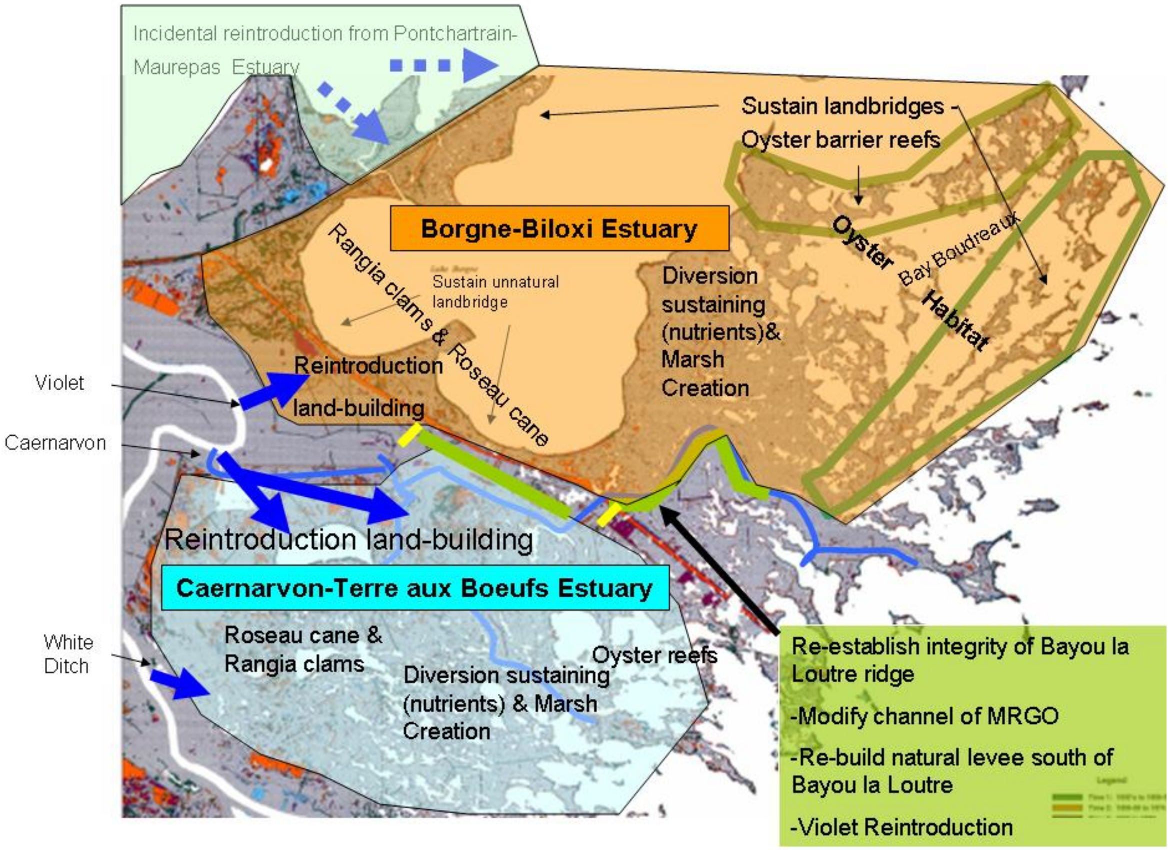

Figure 26: Hydrologic Restoration map for the Lower Sub-basin includes: Modification of the MRGO to re-establish estuarine integrity north and south of the ridge; river reintroductions to establish the target habitats as defined in the reconstructed habitat map **(Figure 15);** and maintain the landbridges.

The primary goal of a channel reduction of the MRGO at Bayou la Loutre is to reduce the daily tidal prism, which is so large that the MRGO is too great a hydrologic barrier to overcome to manage the estuary east of the MRGO, e.g. Lake Borgne and Biloxi marsh. Channel reduction will reduce the tidal prism significantly and potentially allow for effective management of the estuary east of the MRGO through river reintroductions. It would reduce the influence of Breton Sound on Lake Borgne and surrounding marsh.

Re-establishment of the Bayou la Loutre ridge as described above is intended to allow for a more sustainable management of the Lower Sub-basin. Establishment of the basins north and south of the Bayou la Loutre allows for existing or new river reintroductions to manage these basins and achieve the baseline habitats. These reintroductions are discussed in the following.

Borgne-Biloxi Estuary (Violet Siphon and related projects)

The current hydrology, salinity gradients, and habitats of Lake Borgne and the Biloxi marsh have been significantly altered from the baseline conditions. The constriction of the MRGO at Bayou la Loutre is one component of two essential needs to restore this area closer to the baseline conditions. The other component is a Mississippi River reintroduction directly into the lower-sub-basin north of the Bayou la Loutre ridge **(Figure 26)**.

The proposed site of such a reintroduction north of Bayou la Loutre is at or near the Violet siphon located in Violet. This siphon, designed for a discharge of 250 cfs, was constructed around 1980 and operated briefly after completion. The siphon was shut off after a few years of operation. Later it was operated for four years in the mid-1990's and was intended to freshen 17,980 acres of cypress swamp and marsh near the outfall into the Central Wetlands mapping unit. There were several problems with the project. The benefits were not attained because of the small diverted flow and the overwhelming influence of the MRGO. In addition, funds were not available to dredge the Violet canal which was being silted with sediment that interfered with navigation. The siphon was closed around 1998, and the CWPPRA project was de-authorized in 2000. In 2003, repairs were made to rehabilitate the Violet siphon outfall basin and canal (LA. DNR, 2003), and the siphon was reopened shortly after the repairs were made. The siphon is currently open and managed by the St. Bernard levee district. Discharge, when flowing, is estimated to be 100 to 200 cfs, and is far too small to benefit the marshes across the MRGO.

A new siphon located at Violet utilizing the Violet canal should be evaluated for potential reintroduction to achieve the baseline conditions including the salinity reduction of a constriction of the MRGO to ICW dimensions at Bayou la Loutre and considering that reintroductions in the Upper and Middle Sub-basins may incidentally freshen the Lower Sub-basin **(Figure 26).** The discharge from a location at or near Violet will probably need to be substantially larger than the existing siphon capacity (250 cfs), but substantially smaller than the suggested maximum flow through the Bonnet Carre' Spillway (30,000 cfs), which was designed to achieve similar benefits but through a longer, and more uncertain flow of water. The LA Department of Natural Resources contracted a study by Coastal Engineering and Environmental Consultants, Inc to evaluate a combination of a control structure (sector gates) and a freshwater diversion at Violet canal (LA DNR, 1996). This study evaluated reintroductions to freshen the Lake Borgne system, which ranged from 2,000 cfs to 10,000 cfs. Further modeling is required to determine the necessary discharge considering the total array of restoration features such as MRGO constriction, and reintroductions in the Upper and Middle Sub-basins.

Reestablishment of the baseline conditions is an important goal in itself to sustain and best manage this estuary. However a critical aspect of these habitats is to reestablish a highly productive oyster habitat and fishery in the Biloxi marsh. The cumulative and ongoing land loss of the outer Biloxi marsh may profoundly change the landforms and ultimately the hydrology of the region. Bay Boudreaux is centered in this outer marsh. The bay is currently defined by marsh and ridge remnants east and northwest of the bay. If large-scale breaching continues to develop through the perimeter of the bay, it is postulated, at some time, this bay system will perform hydrologically more as a tidal pass allowing increasingly larger volumes to pass through the bay from Chandeleur Sound to Mississippi Sound. It is recommended that the integrity of Bay Boudreaux and nearby bays is maintained by preserving the integrity of the adjacent landbridges **(Figure 26).** It is suggested here that maximizing the conditions for oysters as once existed may significantly enhance the sustainability of these critical landforms. The 1912 map of oyster reefs in St. Bernard indicates approximately 13,000 acres of reef existed in the outer marshes centered on Bay Boudreaux (The text description of map indicates 3,040 acres of natural reef. This discrepancy is presumed to be a typographical error). Establishment of seed ground, developing of hard grounds, enhancement of oyster reef with structure (e.g. Reefballs) are just some management options to consider. Development and protection of oyster reefs as barrier reefs should also be considered. Additional armoring, marsh creation or other restoration methods may be necessary to maintain these critical landbridges.

Within southwest portions of Lake Borgne where intermediate habitat is to be established, Rangia clams should be monitored for potential enhancement and improvement of intermediate habitat. Planting of Roseau cane (*Phragmites australis*) should be considered for shoreline stabilization in un-armored segments of Lake Borgne.

Additional recommended projects related to the MRGO:

In addition to the channel modification of the MRGO at Bayou la Loutre, previously discussed, other restoration features related to the MRGO are recommended.

1. The LCA environmental Restoration Plan (2004) proposes placement of rock for armoring of the unnatural landbridge between the MRGO and Lake Borgne. Considering the short-term implications of large scale breaches from Lake Borgne into the MRGO, additional project work for habitat restoration is warranted. Stabilization of the north bank of the MRGO and armoring of the southwest shore of Lake Borgne in critically narrow reaches is recommended.

2. It is also recommended that area of reduced ship speed be immediately extended to all of the inland section of the MRGO. Enforcement should be increased for existing or new restrictions.

3. Local marsh restoration should be evaluated by utilizing or degrading the spoil bank south of the Bayou la Loutre to create marsh where there is existing rock protection along the MRGO south bank.

4. Another feature related to the landbridge between the MRGO and Lake Borgne is to constrict the passes to limit the exchange of water through the passes and prevent the enlargement of these passes. This is an interim feature to limit detrimental impact to Lake Borgne until constriction of the MRGO channel at Bayou la Loutre.

5. An interim MRGO restoration feature previously described for the Middle Sub-basin is to construct a sill within Lake Pontchartrain to prevent a saltwater anoxic/hypoxic zone from developing in Lake Pontchartrain.

6. Another interim project, until the channel is rebuilt to smaller dimension, is to stop the practice of advanced maintenance dredging by the USACE. This practice effectively increases the navigable depth beyond the authorized depth (36 feet) and creates opportunity for vessels of draft greater than 36 feet to use the channel. Reported dockside draft underestimate the actual draft of ships underway. Vessel draft is greater including increased draft (squat) at the stern of vessels while underway (including squat, drafts are as great as 41 feet). The passage of these larger vessels accelerates and accentuates the destructive forces of bank erosion and channel slumping. Both contribute to wetland loss.

Since there is no regulatory enforcement of vessel size on the MRGO, eliminating the advance maintenance dredging, will force vessels to adhere to the authorized draft of the MRGO and reduce future environmental impacts.

7. Constriction of the MRGO, as recommended, will reduce or eliminate the need for maintenance dredging. Advanced maintenance dredging should be eliminated immediately (unless ship with drafts greater than the authorized depth of 36 feet are otherwise eliminated from the MRGO). Nevertheless, whenever dredging does continue in the MRGO, dredge material should be used opportunistically for restoration.

Caernarvon-Terre aux Boeufs Estuary (Caernarvon Freshwater Diversion and Related Projects)
The Caernarvon Freshwater Diversion has been in operation for just 12 years and although the full consequences of the diversion are still uncertain, priority should be given to optimizing the potential habitat benefits that may be derived from this existing restoration feature. At the same time, close monitoring and adaptive management must continue to better understand and manage this reintroduction. Three recommendations for this diversion follow.

1) Use outfall management to increase volume of reintroduced river water east of Bayou la Loutre and Bayou Terre aux Boeufs. This might include features such as improving the Olivia canal near Lake Lery and opening it to Bayou la Loutre. Reintroducing water into Bayou la Loutre will allow freshening of the adjacent dying cypress and oak forests. Water should primarily be managed to enhance productivity of marsh south of Bayou la Loutre including the areas east of Bayou Terre aux Boeufs (see **Figure 26**).
2) Caernarvon management plan should incorporate the baseline habitat goals of the CHMP, which may require some increase in flow. Past Caernarvon reintroduction has already significantly restored habitats closely to the baseline conditions.
3) Caernarvon freshwater diversion management plan should incorporate spring flows (April – June). This may be done first on a trial basis. The introduction of nutrients coinciding with spring growing season emulates the natural overbank process and may have additional benefits to rebuild marsh. In addition, sediment load may be greater in the spring and accelerate the land building of the reintroduction.

White Ditch Diversions

The White Ditch Resurrection and Outfall Management project approved for Phase I under CWPPRA PPL 14 is recommended for construction. This project should re-establish fresh habitat adjacent to the Mississippi River by reintroduction (proposed 500 cfs total flow) through two siphons located 10 – 15 miles down river from the Caernarvon siphon structure. Water reintroduced at Caernarvon typically bypasses the benefit area of the White Ditch Resurrection and Outfall Management Project.

Eloi –Athanasio System

One portion of the estuary, which would not directly benefit from the regional restoration plans of reintroductions and MRGO modification, is the area north of the MRGO and south of Bayou la Loutre. It is unlikely a scenario can be developed to introduce any significant fresh water to this area. Historic habitats are brackish and saline, which is not too different from the current habitats.

Freshening may not be justified. Landloss patterns as seen on USACE wetland loss maps (Britsch and Dunbar, 1996) and the recently released data for 1990 to 2001 (also USACE) indicate that the dominant wetland loss process is shoreline erosion particularly near the outer bays and lakes. The critical habitat threat appears to be accelerated loss rates due to collapse of outer peninsulas, which maintain the lake-bay integrity. Armoring of two shorelines would maintain separation from Eloi Bay and Lake Eloi, and from Lake Eloi and Lake Athanasio. Armoring options should be assessed for these shorelines to maintain the integrity of the lakes and prevent the shift of the sound into the interior lakes.

Barrier Islands

The ecologic functions of the Chandeleur – Breton barrier island chain need to be evaluated for recent changes due to numerous physical impacts of recent storms (hurricanes and tropical storms). The ecologic functions of the barrier islands should be maintained. The role of these islands to reduce wave energy and protect interior marsh, such as the Biloxi marsh, from wave erosion should be considered in the need and design of barrier island restoration.

Restoration Recommendations in delta region of the Lower Sub-basin

The long term and continued high rate of wetland loss in the region near the delta warrants caution. This region is inherently unstable due to high subsidence rates, poor soils and other factors. Restoration in this region must be exceptionally effective either because of the wetland extent restored or because it is low cost to restore the wetlands to warrant consideration.

Delta crevasses: One successful project of modest cost in the lower delta is the “Delta-wide Crevasse Project” constructed by the CWPPRA program. This project included construction of small breaches through the existing natural levee and allowing the river to naturally build crevasse splays along the passes, including Pass a Loutre and Main Pass. The capacity of these breaches to build wetlands tends to diminish over time. Additional crevasses and crevasse maintenance will continue to build wetlands in a relatively cost effective manner. Continuation or expansion of this crevassing in the lower delta is recommended.

Benney’s Bay Diversion is an approved CWPPRA project (MR-13) located just up river from Main Pass. The project would reintroduce 50,000 cfs river water into shallow bays adjacent to the Mississippi River. This project is recommended.

Bayou Lamoque Freshwater Diversion is a candidate project under the CWPPRA program in 2005. The project is still conceptual but contemplates utilizing two existing diversion structures for restoration. This might include removal of control gates so that the discharge would become an uncontrolled reintroduction. The combined discharge could be 12,000 cfs. Contingent on favorable evaluations by the Engineering and Environmental Workgroups of CWPPRA, the Bayou Lamoque project is recommended.

The **Mississippi River Sediment Trap** (MR-12) project is an approved CWPPRA project currently in Design (Phase I). The project is to dredge a large hole in the Mississippi River channel to capture bottom sediment. Subsequently material will be removed and used beneficially for marsh creation. In principal this project may be warranted. However it is essentially a marsh creation project and it is questionable if marsh creation by dedicated dredging is justified in areas of the lower delta where high loss rates and high subsidence are well known. It is suggested that the project be moved up river so that material can be pumped with the same cost but with greater benefit by creating marsh in more stable areas. Three areas to consider are described below.

Lake Lery – Preliminary estimates indicate severe wetland loss around Lake Lery due to Hurricane Katrina (see appendix E). As much as 19,000 acres of emergent marsh may have been converted to open water by this event. This is very large potential impact which hopefully is an over estimate due to residual high water in the marsh. At this time it would seem the area is in serious need of restoration. The integrity of Lake Lery may be lost. It is recommended that marsh creation by use of the sediment trap be utilized to restore marsh in the vicinity of Lake Lery to maintain the integrity of the lake and surrounding marsh.

Between Bertrandville and Phoenix. The wetlands east of this reach of the river are an area of accelerated landloss in the 1990's, but still less than rates of the lower delta. Wetlands created here would have the benefit of sustaining reintroductions such as Caernarvon or White Ditch siphons.

Bayou Lamoque - If the Bayou Lamoque structures are reopened for river reintroduction, this river reach should also be considered for the sediment trap due to the proximity of the river reintroduction to the marsh creation by the sediment trap project, i.e. the freshwater diversion should be utilized to sustain the newly created marsh.

Delta Management Study: Large scale alteration of the Mississippi River channel or passes has been occasionally studied either for the benefit of navigation or of environmental restoration. A Delta Management study is included in the LCA Environmental Restoration Plan (2004) as a long term study. One reported goal of such studies is to separate the navigation from restoration management so that both can function independently with less conflict. The generally proposed solution is a project euphemistically referred to as "hang-a-left". The "hang-a-left" concept is to build a deep-draft navigation channel somewhere above head of passes extending from the river directly to the Gulf of Mexico through Breton Sound. An alternative western channel (hang-a-right) is outside the Pontchartrain Basin and is also proposed. Either alternative would allow river traffic to bypass the lower delta. Massive locks on the new channel would create a slack water channel so that sediment is kept in the river (presumably available for restoration while keeping the sediment out of the new channel (presumably avoiding dredging maintenance). The issues of such proposals are far reaching and ultimately would be determined by costs.

A couple of key points should be made regarding "hang-a-left". Experience with the MRGO shows that open water channels will silt-up and need significant maintenance dredging. Canals and channels in general have been a major contributor to wetland loss and still hamper restoration efforts. Any new channel will still have conflict just by being located in the Louisiana coast. If a Delta Management Study is initiated, it is suggested that the following proposal be considered as an alternative, to possibly avoid some of these issues.

A "Pass Closure" plan should be considered for redesigning the lower delta for better management of both restoration and navigation. The pass-closure plan is to close two or three existing passes to leave one principal pass open for navigation. From the standpoint of the environment and possibly for navigation the preferred choice would be to close Southwest Pass and South Pass. Pass a Loutre would be dredged and maintained as the new navigation channel. This pass provides a shorter route for shipping. Flow in this new navigation channel could have the discharge optimized to minimize maintenance dredging. The environmental benefits could be far-reaching.

A pass closure project could make available 2/3 of the river flow for river reintroductions for restoration without reducing flow necessary to maintain the navigation channel. In addition, water and sediment which do reach the Gulf of Mexico have a much greater chance of being incorporated into the delta plain simply because of the discharge position relative to the delta and prevailing winds. The discharge plume through Pass a Loutre will tend to be pushed into the adjacent bays. These bays include two wildlife refuges which have seen 62% - 83% loss of wetlands. Dredge material from Pass a Loutre could be used beneficially to dramatically offset this loss within areas already under conservation. Under existing conditions Southwest Pass is in a very poor position to entrain sediment into the delta. The discharge plume from Southwest Pass is generally pushed by winds and currents away from the delta and into the open gulf water. Southwest Pass could still be used by commercial and recreational vessels and could become a harbor and fishing reef. It would be a valuable asset even without deep draft navigation. It is recommended that if a Delta Management study proceeds, that pass-closure alternatives are evaluated considering navigation and environmental restoration benefits.

Lower Sub-basin Conservation: Conservation should be expanded in the Lower Sub-basin. The Delta National Wildlife Refuge and the Pass a Loutre Wildlife Management Area have seen dramatic decline in wetlands and have diminished in ecologic value. Although some recovery will occur other conservation efforts are warranted.
Conservation priorities should be on the following:

1) Rare or endangered habitats such as, natural ridge habitat, oyster barrier reefs, cypress swamp, saline marsh, seagrass beds associated with barrier islands
2) Land bridges critical to maintaining the landforms of the estuary such as the landbridges identified in the Biloxi marsh
3) Benefit areas of major restoration projects, which need protection

In addition, the regulations for the Biloxi Wildlife management area should be reviewed considering the restoration goals of the CHMP and sustainability of this marsh. The Biloxi marsh remains one of the least impacted marsh areas of the entire Louisiana Coast and should be protected to assure it will give maximum ecologic benefit in the future.

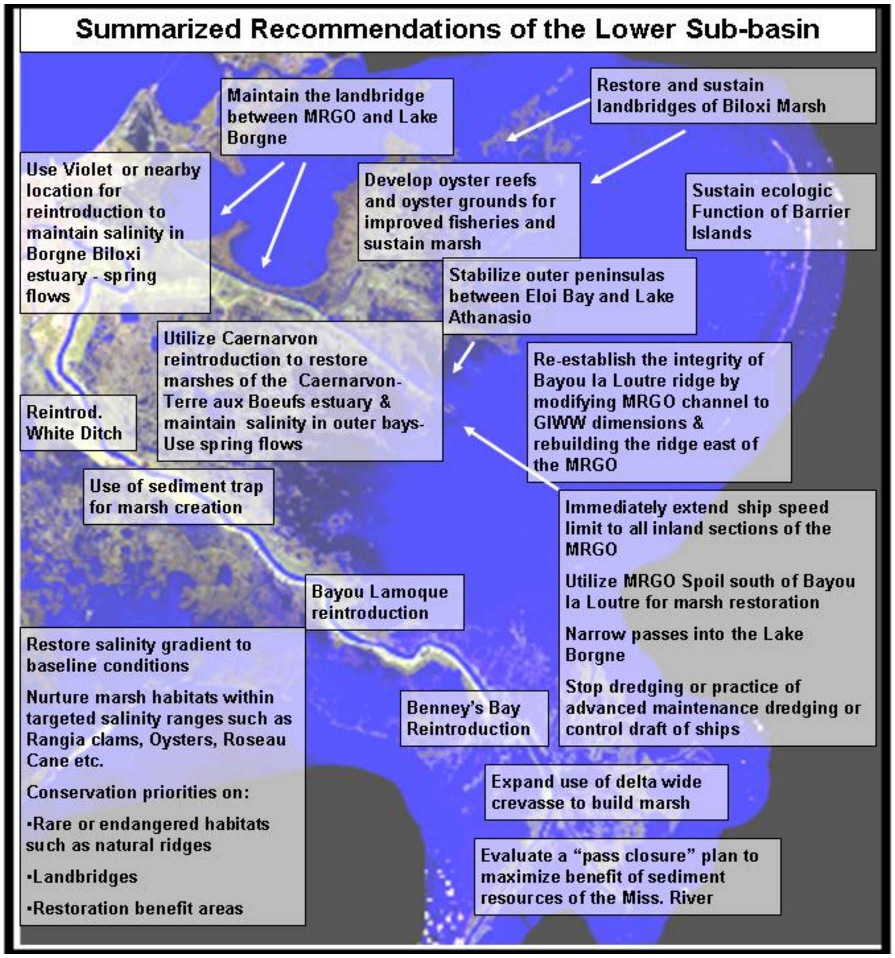

Figure 27: Map of General restoration recommendation in the Lower Sub-basin (St. Bernard and Plaquemines Parishes). See text for detailed and complete recommendations.

RESEARCH AND DATA NEEDS FOR THE PONTCHARTRAIN BASIN

(Note: The list reflects apparent deficiencies in data and ongoing research addressing the Pontchartrain Basin. It is not meant to include all the data and research which may be ongoing and which may be just as significant as those listed.)

1. **Annual Dead Zone Mapping-** The annual or seasonal cycles of the development and impact of saltwater stratification in Lake Pontchartrain need to be documented and reported to local fishermen and the scientific community. This research should include: direct mapping of low DO and high salinity water within the Lake's water column, obtaining current field data on the distribution and duration of episodic anoxia and hypoxia, and determining the effect on the benthic community by anoxia or hypoxia.
2. **Economics of Coastal Wetland Forests –** The ecologic value and cultural significance of bald cypress-tupelo (*Taxodium distichum – Nyssa aquatica*) forests may be better understood than the economic issues. The value of bald cypress forests to reduce storm surge impacts or reduce subsidence is unknown. The potential economic value of ecotourism, and sustainable hunting and fishing should also be examined. Included in this is the economic value of summer homes and camps already common and expanding on the fringe of many swamps. Dramatic increases in property values are being realized by competitive forces to have occasional home sites near "natural swamp habitat". What is the total impact of conversion of a coastal wetland forest to marsh? The cost of truly sustainable silviculture practices or BMP's should be assessed.
3. **Fish Assemblage Research –** Further research is needed to determine shifts in fish assemblage and identification of related stressors affecting in Lake Pontchartrain. Atlantic croaker ***(****Micropogonias undulatus****)*** has been identified as an indigenous species probably impaired since 1954. The cause for the loss in Atlantic croaker or fish assemblage shifts is unknown.
4. **Bathymetry of Lakes and Passes–**Lake Pontchartrain bathymetry was generally acquired from 1860 to 1890 using obsolete equipment and standards. Bathymetry has changed due to enlargement of lakes and passes, relative sea-level rise and numerous other influences. New bathymetry needs to be acquired for the lakes and surrounding estuary including the bays, passes and sounds to understand estuarine hydrology and to provide accurate models of future storm surges. Accurate bathymetry integrated with LIDAR could greatly improve our physical landscape model for designing projects and improve the understanding of hydrologic and ecologic conditions throughout the Pontchartrain Basin.
5. **Barrier Island Ecology -** Breton and Chandeleur Sound estuarine ecology is not well understood or documented. The relationships of bivalves, seagrasses and water clarity may be critical to the ecology and should be investigated.
6. **Rangia clams in St. Bernard and Plaquemines Parishes–** Rangia clams *(Rangia cuneata)* are the dominant species and effective indictor species in Lake Pontchartrain. Rangia clams or other bivalves are understudied in St. Bernard and Plaquemines Parishes. The extent, habitat range and predation of bivalves and their effect on water quality in the Lower Sub-basin portion of the Pontchartrain Basin may play important role in the estuarine ecology and needs additional study.
7. **Natural Oyster Reefs -** Ecology and structure of natural, historic oyster (*Crassostrea virginica*) reefs in St. Bernard Parish should be studied for their physical and biological roles in the marsh, such as in the historic reefs in the Biloxi marsh. Also to be investigated

is the potential use of oyster reefs for restoration and preservation of the coastal marshes, such as barrier reefs.

8. **MRGO Habitat-** The ecologic condition and water quality of the Mississippi River Gulf Outlet (MRGO) is virtually unknown and yet the channel influences a vast area of lakes and marsh in the Pontchartrain Basin. Basic biological and water quality characterization should be undertaken to assess MRGO habitat value and its impact on the surrounding estuary including commercial species such as shrimp, crab and oyster.
9. **Accelerated Wetland Loss –** The 1990 to 2001 average annual rate of wetland loss is 4.3 sq. miles/year in St. Bernard and Plaquemines Parish, which is significantly higher than the prior periods investigated (1974 to 1983 and 1983 to 1990). The processes or causes of accelerated wetland loss in the Pontchartrain Basin need to be identified as quickly as possible.
10. **Non-commercial species in St. Bernard and Plaquemines Parishes-** Study of the ecology and interaction of non-commercial and non-game species, such as birds and fish, in St. Bernard and Plaquemines Parishes should be undertaken.
11. **Blue crab *(Callinectes sapidus)* in Lake Pontchartrain–** The impact of anoxia or hypoxia on blue crab ecology and fishery in Lake Pontchartrain has not been examined although it is likely be occurring annually. Study should include the impact on trophic dynamics and on crab harvest.
12. **West Indian Manatee (*Trichechus manatus)* -** Migratory patterns and activity of manatee (*Acipenser oxyrinchus desotoi)* into the Pontchartrain Basin have been poorly studied for these endangered species. In July of 2005, 200 to 300 manatees were observed within Lake Pontchartrain indicating much greater significance the Pontchartrain basin habitats to this species and its potential recovery (Pers. Comm., Dr. Steve Miller with Audubon's Aquarium of the Americas; see also, http://www.aoml.noaa.gov/general/lib/pasca.html). The dependence of manatee on SAV occurrence and the impact of manatee on SAV should be investigated as well as any other critical habitat interactions.
13. **Rio Grande Cichlid (*Cichlasoma cyanoguttatum)* –** The potential ecologic threat to the Pontchartrain Basin by the Rio Grand Cichlid should be investigated since it has been identified in local drainage canals and one specimen at Irish Bayou.
14. **Striped Bass *(Morone saxatilis)* and Gulf sturgeon (*Acipenser oxyrinchus)* –** The potential for expanding native striped bass and other anadromus species populations within the north shore streams and Lakes Pontchartrain and Maurepas should be examined due to their decline and importance for recreation or commercial fishing.
15. **Sea Turtles on Barrier Islands -** Impact to sea turtle nesting sites should be examined because of significant impacts by recent storm impacts to the Chandeleur Islands and other nesting sites. The islands have reduced areal extent and have a more fragmented geomorphology. The status of utilization by the islands by endangered or threatened species should be determined.
16. **Hydrologic Modeling –** This Comprehensive Habitat Management Plan includes proposals such as small freshwater reintroductions between New Orleans and Baton Rouge and a larger diversion at (or near) Violet, LA. Included in the restoration plan is a significant constriction of the MRGO at Bayou la Loutre. The combination of channel modification and reintroductions are intended to reestablish historic habitats as far distant as the Biloxi marsh and possibly Mississippi Sound. Modeling is needed to test the hydrologic feasibility of salinity control and management by the freshwater diversions and

hydrologic restoration of Bayou la Loutre at the MRGO breach. Modeling should include the entire coastal zone of the Pontchartrain Basin and Mississippi Sound.

17. **Poorly Planned Growth -** While we generally know that poorly planned growth negatively affects the Pontchartrain Basin's water quality and habitats, there is a need to quantify these impacts. Examples include: how does the percent of impervious cover (sidewalks, roads, roofs, etc.) from new development impact water quality due to increased runoff loads?; how much riparian habitat is being impacted by development?; what kinds of wetlands are being developed, are they in the coastal zone? This research will provide decision-makers with the information to back up the need for Smart Growth and Sustainable Development policies and regulations.
18. **Biotic hotspots.** Certain terrestrial and wetland habitats are known to be hotspots of biological activity. These include wet flatwood savannas with large numbers of rare plants, floodplain forests that provide migratory birds with resting areas, bird rookeries, fish and turtle nesting areas, wildlife corridors, etc. These habitats need to be identified and mapped in a GIS framework. The importance of such hotspots needs to be communicated through public education. For each type of hotspot, we need a review of existing tools for protection, with updating of the tools and management techniques as needed.
19. **Copper contamination in Lake Pontchartrain-** Identification of the source of reported copper in Lake Pontchartrain and nearby waterways leading to water body "not supporting" classification for fish and wildlife (See LA DEQ water body impairment data 2000 and 2002).
20. **Sand and Gravel Mine Impact -** Hydrologic, ecologic, water quality and geomorphic studies need to be conducted to understand the long-term alterations to streams and rivers in the Upland Sub-basin due to sand and gravel mining operations.
21. **Subsidence and Relative Sea-level Rise –** Precise measurement of actual land subsidence and the net rate of relative sea-level rise is needed to accurately forecast future conditions with or without restoration projects. Understanding of the underlying processes is equally important and needs further research.
22. **Delta Management Study**- Alternatives to better manage deep-draft navigation on the Mississippi River and the river's natural sediment and water resources need to be evaluated. Reduction in sediment load and the continued deposition of sediment at the shelf edge warrant consideration of better management of the river's sediment resource. Alternatives should include at-least selective closure of passes on the Mississippi River.
23. **Habitat Inventory –** A ten-year reoccurring habitat inventory should be conducted for the entire Pontchartrain Basin. The classification for this inventory should be appropriate for the restoration goals and strategies of the CHMP. Sequential habitat inventories will should provide critical monitoring data and to serve as a benchmarks for restoration goals. Base scale for mapping is preferably 1:12,000 with a maximum scale of 1:24,000. The last comprehensive habitat (land-use) inventory was conducted circa 1988 to 1993 (Handley, et al., 2001).

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APPENDIX A

Comprehensive Habitat Management Plan
CHMP Draft Committee and Reviewers

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Dr. Bob Hastings	Former Director, Turtle Cove Environmental Research Station	Entire report
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Britt Paul	Natural Resource Conservation Service	Partial review
Rick Hartman	National Marine Fisheries Service	Entire report
Dr. Jimmy Johnston	U.S. Geological Survey	Partial review
Dr. Latimore Smith	The Nature Conservancy	Partial review
Dr. Fred Kopfler	EPA GOM Program	Entire report
Dr. Bill Good	LA Geol Survey	Entire report
Dr. Martin O’Connell	University of New Orleans	Partial review
Nelwyn McGinnis	The Nature Conservancy	Partial review
Dr. Mark Ford	Coalition to Restore Coastal Louisiana	Entire report

APPENDIX B

Synopsis of Comprehensive Management Plan Development for LPBF
(EPA Grant # X-006710-01-4)
"A distillation process"
Phase I
Public meetings in upper and middle basin meeting 1991 completed 1992 > # 1 Priority on "Institutional problems"
Reference Summary Report of the October 1991 Public Meetings: Citizen Concerns about the Pontchartrain Basin, Lake Pontchartrain Basin Foundation, EPA Grant # 006710-01-4

Phase II
Sub-Committees (agency reps) for the Five categories of citizen concerns developed responses 1993
LPBF Programs
1) Education/Public Outreach > Education/Public Outreach
2) Institutional >
Addressed as needed
3) Uses of the basin
Items 4 & 5 items had additional work in Phase III
4) Pollution > Water Quality
5) Well being of Renewable resources > Essential habitat > focus on estuary
Reference: Subcommittee Final reports addressing Citizen's Concerns prepared by the UNO College of Urban Affairs August 1992, EPA Grant # X006710-010
Phase III
Drafted by specialists completed 1995 – 3 components
(edited By Dr. Steve Gorin)
1) Stormwater - Dr. Don Barbe'
2) Sewage - Dr. Al Knecht
3) Salt water Intrusion and Wetland Loss

Reference: Comprehensive Management Plan Phase III, 1995, Lake Pontchartrain Basin Foundation, EPA Grant # X-006710-01-4

APPENDIX C
CHMP Timetable
CHMP Draft Committee meetings

2004

January 28, 2004	July 30, 2004
March 5, 2004	August 13, 2004
March 26, 2004	August 27, 2004
April 30, 2004	October 1, 2004
June 25, 2004	October 29, 2004
July 16, 2004	November 19, 2004

2005

February 11, 2005	April 1, 2005
February 25, 2005	April 8, 2005
March 18, 2005	April 15, 2005
March 24, 2005	April 29, 2005

3rd Party Academic Review

June -August, 2005

Public Meetings

Public Meetings were being scheduled for August and September 2005 when Hurricane Katrina struck Louisiana on August 29, 2005. Due to the highly scattered population the CHMP was posted on the LPBF website initially. Public meetings will be held when feasible.
The draft reported was posted on SAVEOURLAKE.ORG in November 2005. Draft comments were received until December 31, 2005.

Post-Hurricane Katrina

In response to the impacts of Hurricanes Katrina and Rita, the CHMP draft committee was questioned about what changes should be made to the CHMP. The following changes were recommended:

1) Replace habitat baseline map to include middle sub-basin (This was requested by USACE just prior to Hurricane Katrina)
2) Add a more explicit restoration recommendation (beach nourishment) for Chandeleur Islands
3) Add an addendum regarding preliminary estimate of Hurricane Katrina impacts
4) Add discussion in Executive Summary and Introduction explaining linkage and need for both engineered hurricane protection and coastal restoration.
5) Recommend expanded marsh creation for north shore marsh due to Hurricane Katrina
6) Recommend marsh creation around Lake Lery area for sediment trap project due to Hurricane Katrina
7) Expand flood discussion in the MRGO section (LSU Hurricane Center Modeling)

APPENDIX D
RARE AND ENDANGERED SPECIES FOR THE EASTERN LONGLEAF PINE SAVANNAH IN THE PONTCHARTRAIN BASIN

Rare Plant Species of Eastern Longleaf Savannahs and Uplands in Louisiana

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Scientific Name[1]	Common Name	State Rank	Global Rank[2]	Federal Status	Wetland Code[3]	Distribution by Parish[4,5]	Natural Plant Communities[6,7]
Agalinis aphylla	coastal plain false-foxglove	S1	G3G4	---	FACW	StTa	E Longleaf Pine Flatwoods Savannah
Agalinis filicaulis	purple false-foxglove	S1	G3G4	---	FAC+	Alle Calc StTa Vern	E & W Longleaf Flatwoods Savannah
Agalinis linifolia	flax-leaf false-foxglove	S1	G3G4	---	FACW	StHe StTa Tang?	E Longleaf Flatwoods Savannah
Agrimonia incisa	incised grooveburr	S1	G3	---	---	Wash	E Upland Longleaf Pine Forest
Amianthium muscitoxicum	fly poison	SH	G4G5	---	FAC	Orle (locality in question) Wash	E upland Longleaf Pine Forest
Asclepias humistrata	pine-woods milkweed	S1	G4G5	---	---	StTa Wash	E Xeric Longleaf Pine Forest
Asclepias michauxii	Michaux's milkweed	S2	G4G5	---	FAC+	StTa Tang Wash	E Longleaf Pine Flatwoods Savannah
Botrychium jenmanii	Alabama grape-fern	S1	G3G4	---	NI	Wash	E Upland LL Pine, Mixed Hardwood-Loblolly
Calopogon multiflorus	many-flowered grass-pink	S1	G2G3	---	FACW	StTa	E Longleaf Pine Flatwoods Savannah
Calopogon pallidus	pale grass-pink	S2	G4G5	---	OBL	StTa Tang	E & W Longleaf Flatwoods Savannah
Carya pallida	sand hickory	S2	G5	---	---	Cadd StHe Tang Wash	E Upland Longleaf Pine, Mixed Hardwood-Lob
Chrysopsis gossypina ssp. hyssopifolia	golden aster	S1	G5T3T5	---	---	StTa Wash	E Xeric Longleaf Pine Forest
Cirsium lecontei	LeConte's thistle	S2	G2G3	---	FACW-	StTa	E Longleaf Flatwoods Savannah

Notes:

1). Species with an asterisk are new additions to list.

2). For some species, Global Ranks may have been changed since last update from NatureServe - Global and State Ranks are explained on p. 18.

3). Wetland codes are from 1996 COE National List of Plants that occur in wetlands, Southeast Region - see explanation of codes on p. 18.

4). Parish codes are first four letters of parish name with the following exceptions: EBat = East Baton Rouge, EFel = East Feliciana, JDav = Jefferson Davis, Ibev = Iberville WFel = West Feliciana, StMt = St. Martin, StMy = St. Mary

5). Parishes in parenthesis are known from herbarium specimens or literature sources and have not yet been verified by LNHP Staff.

6). Names of natural plant communities associated with each species are from *The Natural Plant Communities of Louisiana*, by Latimore Smith, TNC.

7). Habitats written in lowercase and/or with question marks indicate a degree of uncertainty as to community type.

Coreopsis nudata	Georgia tickseed	S2	G3?	---	FACW+	StTa	E Longleaf Flatwoods Savannah
Dalea pinnata	summer-farewell	S1	G5	---	---	Wash	E Xeric Longleaf Pine Forest
Dichanthelium strigosum	rough-hair witchgrass	S2?	G5	---	FAC	(Calc) Gran Rapi (Sabi) (StHe) (StTa) (Tang) Wash	E & W Hillside Seepage Bog; Upland Longleaf Pine Forest
Drosera tracyi	Tracy's sundew	SH	G5T3T4	---	OBL	StTa?	E Longleaf Pine Savannah
Gratiola ramosa	hedgehyssop	S1S2	G4G5	---	FACW	Beau (Calc) StTa	E & W Longleaf Pine Flatwoods Savannah.
Ilex myrtifolia	myrtle holly	S2	G5?	---	FACW	(Lafa?) StTa Tang	E Longleaf Pine Flatwoods, E Bayhead Swamp

Isoetes louisianensis	Louisiana quillwort	S1	G3	Endangered	OBL	StTa Wash	E Longleaf Pine Flatwoods-sandy blackwater streams
Lechea minor	pinweed	S1?	G5	---	---	(Calc?) (StBe?) (StTa?) (Wash)	Upland Longleaf Forest?
Lechea pulchella	pinweed	S1S2	G5	---	---	(Beau) (Calc) (StHe) (StTa) (Tang)	E & W Longleaf Pine Forest?
Lechea racemulosa	pinweed	S1	G5	---	---	(Wash)	dry longleaf woods?
Licania michauxii	gopher-apple	SH	G4G5	---	---	Wash	E Xeric Longleaf Pine Forest
Lilium catesbaei	southern red lily	S1	G4	---	FAC+	StTa Tang Wash	E Hillside Bog, E Longleaf Pine Flatwoods
Linum macrocarpum	big fruit flax	S1	G2?	---	FAC	StTa	E Longleaf Pine Savannah
Lophiola aurea	golden crest	S2S3	G4	---	OBL	StTa	E Longleaf Flatwoods Savannah
Lupinus villosus	lady lupine	S2	G5	---	---	StTa Wash	E Xeric Longleaf Pine Forest
Lycopodiella cernua	staghorn clubmoss	S2	G5	---	FACW	Natc Ouac StTa	W Hillside Bog, E wet pine flatwoods
Oenothera rhombipetala	evening primrose	S1?	G4G5	---	FACU-	(Boss) StHe Tang	E Upland Longleaf Pine Forest
Panicum tenerum	southeastern panic grass	S2S3	G4	---	FACW	Alle Natc StTa Vern	E & W Longleaf Flatwoods Savannah
Pinguicula lutea	yellow butterwort	S2	G4G5	---	FACW+	StTa Wash	E Longleaf Flatwoods Savannah
Platanthera blephariglottis var. conspicua	white-fringe orchid	S1	G4G5T3T4	---	OBL	StTa	E Longleaf Flatwoods Savannah
Platanthera integra	yellow fringeless orchid	S3	G3G4	---	OBL	Beau Natc StTa Vern	E LL Flatwoods Savannah, W Hillside Bog
Polygala boykinii	Boykin's milkwort	S1	G4	---	---	(Alle) Wash	E & W Longleaf Pine Forest
Polygala chapmanii	Chapman's milkwort	S1	G3G5	---	OBL	Calc StTa	E Longleaf Pine Savannah
Polygala crenata	scalloped milkwort	S2	G4?	---	FACW	Alle Beau Calc StTa Tang	E & W Longleaf Pine Flatwoods Savannah - wet
Polygala hookeri	Hooker's milkwort	S1	G3	---	FACW+	StTa	E Longleaf Flatwoods Savannah
Pteroglossaspis ecristata	wild coco	S2	G2	---	---	Alle Beau Gran JDav StTa Tang Vern Wash	E & W Upland Longleaf Pine Forest, Coastal Prairie
Quercus laevis	turkey oak	S1	G5	---	---	StTa Wash	E Xeric Longleaf Pine Forest
Quercus macrocarpa	burr oak	S1	G5	---	FAC	Boss Cadd	Small Stream Forest, Bottomland Hardwoods
Quercus oglethorpensis	Oglethorpe's oak	S1	G3	---	FAC+	Cald Cata	Calcareous Forest - moist
Rhynchospora chapmanii	Chapman beakrush	S2	G4	---	OBL	StTa Wash	E LL Flatwoods Savannah, E Hillside Bog?
Rhynchospora ciliaris	ciliate beakrush	S2	G4	---	OBL	StTa	E Longleaf Pine Flatwoods Savannah
Rhynchospora compressa	flat-fruit beakrush	S1S2	G4	---	OBL	Beau StTa Tang Wash	E & W LL Flatwoods Savannah, Hillside Bog?
Rhynchospora debilis	savannah beakrush	S1	G4?	---	---	Alle (Beau) (Clai) StTa (Tang) (Wash)	E Longleaf Pine Flatwoods Savannah
Rhynchospora divergens	beakrush	S1	G4	---	OBL	Calc StTa	E & W Longleaf Flatwoods Savannah
Ruellia noctiflora	night-flowering wild-petunia	S1	G2	---	FACW	StTa	E Longleaf Flatwoods Savannah
Saccharum brevibarbe	short-beard plumegrass	SH	G3G5	---	FACW	Calc StTa	E Longleaf Flatwoods Savannah, wet Coastal Prairie?
Salix caroliniana	coastal plain willow	S1	G5	---	OBL	(Calc) (Fran) (Iber) (StMy) StTa (Wash)	Wet pine flatwoods?
Salix humilis var. tristis	dwarf gray willow	S2	G5T4T5	---	FACU	StHe StTa Tang	E Upland LL Pine
Sarracenia psittacina	parrot pitcherplant	S3	G4	---	FACW+	StTa Tang Wash	E LL Flatwoods Savannah, E Hillside Bog
Sarracenia purpurea	pitcher plant	SH	G5	---	OBL	StTa	E Longleaf Flatwoods Savannah?
Saxifraga virginiensis	Virginia saxifrage	SH	G5	---	FAC-	Unio WFel	Hardwood Slope, Mixed Hardwood-Lob
Sericocarpus linifolius	narrowleaf aster	S2	G5	---	---	StTa Tang Wash	E Xeric Upland Longleaf
Tephrosia hispidula	hoary pea	S2?	G4G5	---	---	StTa (Tang)	E Longleaf Pine Flatwoods Savannah

Tofieldia racemosa	coastal false-asphodel	S2S3	G5	---	OBL	StTa Wash	E Hillside Bog, E LL Fltwd/Savannah
Tridens carolinianus	Carolina fluff grass	S2	G3	---	---	StHe Tang Wash	E Upland Longleaf Pine Forest
Triglochin striata	arrow-grass	S1	G5	---	OBL	Lafo Plaq Terr	Brackish to Saline Marsh
Triplasis americana	perennial sandgrass	S1	G5	---	---	Wash	E Xeric Longleaf Pine Forest
Xyris fimbriata	yellow-eyed grass	S2?	G5	---	OBL	Calc StTa (Wash)	E LL Flatwood/Sav., E seepage bog
Xyris louisianica	LA yellow-eyed grass	S2S3	G3	---	---	(Alle) (Beau) (Calc) (StTa) (Tang) (Vern) (Wash)	E & W Longleaf Pine Flatwoods Savannah - wet
Xyris serotina	yellow-eyed grass	SH	G3G4	---	OBL	StTa	E Longleaf Flatwoods Savannah
Xyris stricta	yellow-eyed grass	S1	G3G4	---	OBL	StTa	E Longleaf Flatwoods Savannah
Zigadenus densus	black snakeroot	S2	G5	---	FACW+	(StTa) Vern Wash	E & W Hillside Bog, E LL Flatwoods Savannah
Zigadenus leimanthoides	deathcamas	S1	G4Q	---	FACW	StTa Vern	E Longleaf Flatwood/Savannah
Zornia bracteata	viperina	S2	G5?	---	---	Cadd Natc Vern Tang Wash Winn	W Xeric Sandhill, E Xeric Longleaf Pine

---

EXPLANATION OF RANKING CATEGORIES EMPLOYED BY NATURAL HERITAGE PROGRAMS NATIONWIDE

Each element is assigned a single global rank as well as a state rank for each state in which it occurs. Global ranking is done under the guidance of the Science Department of NatureServe, Arlington, VA. State ranks are assigned by each state's Natural Heritage Program, thus a rank for a particular element may vary considerably from state to state.

GLOBAL ELEMENT RANKS

G1 = Critically imperiled globally because of extreme rarity (5 or fewer known extant populations) or because of some factor(s)) making it especially vulnerable to extinction

G2 = Imperiled globally because or rarity (5 to 20 known extant populations) or because of some factor(s) making it very vulnerable to extinction throughout its range.

G3 = Either very rare and local throughout its range or found locally (even abundantly at some of its locations) in a restricted range (e.g., a single physiographic region) or because of other factors making it vulnerable to extinction throughout its range (21-100 known extant populations)

G4 = Apparently secure globally, though it may be quite rare in parts of its range, especially at the periphery (100 - 1000 known extant populations).

G5 = Demonstrably secure globally, although it may be quite rare in parts of its range, especially at the periphery (1000+ known extant populations).

GH = Of historical occurrence throughout its range, i.e., formerly part of the established biota, with the possibility that it may be rediscovered (e.g., Bachman's warbler).

GU = Possibly in peril range-wide but status uncertain; need more information

G? = Rank Uncertain. Or, a range (G3G5) delineates the limits of uncertainty

GQ = Uncertain taxonomic status

GX = Believed to be extinct throughout its range (e.g., Passenger Pigeon) with virtually no likelihood that it will be rediscovered

T = Subspecies or variety rank (e.g., G5T4 applies to a subspecies with a global species rank of G5, but with a subspecies rank of G4

WETLAND CODES
UPL - Obligate Upland - almost always (>99%) in uplands.
FACU - Facultative Upland - usually occur in uplands (67-99%) but occasionally found in wetlands.
FAC - Facultative - similar likelihood (33-67 %) of occurring in both wetlands and nonwetlands.
FACW - Facultative Wetland - usually (>67-99%) in wetlands.
OBL - Obligate Wetland - almost always (>99%) in wetlands.
NI - no indicator.
Positive **(+)** and negative **(-)** signs indicate higher frequency or lower frequency in wetlands, respectively.
Species with a "---" ranking do not occur in wetlands anywhere in their range

Louisiana Natural Heritage Program
Louisiana Department of Wildlife & Fisheries
P.O. Box 98000
2000 Quail Drive
Baton Rouge, LA 70898-9000'

STATE ELEMENT RANKS
S1 = Critically imperiled in Louisiana because of extreme rarity (5 or fewer known extant

APPENDIX E
PRELIMINARY ESTIMATE OF HABTAT IMPACTS IN THE PONTCHARTRAIN BASIN DUE TO HURRICANES KATRINA AND RITA

List of Figures

List of Tables

Appendix E
Preliminary Assessment of Habitat Impacts in the Pontchartrain Basin due to Hurricanes Katrina and Rita in 2005

Completed February 2006

Introduction

This report was compiled five months after Hurricane Katrina (8/29/05) and four months after Hurricane Rita (9/24/05), and therefore should be considered a preliminary and incomplete assessment. It is included in the appendix of the final CHMP report to capture general findings identified at that time. Those who review the CHMP should consider the recent hurricane impacts to habitats because they do appear to be significant in the Pontchartrain Basin. It is anticipated that, by the fall of 2006, more detailed and better documented analyses of the habitat impacts will have been completed. The USGS, UNO, DEQ, LSU and others will be completing ongoing research. Much of this is will be presented at the fall 2006 Basics of the Basin Symposium.

The tracks of Hurricanes Katrina and Rita are shown on **Figure E1**. The eye of Hurricane Katrina passed directly over the Lower Sub-basin and a portion of the Middle Sub-basin as a category 3 hurricane. Its path was directly over the outer marsh adjacent to Breton Sound, over the intersection of the MRGO with Bayou la Loutre ridge, over eastern Lake Borgne, and over the Lower Pearl River (**Figure E2**). The storm produced hurricane force winds and very high-water storm surge throughout the Pontchartrain Basin estuary. The FEMA inundation map indicates that maximum surge on the north shore of Lake Pontchartrain from Hurricane Katrina was six feet

Figure E1: Swath of Hurricane Katrina's eye wall across the Lake Pontchartrain Basin on August 29, 2005. The leading edge of the hurricane had east winds forcing water to rise between the Mississippi River and the Mississippi Gulf Coast. The trailing edge of the hurricane had west winds which blew water to higher levels in eastern Lake Pontchartrain. Hurricane Rita came ashore September 24, 2005 as a Category 3 hurricane with maximum sustained winds of 120 mph.

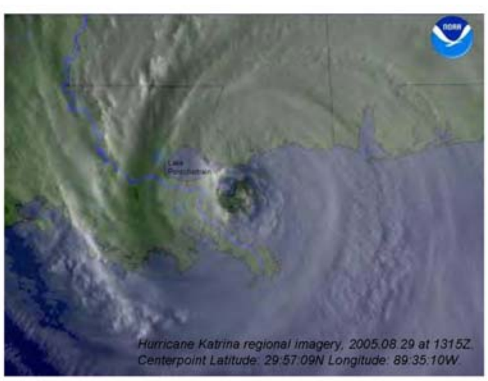


Figure E2: Hurricane Katrina's position over the Lake Pontchartrain Basin on August 29, 2005. The storm at landfall was a category 4 and a category 3 at the time this satellite image was taken with the center located over the Biloxi marsh. The eye is also located over the southeastern edge of Lake Borgne and the Mississippi River Gulf Outlet. Hurricane force winds extended as much as 120 miles from the eye of the storm.

in the western portion of the Lake and fifteen feet in the eastern most portions of Lake Pontchartrain (FEMA website, 1-06). The surge levels in Lake Pontchartrain peaked as the storm moved into Mississippi, and strong westerly winds forced water to rise on the eastern side of Lake Pontchartrain. These are record surge levels for Lake Pontchartrain. Surge levels of 16 feet to 20 feet were unofficially reported along the MRGO in St. Bernard Parish. Rainfall totals from August 24 to 30 were generally 7 to 10 inches (NCDC website, 1-06). Because of the storm surge, much of the flood water had higher salinity **(Figure E3).** Higher salinity conditions in Lake Pontchartrain increased after Hurricane Rita due to a lack of rainfall for two months following the hurricanes. In December, normal rainfall began to occur and salinity in Lake Pontchartrain began to decrease. On February 13, 2006 the highest salinity in Lake Pontchartrain was 7.1 ppt according to the LPBF water quality monitoring program.

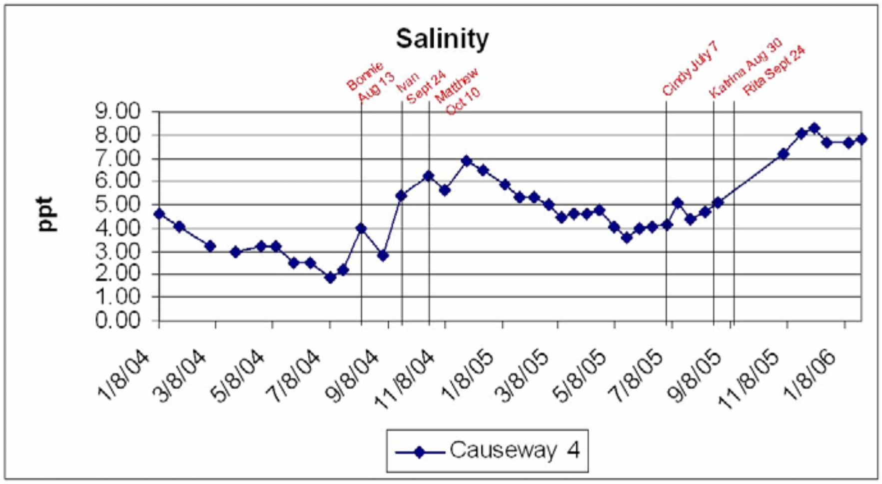


Figure E3: Salinity from mid-lake position in Lake Pontchartrain. Graph provided by Department of Biological Sciences of the University of New Orleans

Land Loss (Conversion of emergent marsh to open water)

The USGS completed an analysis of land change by comparing Landsat Thematic Mapper satellite imagery before and after Hurricane Katrina (Barras and others, 2006). Multiple scenes were used over a range of dates to optimize image characteristics such as cloud cover. The pre-Katrina imagery was acquired November 2004 and the post-Katrina imagery was acquired September and October 2005. Water levels were considered in selection to reduce the risk of mapping land as water due to simply transient, or residual perched water over the marsh. Nevertheless, this type of analysis has inherent uncertainty due to map resolution and difficulty of entirely addressing the potential for error due to high water conditions.

Table E1: Pontchartrain Basin land loss of selected areas (Barras and Johnston, 2006)

Middle Sub-basin	
North shore marshes	2.1 square miles (**Figure E5**)
LaBranche wetlands area	1.2 square miles (**Figure E6**).
Lower Pearl River	4.4 square miles
East Orleans Landbridge	1.2 square miles (**Figure E7**)
Lower Sub-basin	
"Breton Basin" (CWPPRA)	40.9 square miles
Chandeleur Islands	3.6 square miles
Lower Mississippi River delta *	~15.0 square miles
Total of Pontchartrain Basin (all area east of the Mississippi River or "Subprovince 1")	79.2 square miles

*USGS estimate included some area of loss outside of the Pontchartrain Basin. The estimate here is just for the area within the Pontchartrain Basin (east of South Pass)

The indicated land loss from Hurricanes Katrina and Rita is extraordinarily high and is estimated to be 118 square miles (75,520 acres) in southeast Louisiana. Unfortunately, the majority of this loss (67%) occurred within the

Pontchartrain Basin (**Table E1 and Figure E4**). Land loss was negligible in the Upper Sub-basin (Maurepas region). Total land loss in the Middle Sub-basin (Lake Pontchartrain region) was 9-14 square miles.

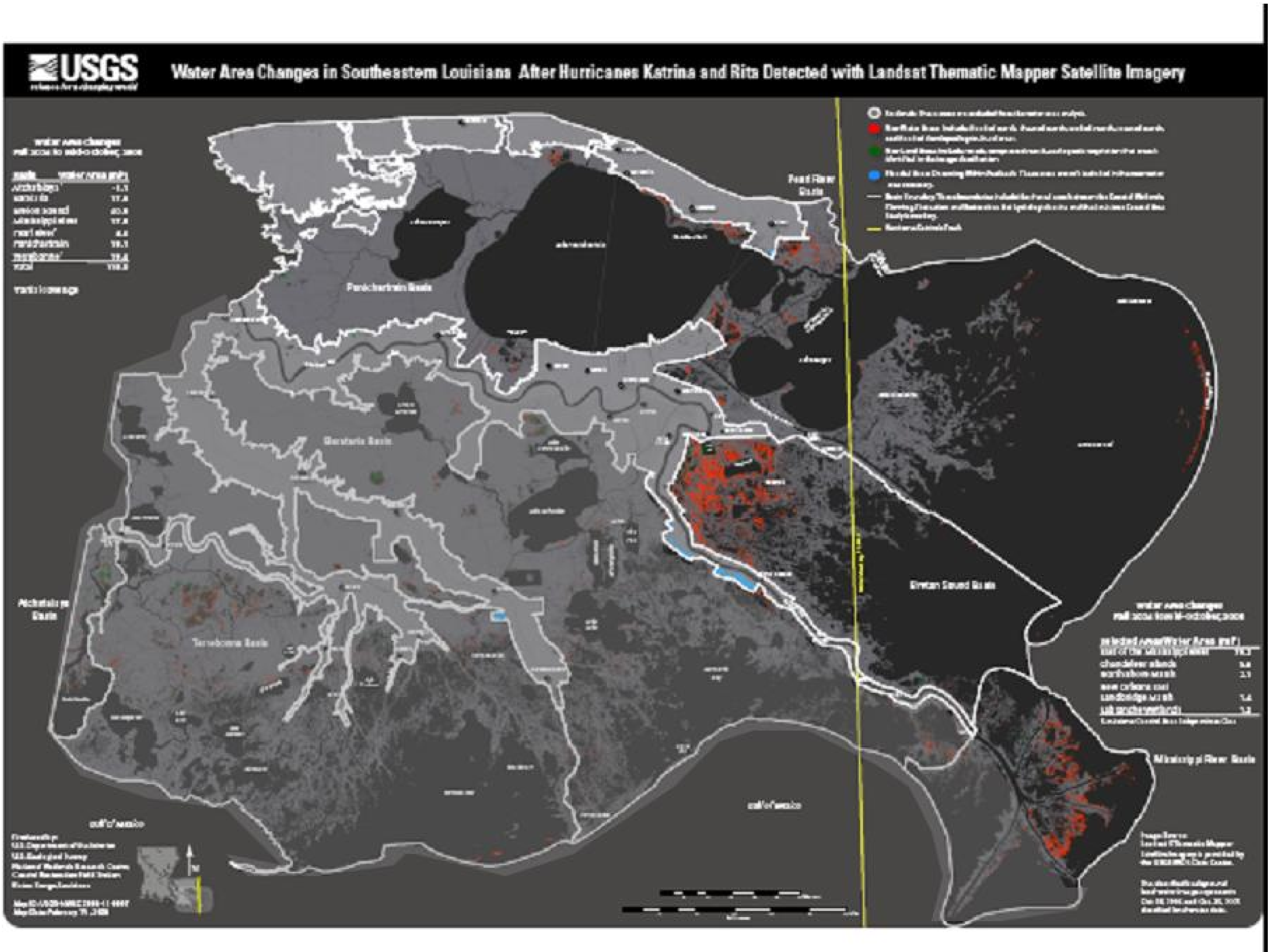


Figure E4: Post-Katrina and Rita landloss shown in red based on fall 2004 and fall 2005 Thematic Mapper satellite imagery. (Barras and Johnston, 2006)

Figures E5 and E6 contain imagery indicating the landloss in the Middle Sub-basin. This loss is presumably due to the physical forces of wave and currents across the marsh surface. Shear zones within marsh vegetation are indicated in numerous areas. **Figure E7** depicts the land loss on the East Orleans Land Bridge, which suffered significant interior loss north of Alligator Point.

The area of greatest apparent land loss from Hurricane Katrina is between Bayou Terre aux Boeufs and the Mississippi River (**Figure E8 and E9**). The USGS reports this area as the “Breton Basin” as defined under the CWPPRA program, but it is part of the Pontchartrain Basin as defined here. The landloss in the Breton Basin is estimated to be 40.9 square miles (26,176 acres). Over-flight observations on November 11, 2005 by John Lopez confirm that large areas around Lake Lery appear to have lost visible vegetation and are generally open water (**Figure E10, left**). A second over-flight in January 20, 2006, when water levels were lower, indicated that much of the marsh platform may be intact (**Figure E10, right**). The remaining marsh around Lake Lery appeared damaged also. Most open water areas had small broken pieces of marsh grass (“marsh balls”) scattered throughout.

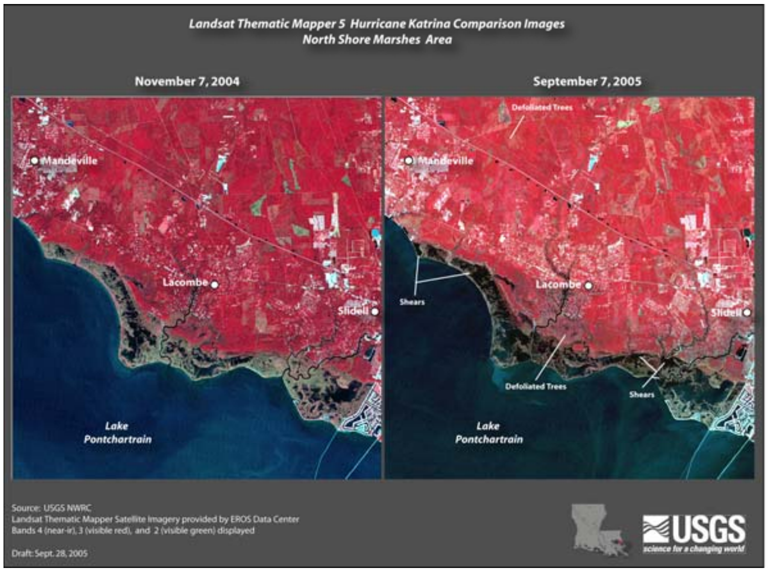


Figure E5: Pre and post-Hurricane satellite images indicate areas of loss of wetlands on the north shore of Lake Pontchartrain. Shoreline is 15 miles west of the track of the eye of Hurricane Katrina. Within the map area, 2.1 square miles of wetlands may have been lost due to this single storm event. Satellite images provided courtesy of the National Wetlands Research Center - U.S. Geological Survey

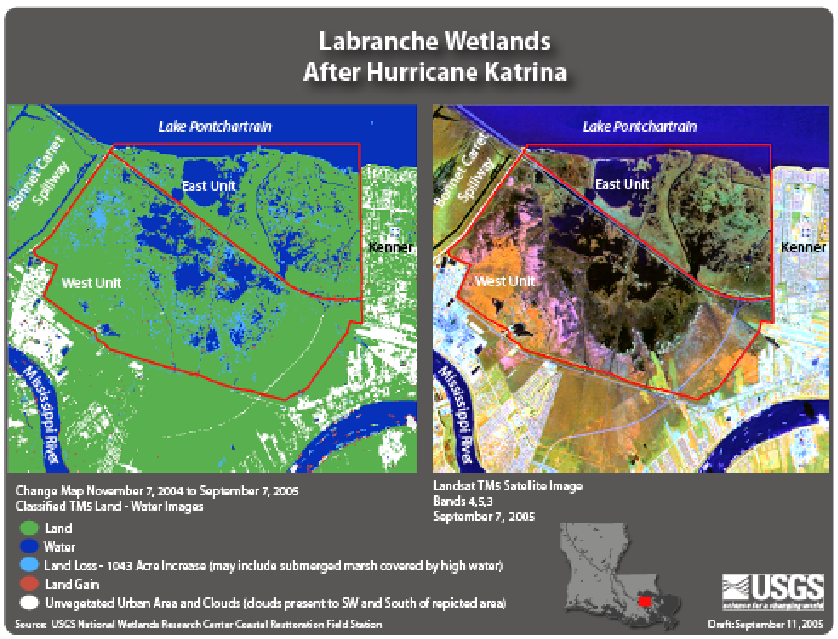


Figure E6: Maps indicate areas of loss of wetlands on the south shore of Lake Pontchartrain. Shoreline is 15 miles west of New Orleans and 40 miles west of the eye of Hurricane Katrina. Within the map area, 1.2 square miles of wetlands may have been lost due to this single storm event. Satellite images provided courtesy of the National Wetlands Research Center - U.S. Geological Survey

It is may be significant to note that the dominant type of marsh that was lost in the "Breton Basin" area was intermediate and a small amount of fresh **(Figure E9).** Also of interest is that the brackish and salt marshes more directly in the path of Hurricane Katrina had reports of little land lost (also little damage as observed during the November 20, 2005 over-flight). It appears that fresh and intermediate marsh here may be more vulnerable to severe storm conditions than brackish or salt marsh.

Figure E11 shows two land loss data sets. The left map is pre-Katrina monitoring data which indicates a mix of land loss and land growth during the 1990's. The right map is US Army Corps of Engineers data indicating that more distant to Caernarvon (south of Grand Lake), significant interior land loss seems to have occurred from 1990 to 2001 as noted in the CHMP main report. The land loss that has occurred due to Hurricanes Katrina and Rita seems to corroborate that the areas south of Lake Lery and around Grand Lake were in a pattern of land loss prior to Hurricane Katrina. Since there were storms in the 1990 to 2001 period, it is possible that this pattern of loss is largely due to hurricane damage. The causes of loss are under investigation.

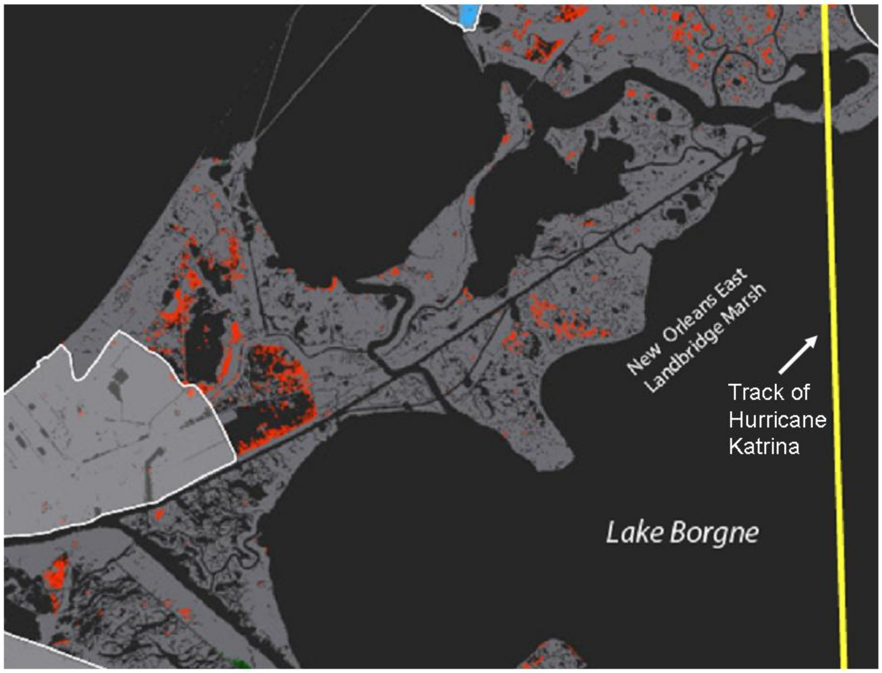


Figure E7: East Orleans Landbridge: Post-Katrina and Rita landloss shown in red, based on fall 2004 and fall 2005 Thematic mapper satellite imagery. (Barras and Johnston, 2006)

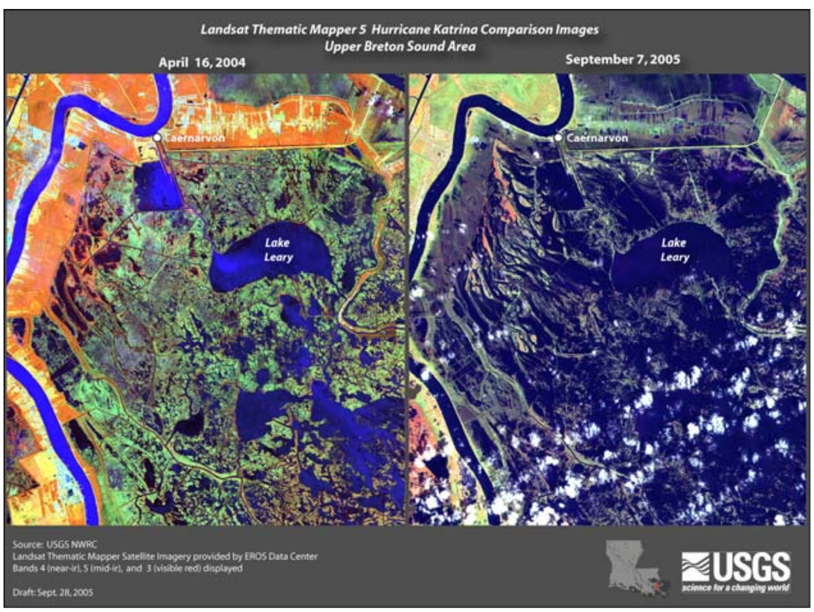
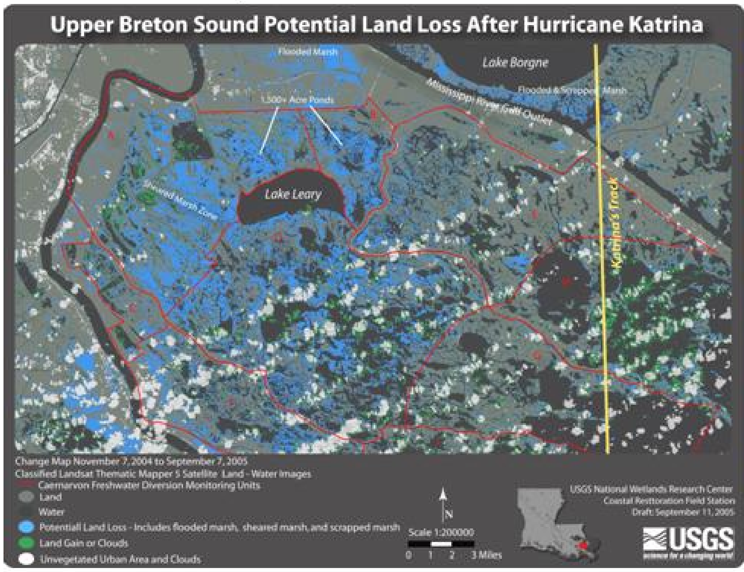


Figure E8: Pre- and post-Hurricane Katrina satellite images indicate areas of extensive loss of wetlands southeast of New Orleans. The eye wall passed just a few miles east of the map area. Within the map area, 40.9 square miles of wetlands may have been lost due to this single storm event. Satellite images provided courtesy of the National Wetlands Research Center - U.S. Geological Survey

Land loss Fall 2004 to Fall 2005 (primarily attributed to Hurricane Katrina)



2001 Habitat map, (Steyer, 2003)

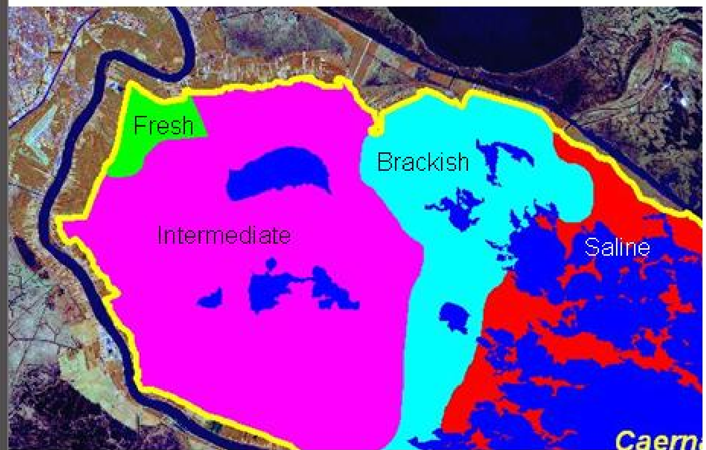
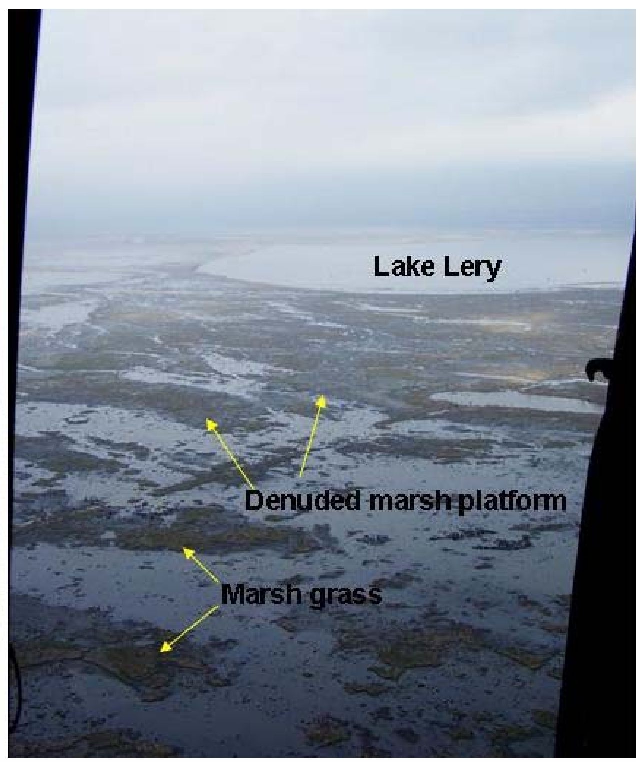


Figure E9: Left image is a map of wetland loss (Blue) and gain (green) comparing satellite imagery from the fall of 2004 to the fall of 2005 (post-Katrina and Rita). Landloss in this area (Breton Basin) is estimated to be 40.9 square miles. Right map is habitat distribution in 2001 (Steyer, 2003) showing the dominate habitat loss was intermediate.

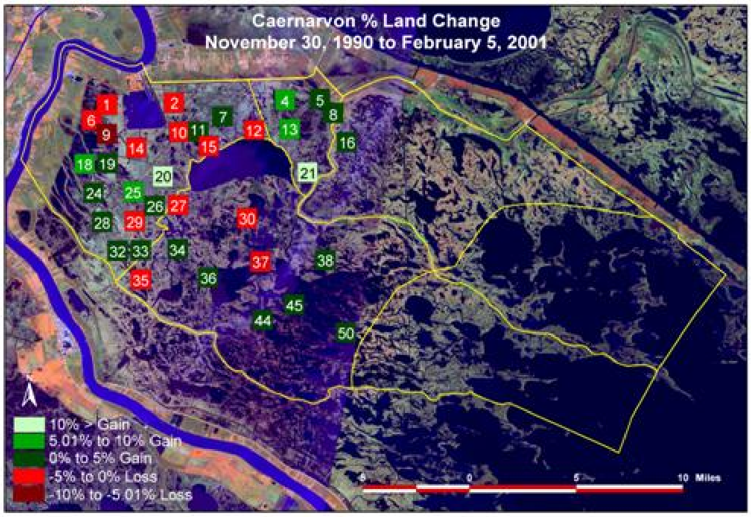
November 15, 2005, apparent higher water condition, view eastward across SW shore of Lake Lery



January 20, 2006, apparent low water condition after a cold front passage, view north across SW and west shore of Lake Lery

Figure E10: Two post-Katrina photographs of the Lake Lery shoreline. The photograph on the left has higher water than on the right. The photographs suggest that large areas of denuded vegetation near Lake Lery may still have a shallow marsh platform intact.

Landloss or gain of reference areas for Caernarvon FW Diversion monitoring (Steyer, 2003)



Landloss 1932 to 2001, note loss in red 1990 to 2001 period (USACE, 2004)

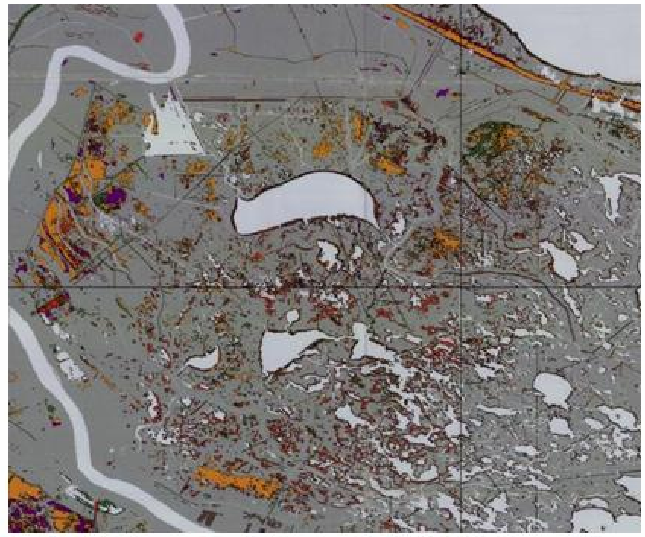
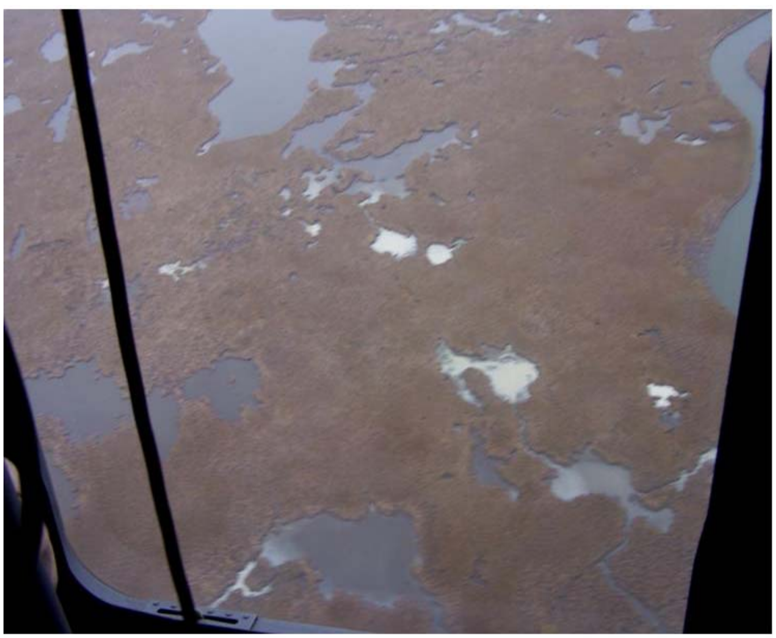


Figure E11: Left map is wetland loss and gain for reference areas prior to Hurricane Katrina (through 2002). Red indicates loss and green indicates gain. Map on right is land loss map for five periods from 1932 to 2001. The 1990 to 2001 period loss is shown in red. (Britsch and Dunbar, 2004). These maps show that, prior to Hurricane Katrina, land loss has been occurring since 1990.



Overflight picture taken January 20, 2006, of small ponds and distal drainage in the Biloxi marsh with white coloration to water which may be weathered crude oil and water mixture. Numerous spill occurred throughout the Louisiana and Texas coast as a result of Hurricanes Katrina and Rita

Figure E12: Photograph taken January 20, 2006 of the Biloxi marsh with small ponds of possibly contaminated water.

Barrier Islands Impact

The Chandeleur Islands have had significant recent hurricane impacts from several storms, including Hurricane Georges in 1998, Tropical Storms Isidore and Hanna in 2002, Tropical Storm Bill in 2003, Hurricane Ivan in 2004, Tropical Storm Cindy, Hurricane Dennis and Hurricane Katrina in 2005. Hurricane Katrina appears to have done the most severe damage. **Figure E13** indicates that a large portion of the islands were washed away by the hurricane. **Figure E14** indicates the type and extent of the damage. Much of the unvegetated sand portions of the islands are no longer emergent. The USGS preliminary estimate is that the Chandeleur Islands lost 3.6 miles of land area from fall 2004 to fall 2005 (Barras and Johnston, 2006).

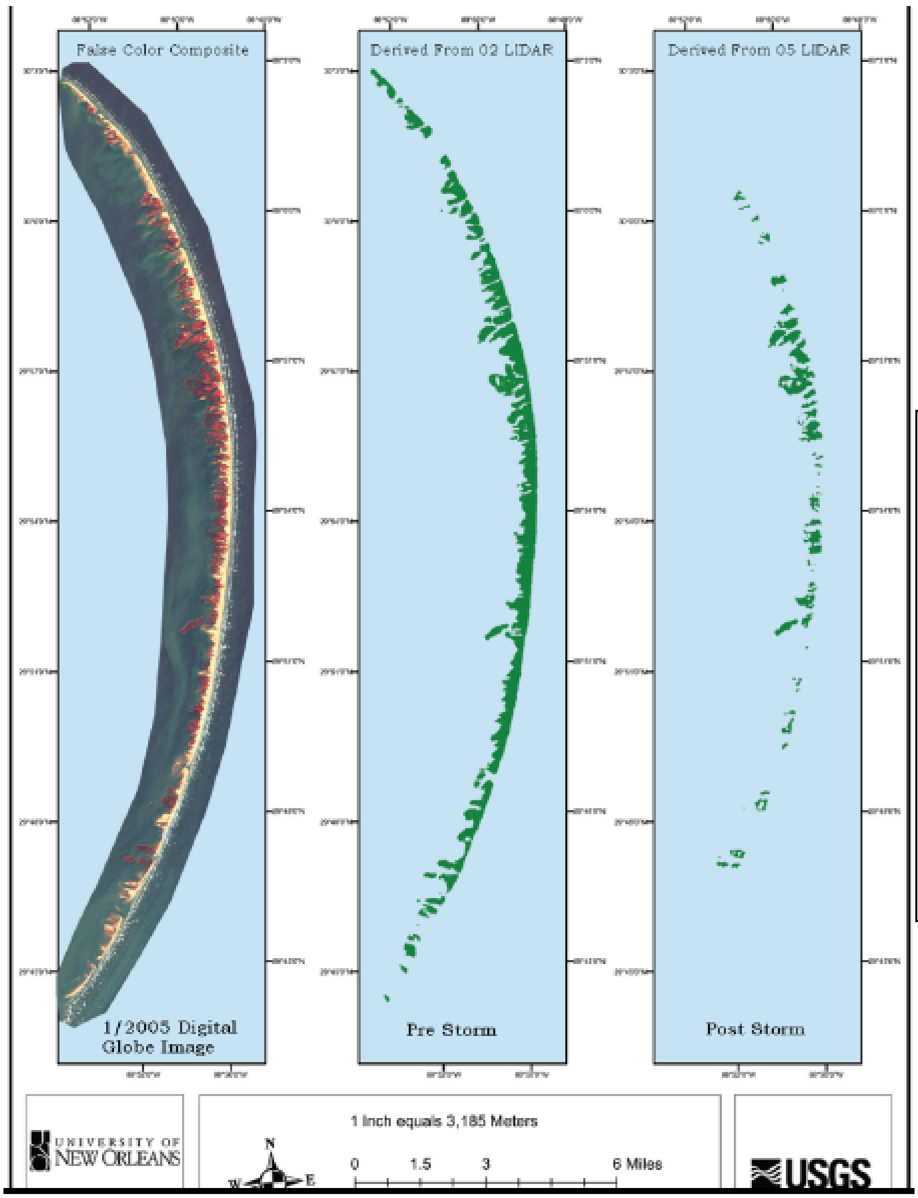


Figure E13: Left and center images are pre-Hurricane Katrina. The map on the right is LIDAR data taken after Hurricane Katrina. Preliminary estimates suggest ~60% of the Chandeleur Islands were lost following the hurricanes. Image provided by Pontchartrain Institute for Environmental Sciences.

The USGS estimates 3.6 square miles of the Chandeleur Islands were lost from the two hurricanes in 2005 (Barras and Johnston, 2006)

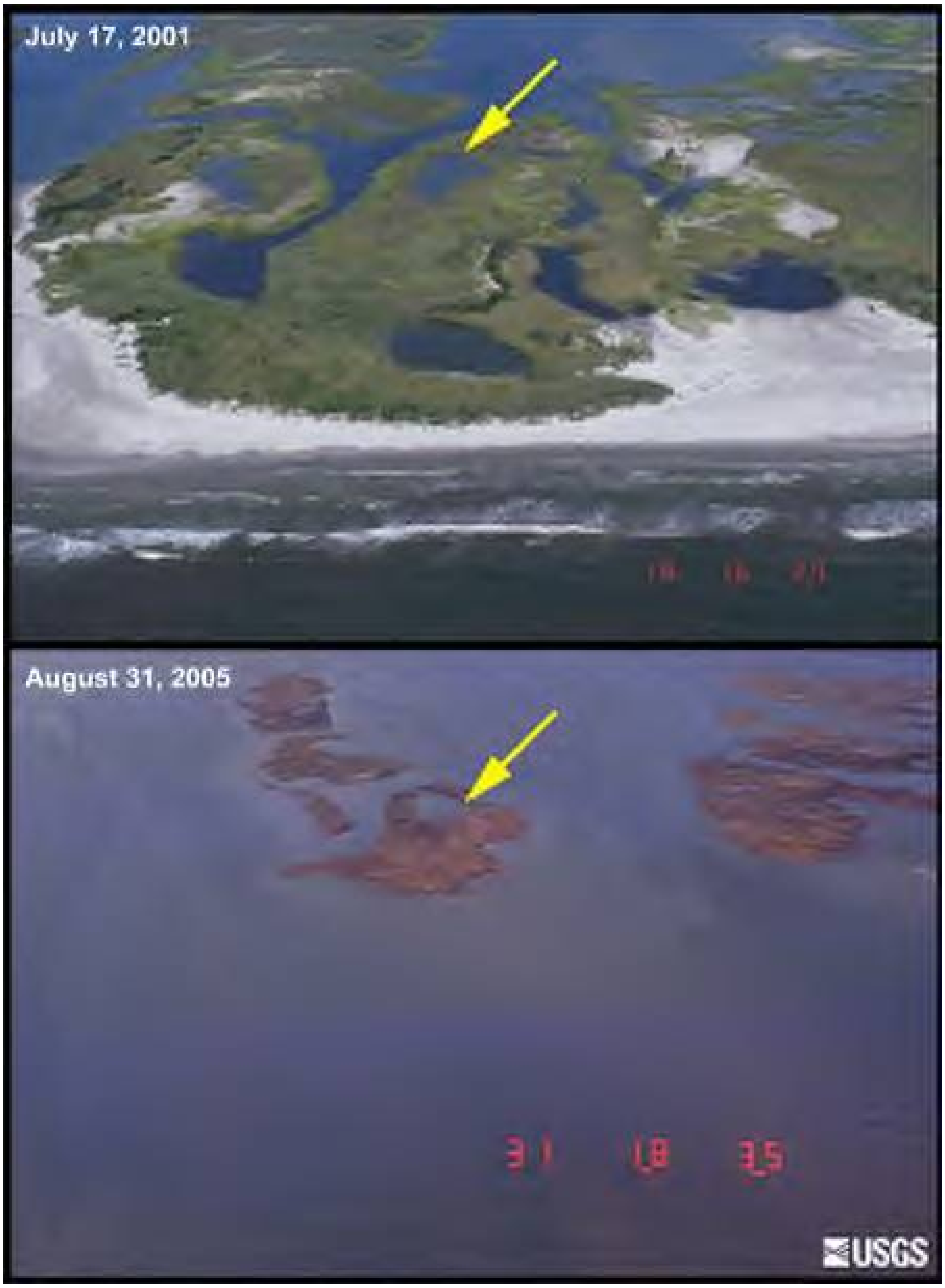


Figure E14: Oblique aerial photographs of a segment of the Chandeleur Islands in the easternmost area of the Pontchartrain Basin in southeastern Louisiana. (Arrows mark a common referenced location.) The photographs were taken before and after four hurricane passages occurring between 2001 and 2005. Note the extreme overwash of the barrier island in which most sand (white area) was washed away. Much of the vegetated platform (dark area) was also eroded. Imagery from the U.S. Geological Survey – St. Petersburg Florida.

Dr. Michael Poirrier, with the Department of Biological Sciences at University of New Orleans, has been conducting research on SAV, Rangia clams, water quality and other aspects of Lake Pontchartrain for over twenty years. In spite of Hurricane Katrina's impacts at UNO and to Dr. Poirrier's lab, critical data were collected in the immediate aftermath by Dr. Poirrier and his associates. The information below is summarized from information provided through these efforts.

Impact on SAV in Lake Pontchartrain

Common species of submersed aquatic vegetation in Lake Pontchartrain are *Ruppia maratima* L., *Najas guadalpensis*, and *Valisneria americana*. **Figure E15** is a graph of average SAV abundance from five north shore sites in Lake Pontchartrain collected from 1996 to 2005 (post-Katrina). The graph indicates a significant decrease in overall abundance of SAV post-Katrina. High water, fast currents and wave energy during Hurricane Katrina probably caused the loss of the SAV which are concentrated along the shallow shoreface of the lake's north shore. A contributing possible cause to the decline in SAV abundance in Lake Pontchartrain in 2005 was the apparent unusual mass migration of West Indian manatee (*Acipenser oxyrinchus desotoi)* into Lake Pontchartrain. As many as 200 manatees were reported to have been spotted from an aerial survey conducted for NMFS between late-July and August 2005 by Stephen Miller, D.V.M., (Senior Veterinarian, Audubon Nature Institute, Aquarium of the Americas). Although the manatee were generally seen more than a mile from shore and not directly within the SAV habitat, it is well documented that manatee consume large volumes of SAV. It is anticipated that the SAV in Lake Pontchartrain will recover to some uncertain extent.

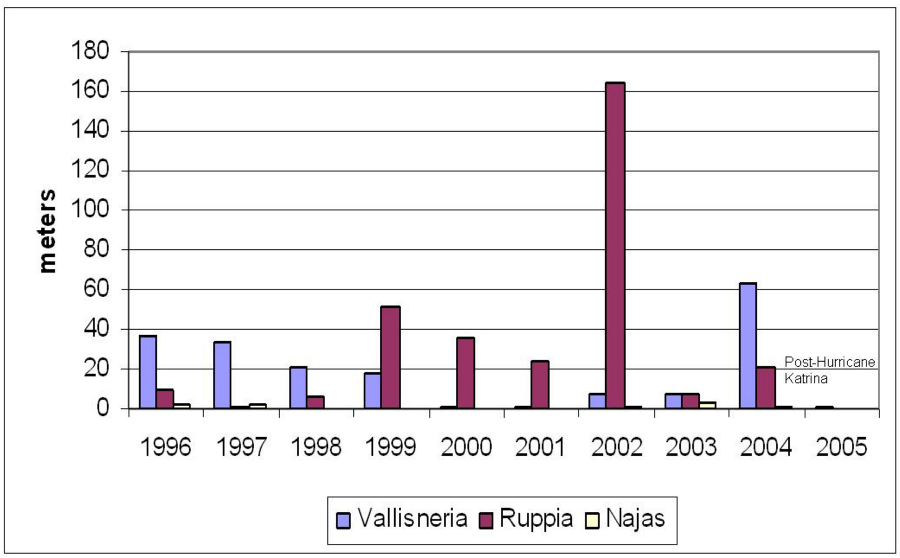


Figure E15: Bar graph of average SAV abundance of five north shore sites in Lake Pontchartrain. Data source: Department of Biological Sciences- University of New Orleans

Impact on Rangia Clams in Lake Pontchartrain

Post-Katrina data collection on Rangia clams (*Rangia cuneata*) in Lake Pontchartrain indicates a significant decline in large-clam abundance in the mid-lake portions of east-west transect surveys **(Figure E16).** Decline in large clam abundance due to saltwater stratification and resulting low DO is well documented in Lake Pontchartrain (see discussion in Middle Sub-basin). Due to limited access and damaged equipment, only limited documentation of a stratification event was collected immediately after the hurricanes. On September 30, 2005 (after passage of Hurricanes Katrina and Rita), saltwater stratification and lowered DO were observed along the north shore of Lake Pontchartrain. An attempt to further document this occurrence a week later found the stratification was not present. A cold front passage in the interim probably caused mixing and loss of stratification. The presence of stratification was probably due to rain from Hurricane Rita in the aftermath of elevated salt water being introduced by Hurricane Katrina. It is unknown if the stratification event and lowered DO caused the decline in large clam abundance.

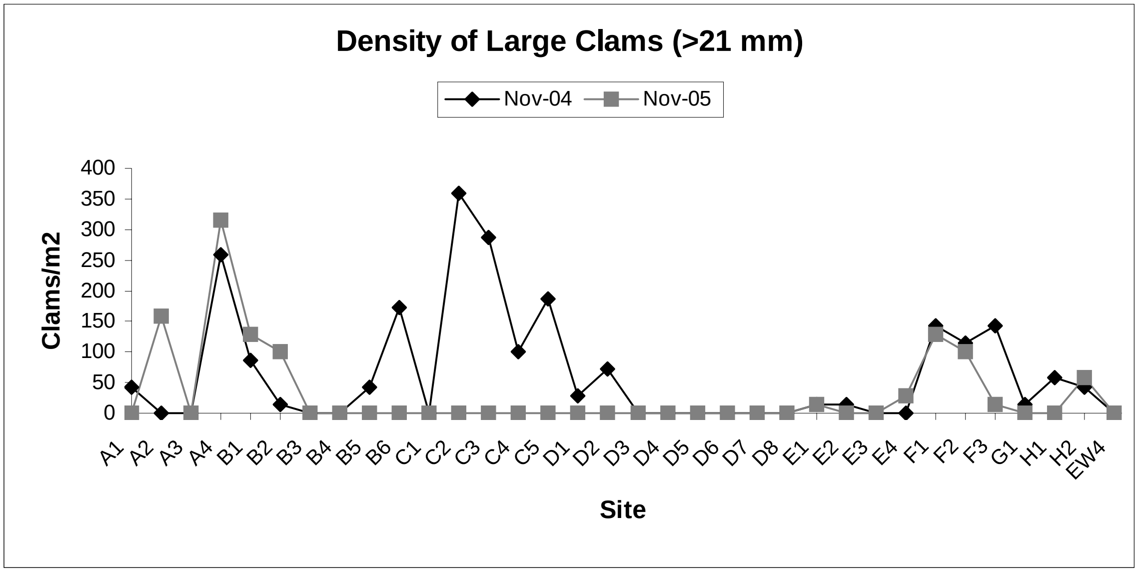


Figure E16: Graph of large Rangia clam density along an east-west transect across Lake Pontchartrain (east is on the right side). Stations B5 through D4 seem to have been impacted by Hurricane Katrina. Stations D4 through F1 are within the "dead zone" that occurs annually in Lake Pontchartrain due to saltwater intrusion through the Inner Harbor Navigation Canal (see discussion in Middle Sub-basin). Data source: Department of Biological Sciences- University of New Orleans

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APPENDIX F

Table of CHMP Recommendations

Appendix F: Table of CHMP Recommendations (see main report for details)

Sub-basin	CHMP Restortion Recommendations	Type project
	MULTIPLE SUB-BASINS	
Upland, Upper, Middle	Quantification of habitat impacts by poorly planned growth	Research
Upper, Middle, Lower	Bathymetric surveys of Pontchartrain Basin	Research
Entire Basin	Post-Katrina assessment of Pontchartrain Basin	Research
Upper, Middle, Lower	Migratory patterns and activity of West Indian Manatee in Pontchartrain Basin	Research
Entire Basin	Identification of "biotic hotpots"	Research
Upper, Middle, Lower	Measurement and analysis of subsidence to forecast future subsidence	Research
Entire Basin	10-year re-occurring habitat inventory for all Pontchartrain Basin	Research
Entire Basin	Accelerated and sustained programs to reduce invasive plants e.g. tallow trees	Habitat Restoration
Upland Sub-basin	**UPLAND - NORTH SHORE**	**Type project**
upland	Smart Growth planning: reduce impact of sprawl to habitats	Conservation
Upland	Expand Existing Longleaf pine forests >5000 acres @ each site	Conservation
Upland	2 10,000 -20,000 acre research forests Longleaf pine savannah habitat	Conservation
Upland	2 50,000 acre Longleaf pine federal forests conservation & Mgt	Conservation
Upland	Establish cons. area on the Amite R. for inflated heelsplitter mussel	Conservation
Upland	Education Program Longleaf pine habitats	Education & Outreach
Upland	Establish Prescribed Fire Council for burn management	Habitat Management
Upland	Develop BMP's for active mines on rivers and streams	Habitat Management
Upland	Develop additional regulations to protect freshwater mussels	Habitat Management
Upland	De-authorize the Pearl River Navigation Project	Habitat Management
Upland	Restrict sludge disposals in abandoned mine sites	Habitat Management
Upland	Expanded Red-cockaded WP, gopher tortoise & other R&E species	Habitat Restoration
Upland	Poole Bluff & Bogue Chitto R. sills removed, restore hydrology	Habitat Restoration - Hydrologic Restoration
Upland	Re-establish indigenous canebrake habitats	Habitat Restoration - Construct habitat
Upland	Assess other non-Longleaf pine habitats for rarity	Research
Upland	Assess active sand & gravel mine operations on rivers and streams	Research
Upland	Assess historical sand and gravel sites on rivers and streams	Research
Upland	Inventory freshwater mussels in rivers and streams	Research
Upland	Develop a plan to re-establish freshwater mussels	Research
Upland	Comprehensive Assessment of impact to north shore river systems by mining	Research
Upper Sub-basin	**LAKE MAUREPAS REGION**	**Type project**
Upper	Smart Growth planning: reduce impact of sprawl to habitats	conservation
Upper	Protect Alligator Snapping Turtle	Habitat Management

Upper	Conserve and protect the Wetland forests benefiting from restoration	Conservation
Upper	New or expanded conservation on Small Rivers and streams	Conservation
Upper	Increase Wetland Forest Conservation through acquisition	Conservation
Upper	Bayou Manchac (Mississippi R.) Reintroduction	Habitat Restoration - Hydrologic Restoration
Upper	Fountain Bayou (Mississippi R.) Reintroduction	Habitat Restoration - Hydrologic Restoration
Upper	Blind River Basin (Mississippi R.) Reintroduction and Restoration	Habitat Restoration - Hydrologic Restoration
Upper	Maurepas (Mississippi R.) Reintroduction	Habitat Restoration - Hydrologic Restoration
Upper	Amite R. Diversion Canal Gapping, hydrologic restoration	Habitat Restoration - Hydrologic Restoration
Upper	South Slough Hydrologic Restoration	Habitat Restoration - Hydrologic Restoration
Upper	Shoreline Protection - Lake Maurepas N & NE shores	Habitat Restoration - Shoreline Protection
Upper	Introduce Ivory Billed Woodpecker	Habitat Restoration - Target Species
Upper	Expanded beneficial use of treated sewage for restoration N shore	Habitat Restoration
Upper	Economics of Coastal Wetland Forests	Research
Upper	Moratorium of cypress logging of non-sustainable forests	Habitat Management
Middle Sub-basin	**LAKE PONTCHARTRAIN REGION**	**Type project**
Middle	Smart Growth planning: reduce impact of sprawl to habitats	conservation
Middle	Expand Big Branch NWR including lower Pearl River	Conservation
Middle	Regulate the Lake Pontchartrain sanctuary	Conservation
Middle	Conserve Brazalier Island on the E. Orleans landbridge	Conservation
Middle	Conserve Guste Island tract, NW shore of Lake Pontchartrain	Conservation
Middle	River Reintroduction for Frenier Wetlands via Bonnet Carre	Habitat Restoration - Hydrologic Restoration
Middle	River Reintroduction for BC wetlands via Bonnet Carre	Habitat Restoration - Hydrologic Restoration
Middle	River Reintroduction for Bayou Trepagnier Wetlands via Bonnet Carre	Habitat Restoration - Hydrologic Restoration
Middle	River Reintroduction for La Branche Wetlands	Habitat Restoration - Hydrologic Restoration
Middle	Restore littoral habitat Lake Pon shoreline in St. Tammany Parish	Habitat Restoration - Construct habitat
Middle	Bayou St. John Restoration	Habitat Restoration - Hydrologic Manageme
Middle	Expand Artificial reefs in Lake Pontchartrain	Habitat Restoration - Construct habitat
Middle	Hydrologic restoration of Hwy 90 impoundment	Habitat Restoration - Hydrologic Restoration
Middle	Lake Pontchartrain shoreline protection Irish Bayou to Chef Pass	Habitat Restoration - Shoreline Protection
Middle	Restore aquatic access in Bayou Suavage impoundments to LP	Habitat Restoration - Hydrologic Restoration
Middle	Goose Point-Point Platte marsh creation, Expand CWPPRA	Habitat Restoration - Construct habitat
Middle	Labranche Phase II	Habitat Restoration - Construct habitat
Middle	Lake Pontchartrain shoreline restoration- Orleans Parish	Habitat Restoration - Construct habitat
Middle	Lake Pontchartrain shoreline restoration- Jeff. Parish	Habitat Restoration - Construct habitat
Middle	Sill at IHNC to reduce extent of the dead zone in Lake Pontchartrain	Habitat Restoration - Hydrologic Restoration
Middle	East Orleans landbridge	Habitat Restoration - shoreline Protection
Middle	Monitor "dead zone" in Lake Pontchartrain	Research

Middle	Fish Assemblage Research in Lake Pontchartrain	Research
Middle	Impact of anoxia on Blue crab in Lake Pontchartrain	Research
Middle	Ecologic threat of the Rio Grande Cichlid	Research
Middle	Expand populations of indigenous species of striped bass and Gulf sturgeon	Research
Middle	Identification of sources of copper contamination in Lake Pontchartrain water	Research
Middle	Re-establishment of the endangered small-tooth sawfish in Lake Pontchartrain	Habitat Restoration - target species
Middle	Re-establishment of the endangered bald eagle along Lake Pontchartrain	Habitat Restoration - target species
Middle	Re-establishment of bison in Bayou Sauvage NWR	Habitat Restoration - target species
Lower Sub-basin	**ST. BERNARD & PLAQUEMINES Psh's**	**Type project**
Lower	Expand conservation in the Lower Sub-basin	Conservation
Lower	Reduce ship speed in MRGO	Habitat Management
Lower	Ban advance maintenance dredging on MRGO	Habitat Management
Lower	Stop dredging in MRGO	Habitat Management
Lower	Degrade MRGO spoil bank for marsh creation	Habitat Restoration - Hydrologic Restoration
Lower	White Ditch Mississippi R. Reintroduction	Habitat Restoration - Hydrologic Restoration
Lower	Eloi-Athanasio shoreline stabilization	Habitat Restoration - shoreline Protection
Lower	Benney's Bay Mississippi R. Reintroduction	Habitat Restoration - Hydrologic Restoration
Lower	Bayou Lamoque Mississippi R. Reintroduction	Habitat Restoration - Hydrologic Restoration
Lower	Mississippi R. Reintroduction Near Violet, La	Habitat Restoration - Hydrologic Restoration
Lower	MRGO constriction & Bayou la Loutre restoration	Habitat Restoration - Hydrologic Restoration
Lower	Biloxi Marsh landbridge north	Habitat Restoration - Shoreline protection
Lower	Biloxi Marsh landbridge south	Habitat Restoration - shoreline Protection
Lower	Increase Benefits of Caernarvon FW Diversion Structure	Habitat Restoration - Hydrologic Restoration
Lower	Chandeleur Island Restoration	Habitat Restoration - Construct habitat
Lower	Delta Crevasses on the lower delta	Habitat Restoration - Hydrologic Restoration
Lower	Delta Management Study	Research
Lower	Sediment Trap in Mississippi River (CHMP)	Habitat Restoration - Construct habitat
Lower	MRGO - Lake Borgne Landbridge armor	Habitat Restoration - Shoreline protection
Lower	Changing Ecology of the barrier Islands	Research
Lower	Rangia clam ecology in the Lower Sub-basin	Research
Lower	Ecology and Structure of natural oyster reefs	Research
Lower	Ecologic condition of the MRGO	Research
Lower	Causes of accelerated land loss	Research
Lower	Ecology and value of non-commercial species	Research
Lower	Impacts and recent changes to nesting of sea turtles on Barrier islands	Research
Lower	Hydrologic modeling of proposed CHMP restoration plan (BLRR & BBMR)	Research