for Louisiana, the hurricane took a more eastward path, sparing New Orleans and the surrounding area from the brunt of the storm. However, many questions were raised about what would happen if a hurricane did strike near New Orleans.

According to scientists at Louisiana State University, such a hurricane could present a grim scenario (figure 2.3). Computer modeling of a slow category 3 hurricane that makes landfall just west of Houma and travels straight north shows that storm surge could flood almost all areas south of I-10 and most areas between I-10 and I-12. Most of southeast Louisiana east of Houma and south of I-12 would be entirely under water, with some areas under as much as 18 ft of water. As a result of these models and past experiences from Hurricane Andrew, the Red Cross decided that it could not safely operate any hurricane evacuation shelters south of I-10 or I-12 during a category 4 or category 5 hurricane. A large portion of southeast Louisiana would have to be evacuated.

As Louisiana's wetlands rapidly disappear, the effects of storms and hurricanes will only get worse. As barrier islands continue to degrade, they provide less and less protection from harsh waves and storm surges. Damage to vital evacuation routes from coastal areas will increase as a result of heavy traffic and erosion. In short, the loss of wetlands and barrier islands will seriously increase the likelihood of damage caused by hurricanes and storms, risking life, property, and serious economic loss along Louisiana's coast.

*Web-users please NOTE: the Figure 2.3 map and legend, which in the published version spanned across pages 6 and 7, has been rescaled and repositioned from the original published version to make the files easier to access.*

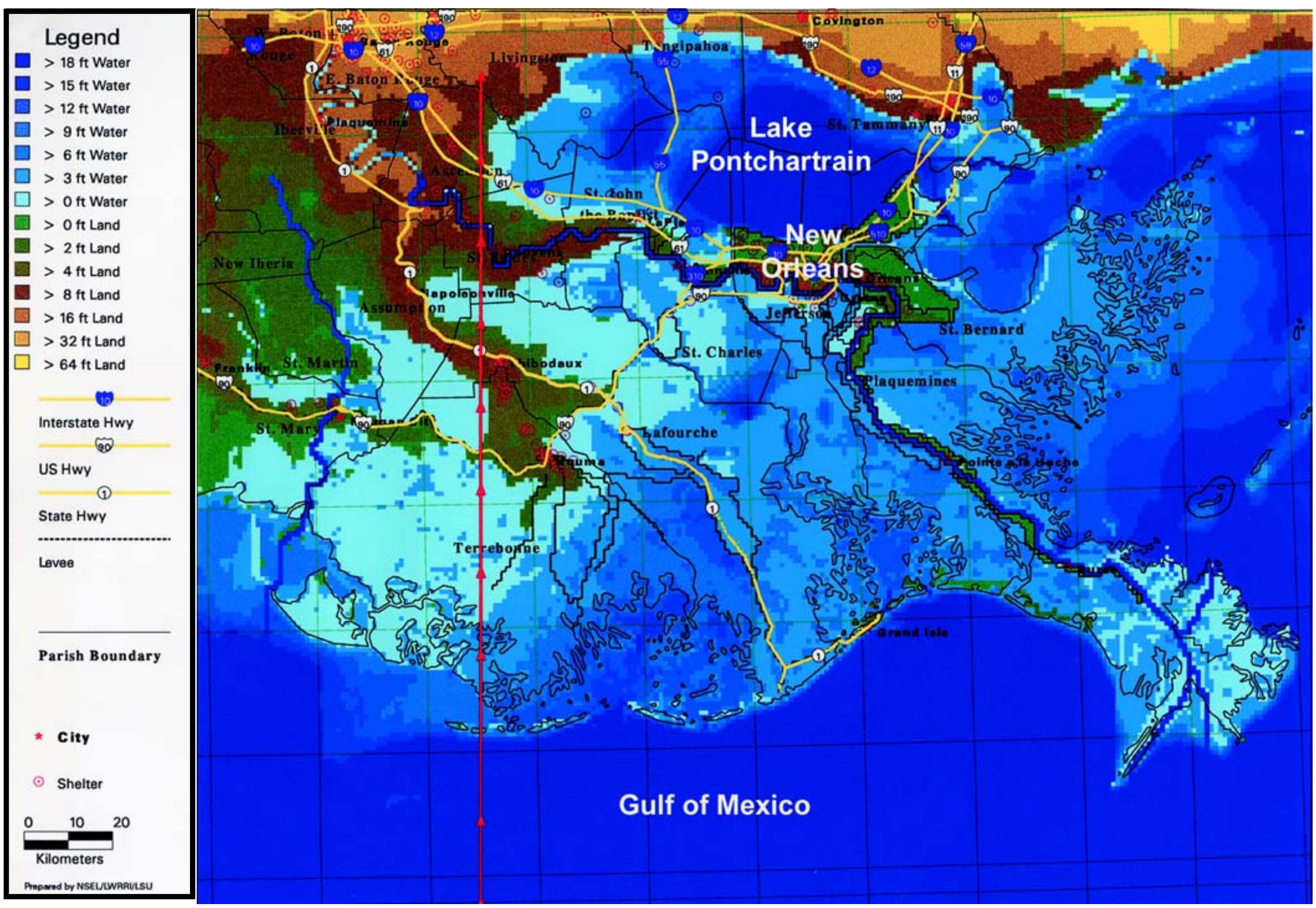



***Figure 2.3*** *Estimates of flooding from a category 3 hurricane traveling a northward path through Terrebonne Bay (indicated by red line).*

Phtoo by LDNR

*Hurricanes and storms can greatly affect coastal wetlands.*

# III–Coastal Wetland Loss in Louisiana

## *History*

Coastal wetlands in Louisiana have been created and have eroded cyclically as the Mississippi River has shifted course over the past 10,000 years, always creating land during the active delta-building phase, and always losing land during deltaic abandonment (Kolb and Van Lopik 1958). With the high sediment load of the river and the shallow continental shelf, the Mississippi River created the land on which south Louisiana exists today. Only recently, in the past 200-300 years, have human activities interfered with this natural process. In the past two centuries, wetlands not only in Louisiana, but also in the entire United States were drained, dredged, filled, leveed, and flooded for urban, agricultural, and residential development (Mitsch and Gosselink 1993). Because of these activities, 22 states have lost 50% or more of their original wetlands. Louisiana currently has 40% of the coastal marshes and 80% of the total coastal marsh loss in the conterminous United States (LCWCRTF 1993).

In the past 2,000 years the modern delta plain of the Mississippi River has lost an average of 350 acres/yr under natural conditions, but from 1930 to 1990 the rate of loss in the delta plain increased over 30-fold to 11,448 acres/yr (Penland et al. 1996). The severity of this problem was first noticed in the 1970's when detailed mapping studies of Louisiana's coast were conducted (Gagliano et al. 1981). Coastal wetlands are currently being lost in Louisiana at a rate between 16,000 and 22,000 acres/yr (LCWCRTF and WCRA 1998), much faster than they are being created. This rate varies across the different hydrologic basins of coastal Louisiana, ranging from 64 acres/yr in the Atchafalaya basin to 7,104 acres/yr in the Barataria basin (figure 3.1). This loss is threatening the sustainability of the entire ecosystem.

## *Causes*

Louisiana's coastal wetland loss problems have been researched extensively over the past several decades and have been attributed to a combination of natural and human-induced causes (Boesch 1982; Mendelssohn et al. 1983; Titus 1986; Turner and Cahoon 1987; Day and Templet 1989; Duffy and Clark 1989; LCWCRTF 1993; Penland et al. 1996). In general terms, wetland loss has resulted from alterations in hydrology leading to changes in salinity and soil inundation (Penland et al. 1996). These changes typically cause a dieback of vegetation and eventually lead to a collapse of marsh substrate, turning coastal wetlands into open water. Soil that is no longer bound by vegetation is rapidly washed away. It is not just one, but combinations of these natural and human-induced factors that have caused the accelerated

*Web-users please NOTE: the Figure 3.1 map, which in the published version spanned across pages 8 and 9, has been rescaled and repositioned from the original published version to make the files easier to access.*

loss of Louisiana's coastal wetlands in the past century.

Natural forces which can be detrimental to the health of coastal wetlands include tropical storm and hurricane impacts, subsidence, and global sea-level rise. Tropical activity, such as Hurricane Georges (1998) and Tropical Storm Hermine (1998) (figure 3.2), can deliver devastating blows to wetlands and marshes that took thousands of years to build (CRCL 1999). Not only do storms erode marsh (including fragile, floating marsh), but storm surges also push salt water into fresh marshes, killing vegetation (LCWCRTF and WCRA 1998). Furthermore, the barrier islands that help protect Louisiana from storms are eroding away into the Gulf of Mexico. As these barrier islands continue to disappear the protection that they provide from storms will diminish (LCWCRTF and WCRA 1998).

Subsidence, the compaction and sinking of the soil, is variable from one part of the state to another (figure 3.3), but it was historically counteracted with accretion of sediments brought to the coastal marshes through annual flooding of the Mississippi River and organic accumulation through continued growth and deposition of vegetated material. In the 20th century, human occupation of the coast led to attempts to stabilize the natural dynamics of wetland growth and decline, shoreline extension and retreat, and especially active river distributary movement across the coast. As a result, the levee system built along the Mississippi River for flood protection and to maintain navigation has stopped the nourishing water and sediments from reaching wetlands (Kesel 1988). Now most of the sediment the river carries is deposited off the continental shelf. Compounding the problem of subsidence is the gradual rise in sea level which may be a result of a rise in global temperatures from rising atmospheric carbon dioxide levels or damage to the ozone layer. In the past century the sea level has been rising at 0.04 inches/yr (1 mm/yr). This trend is expected to continue, and sea level may even increase as much as 8 inches by the year 2050 (Newman et al. 2000;

*Web-users please NOTE: the Figure 3.1 map, which in the published version spanned across pages 8 and 9, has been rescaled and repositioned from the original published version to make the files easier to access.*

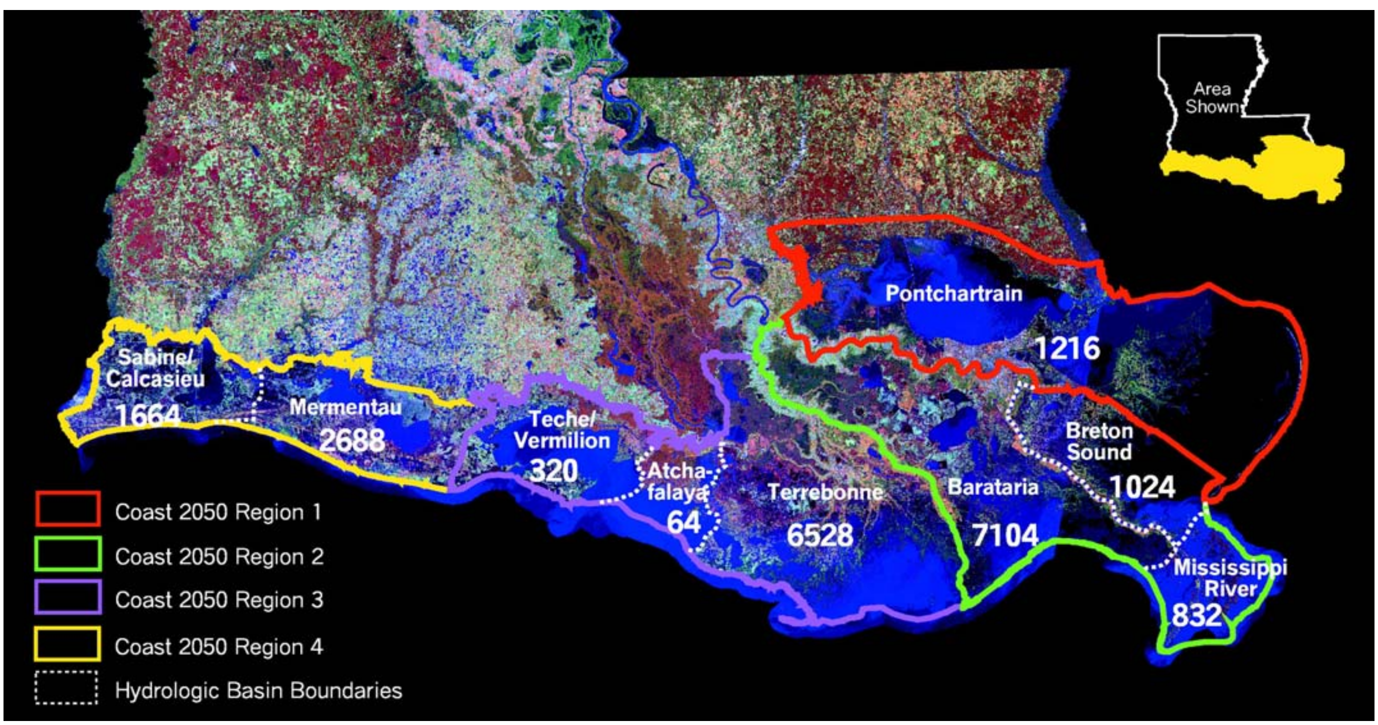



***Figure 3.1*** *Average annual wetland loss (acres/year) between 1978 and 1990 by hydrologic basin. The Coast 2050 Plan ecosystem management regions are also indicated by colored lines.*


***Figure 3.2*** *The paths of selected tropical storms and hurricanes that have impacted coastal Louisiana in the last 60 years.*

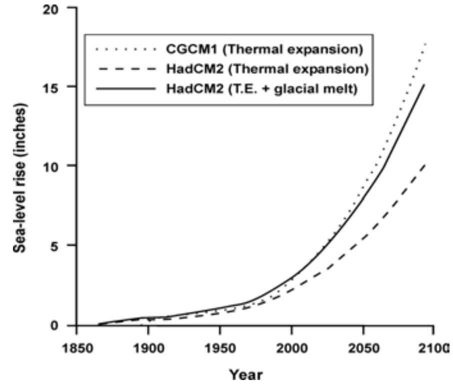



***Figure 3.4*** *Projected estimate of worldwide rise in sea level by the year 2100 from the Canadian Climate Centre (CGCMI) and the Hadley Centre (HadCM2) (from MacCracken et al. 2001).*

Gornitz et al. 1982; figure 3.4). The *combination* of subsidence and sea-level rise (called relative sea-level rise) may be as high as 3 ft in south Louisiana over the next 100 years (Newman et al. 2000). The natural ability of marshes to withstand this rise in sea level has been exacerbated by human influences on the hydrology and geology of the ecosystem.

In the 19th and 20th centuries, Louisiana's wetlands provided sustenance to many communities. As communities settled in the wetlands, conflicts with nature began. Wetlands were drained for agriculture, levees were constructed for flood protection, canals were dredged for ease of navigation, wetland forests were harvested for building materials, and in the early- to mid-20th century, oil and gas exploration activities increased the dredging of canals. North-south canals can provide a direct route for salt water to intrude into the marshes, which in turn kills vegetation. East-west canals hinder sheetflow of water over the marsh, leading to ponding of water and eventual loss of marsh (LCWCRTF and WCRA 1998). Flood-control levees and agricultural levees can also alter natural hydrology and are prone to erosion. Additionally, with the construction of dams along the Mississippi River north of Louisiana, the sediment carried in the river (used to build new wetlands) decreased by more than 50% compared to the sediment that it carried during historic delta building times (Kesel et al. 1992; Mossa 1996).

Herbivory on wetland plants by nutria (*Myocastor coypus*, a South American rodent) is also a major cause of wetland loss in coastal Louisiana. Nutria were accidentally introduced to Louisiana from the escape of a captive population during a hurricane in the 1930's. These herbivores thrived in the Louisiana marsh and grazed heavily on marsh vegetation. With the decline in the fur market in the 1980's trapping pressure has declined, and nutria populations are growing to levels that are very detrimental to the marsh (LCWCRTF and WCRA 1998).

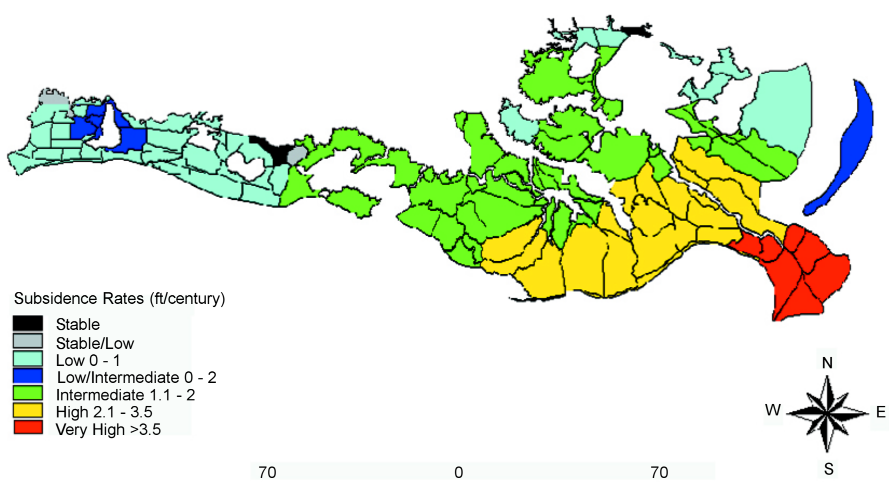



***Figure 3.3*** *Subsidence rates (the compaction and sinking of the soil) throughout coastal Louisiana represented in feet per century. Historically, this sinking was counteracted with accretion of sediments and organic productivity (LCWCRTF and WCRA 1998).*

In the past century, various human induced and natural forces have resulted in a net loss of Louisiana's coastal wetlands. Based on the potential loss of billions of dollars of revenues to the national economy and the potential loss of land for the 50% of Louisiana's population living in the coastal zone, this problem is of catastrophic proportion not only to Louisiana residents, but also to the entire nation.

# *Implications*

## Lost Wetlands

If the current land loss rates continue unabated, by the year 2050 coastal Louisiana is estimated to lose an additional 625,000 acres of marsh *and* swamp even with current restoration efforts. That means 23% of today's wetlands will be lost (LCWCRTF and WCRA 1998)!

Land loss is projected to be the greatest in the Terrebonne and Barataria marshes with nearly 233,000 acres being lost. Western Louisiana will also suffer widespread losses, particularly around Grand, White, and Calcasieu lakes. By 2050, 42% of intermediate marsh will be lost in Region 1. In Regions 2 and 3, 32% of saline marshes will be converted to open water, and in Region 4, 19% of brackish mashes are projected to become open water. With current restoration efforts, including Breaux Act projects and large freshwater diversions, the loss of about 120,000 acres of marsh may be prevented (LCWCRTF and WCRA 1998).

## Economic Impacts

### *Renewable Resources*

Wetland loss not only has significant ecological implications, but also major economic ones. Many coastal communities and economic sectors are at risk, and undue delays in responding to the problem could result in grave economic and social consequences. For example, habitat loss and major changes in the balance of fresh water and salt water in these ecosystems can lead to the loss of fisheries sensitive to this balance, significantly disrupting Louisiana's vitally important seafood production sector. Another example is agriculture. Citrus growers in Plaquemines Parish are experiencing crop losses caused by saltwater intrusion, and rice growers in south-central Louisiana are concerned about the continued supply of fresh water for their crops. Directly or indirectly, the loss of wetlands will reduce production of staples such as sugar, rice, salt, sulphur, and lime, resulting in an impact on national markets.

It is difficult to predict the effects of wetland loss on the fish and wildlife production of Louisiana. Estimates are based on projected land loss for the year 2050 and the resulting changes in habitat. Fish species that live in the estuary will be displaced northward as salinity increases. The American oyster is especially sensitive to salinity changes, and as optimal salinity zones are reduced or shifted, the population of American oysters is expected to decline. In 1998, Louisiana's fisheries harvest, including shrimp, crabs, crawfish, and oysters, had a dockside value of $292 million (figure 3.5; USDOC 1999). Based on average production values per acre of shrimp and crabs (Herke et al. 1992), losing wetlands at the projected rate could mean a potential annual loss of $58 million for shrimp and crab landings at the dock, which translates into a total economic effect loss of $499 million (CRCL 1999). Continued wetland loss will further decrease amphibian populations, which are already declining worldwide. In addition, populations of migratory birds and other wildlife directly dependent on the marshes and swamps will decrease dramatically (LCWCRTF 1993). The disappearance of wooded cheniers and bayou banks that provide critical habitat for migratory species also has national consequences.

### *Nonrenewable Resources*

The oil and gas industry also stands to lose as wetlands and barrier islands disappear. Currently, there are 43,285 oil and gas

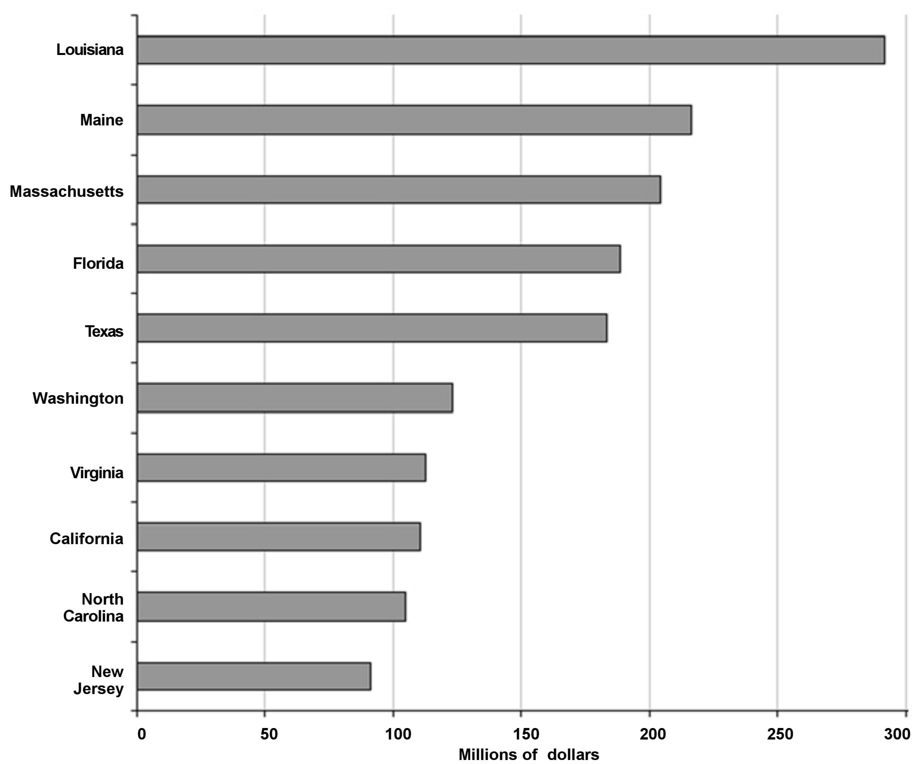



***Figure 3.5*** *Commercial landings of fish and shellfish for the conterminous United States, 1998 (data from USDOC 1999).*

wells in coastal Louisiana with a value of $4.5 billion (LDNR unpublished data; figure 3.6). In 1998, Louisiana produced 22% of all domestic oil and gas (EIA 1999). Barrier islands and wetlands prevent waves and storms from destroying billions of dollars worth of oil and gas infrastructure, including exposed pipelines, canals, roads, oil and gas wells, and platforms. As wetlands and barrier islands are damaged or lost, this valuable infrastructure will be exposed to the elements. Harsh wave action can damage pipelines directly or erode surrounding marsh thus exposing the pipelines and making it easier for them to be damaged by boats. Increased wave action due to loss of wetlands can also result in an increase in boat accidents, chemical spills, and pollution caused by malfunctioning wells.

### *Public Infrastructure*

Louisiana's public infrastructure could suffer greatly as wetlands are lost. The cost and effort required to maintain roadways, navigation waterways, ports, sanitation systems, water supplies, drainage systems, flood control systems, and erosion prevention structures is daunting. Roads, highways, and bridges, many of which are vital evacuation routes, are deteriorating and becoming more congested. Highway 82, for example, in Cameron Parish is being eroded by gulf waves (figure 3.7); between $20 million and $80 million are needed to prevent its structural failure in the next 5 years. As wetlands disappear, the long-term maintenance costs for local drainage and flood control infrastructure will also be prohibitive.

***Figure 3.7*** *Highway 82 in Cameron Parish, Louisiana, during a storm in the Gulf of Mexico. Some roads often become impassible because of overwash.*

### *National Implications*

Wetland loss in Louisiana is not only a Louisiana problem. As wetland loss continues, not only will productivity of these industries decrease, but the infrastructure that supports these industries will also continue to crumble, confounding the problem. People throughout the country will find themselves paying more for gasoline, natural gas, oil, and other items made from petroleum products. Restaurants and consumers will also feel the pinch as prices increase for fish, shrimp, oysters, and crabs. The nation even relies on coastal Louisiana for such staples as salt and sugar! The disappearance of Louisiana's wetlands and barrier islands is a problem that will be felt by the entire nation.

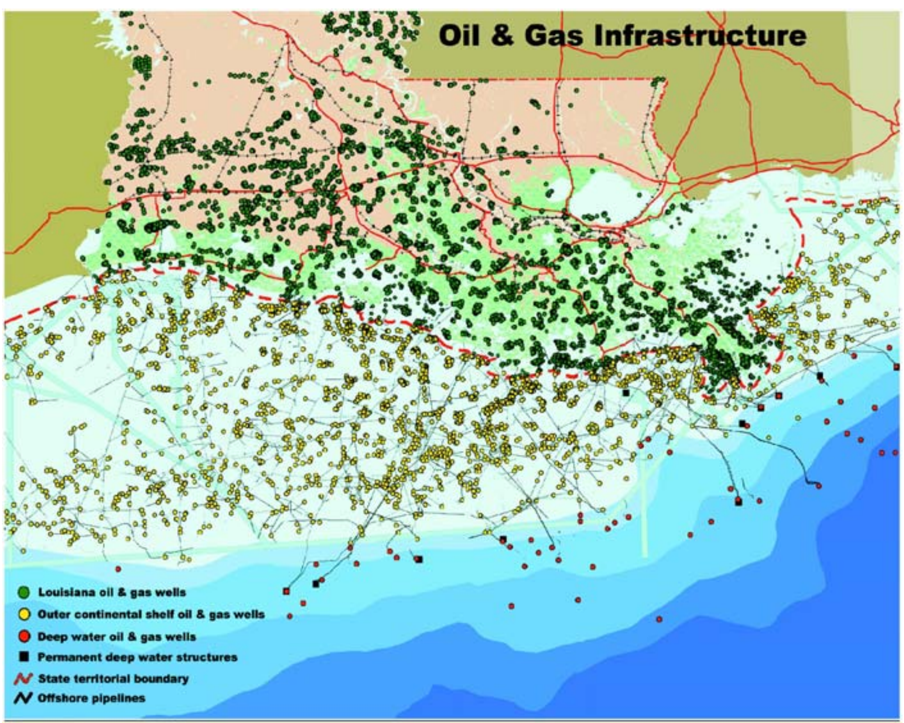




***Figure 3.6*** *Currently there are 43,285 oil and gas wells in coastal Louisiana with a value of $4.5 billion (LDNR unpublished data).*

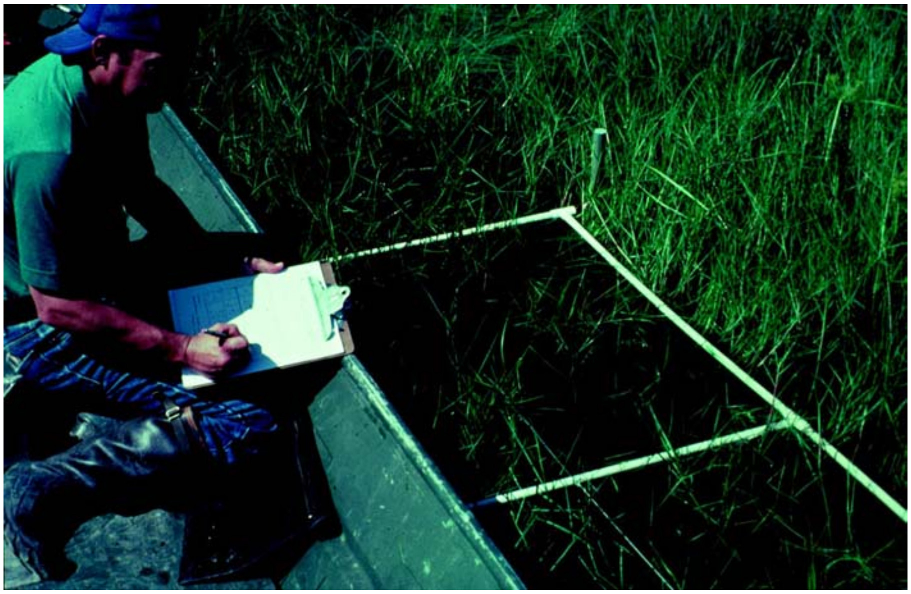


Photo by LDNR

*LDNR monitoring manager Mike Miller collecting vegetation data.*

# IV–The Breaux Act Program

## *Background*

The problem of dramatic wetland loss is not new to the citizens of Louisiana. For more than 30 years the State of Louisiana and others have been studying the problems associated with wetland loss in coastal Louisiana. Under a U.S. Senate resolution in 1967, the USACE Louisiana Coastal Area (LCA) studies evaluated mitigation options. In 1978, the Louisiana State and Local Coastal Resources Management Act established a state coastal management program which emphasized controlling activities that cause wetland loss. The program resulted in the Louisiana Coastal Resources Program, which became a federally approved coastal zone management program in 1980. In 1981, Act 41 of the Louisiana Legislature special session established the Coastal Environment Protection Trust Fund and appropriated $35 million for projects to combat erosion, saltwater intrusion, subsidence, and wetland loss along Louisiana's coast. Then in 1989, the Louisiana Legislature passed Act 6 of the second extraordinary session (R.S. 46:213-214), and a subsequent constitutional amendment was approved by citizens of Louisiana, establishing the Office of Coastal Restoration and Management (OCRM) and the state's Coastal Wetlands Conservation and Restoration Trust Fund (Wetlands Trust Fund) to develop and implement the Coastal Wetlands Conservation and Restoration Plan for Louisiana. Income for the Wetlands Trust Fund is a percentage of the state's mineral revenues and currently varies from $13 million to $25 million annually, depending on oil and gas price and availability.

In 1990, the U.S. Congress recognized the national significance of wetland loss and passed the Breaux Act to contribute federal monies to coastal restoration activities. In Louisiana, the Breaux Act created a partnership between state government and five federal departments: U.S. Departments of Army, Agriculture, Commerce, and Interior and the U.S. Environmental Protection Agency. An agency-level representative from each of the five federal departments—the U.S. Army Corps of Engineers, the Natural Resources Conservation Service, the National Marine Fisheries Service, the U.S. Fish and Wildlife Service, and the U.S. Environmental Protection Agency—and a representative of the State of Louisiana make up the Louisiana Coastal Wetlands Conservation and Restoration, or the Breaux Act, Task Force. The Task Force is the governing body over the Breaux Act in Louisiana and is charged with implementing a "comprehensive approach to restore and prevent the loss of coastal wetlands in Louisiana" (Breaux Act, section 303b, subsection 2).

Overall, the Breaux Act dedicates approximately $50 million per year to wetland restoration activities in Louisiana. The federal dollars are cost-shared with state-funds, with Louisiana's share derived from its Wetlands Trust Fund and state general funds. The Breaux Act has enabled the State of Louisiana to form partnerships with its federal cosponsors, local governments, private industry, academia, and the general public to find solutions to Louisiana's enormous wetland loss problem (figure 4.1). The additional restoration funds resulting from the Breaux Act have provided critical resources necessary to begin implementing a comprehensive, large-scale, long-term restoration program that is essential not just to Louisiana, but also to the entire nation.

In November 1993, a comprehensive wetland restoration plan (LCWCRTF 1993) was submitted to the U.S. Congress identifying


*Under the Coast 2050 Plan, the Louisiana coastline is divided into four regions, based on large-scale watersheds.*

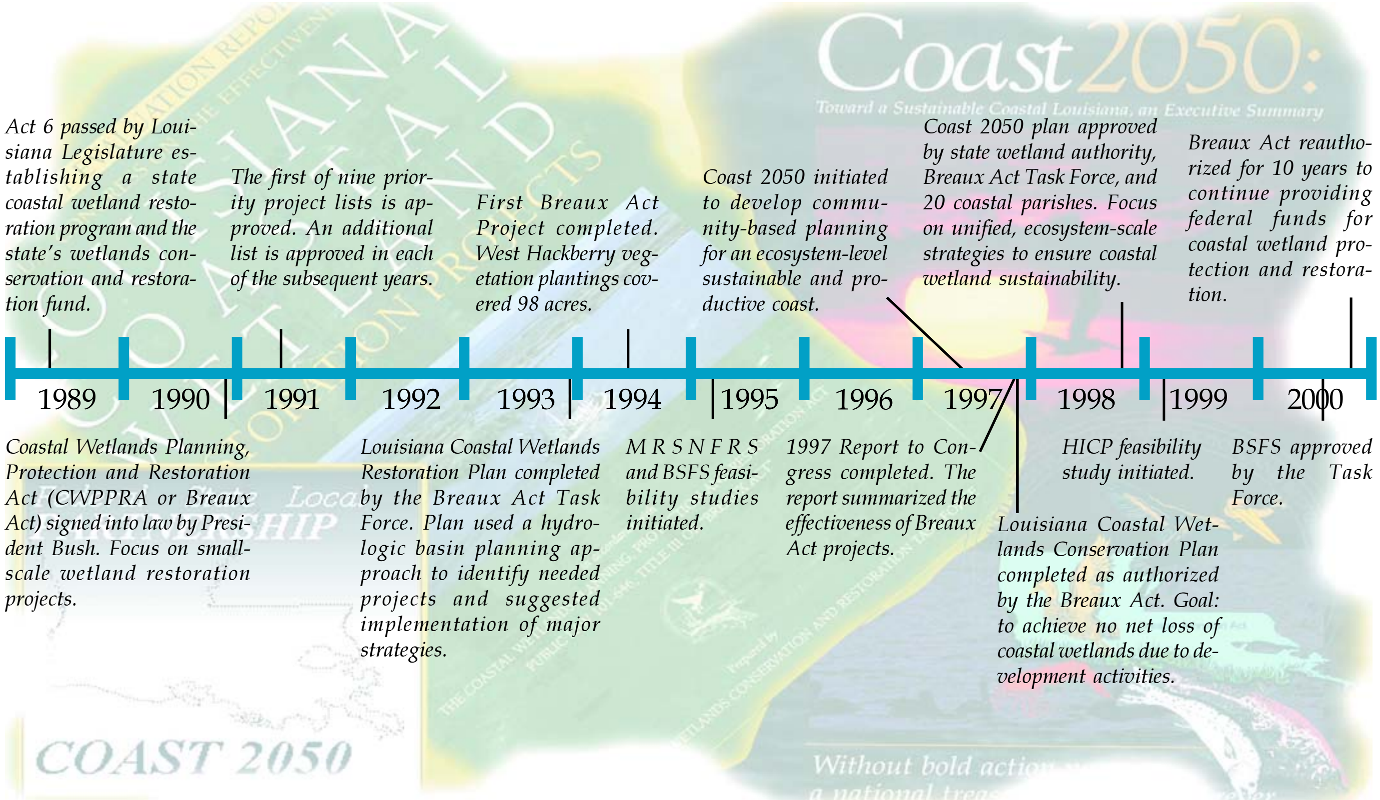



***Figure 4.1*** *A decade of the Breaux Act (after LCWCRTF 1998).*

restoration projects needed to address critical wetland loss problems in Louisiana. Section 303b of the Breaux Act directed that the 1993 plan be further developed and be consistent with the state's existing Coastal Wetlands Conservation and Restoration Plan. The Breaux Act Restoration Plan divided coastal Louisiana into nine basins distinguished by geology and hydrology (see figure 3.4). Strategic plans and restoration priorities were developed for each of these basins, and near-term and long-term strategies were outlined. The near-term strategies focused on easy-to-implement projects designed to reduce wetland loss in specific areas of each basin. The long-term strategies focused on implementing large-scale, more costly projects identified through feasibility studies undertaken during implementation of the near-term strategies.

## *Project Selection Process*

Restoration strategies, or project types, are designed to address site-specific problems and to maximize the available resources within an area. For example, in Barataria, Breton Sound, and Mississippi River basins, 40% of the priority list projects will utilize water from the Mississippi River to deliver fresh water and sediment to areas which have been isolated from riverine input. In interior wetland areas where water flow patterns have been altered by dredged canals and spoil banks, marsh management and hydrologic restoration projects aim to reverse some of these alterations by plugging canals and installing structures to control water exchange. Areas with high rates of shoreline erosion have been targets for shoreline protection projects of varying degrees, depending on the energy of the system. For example, along navigation canals with high boat and barge traffic, rock dikes paralleling the shoreline have been proven to be effective. In lower energy situations, vegetation planted along shorelines has stabilized and trapped sediment to stop continued erosion. Restoration project types were developed to address the original critical basin objectives identified in the 1993 restoration plan. The implementation of project types across the coast is illustrated in figure 4.2. The methods employed for each project type are described in table 4.1. The Breaux Act also supports innovative approaches and new technologies in the form of demonstration projects. These demonstration projects are typically 5 years in duration and function to evaluate the effectiveness of new and innovative project designs prior to large-scale implementation.

Projects considered for annual priority project lists are nominated at public meetings sponsored by the Breaux Act Task Force. The project selection process is continuously evolving as agencies and stakeholders gain more experience in restoration planning. To insure general input from the diverse interests across Louisiana's coastal zone, the Task Force also established the Citizen Participation Group (CPG) to provide public review and input to the plans and projects. The Task

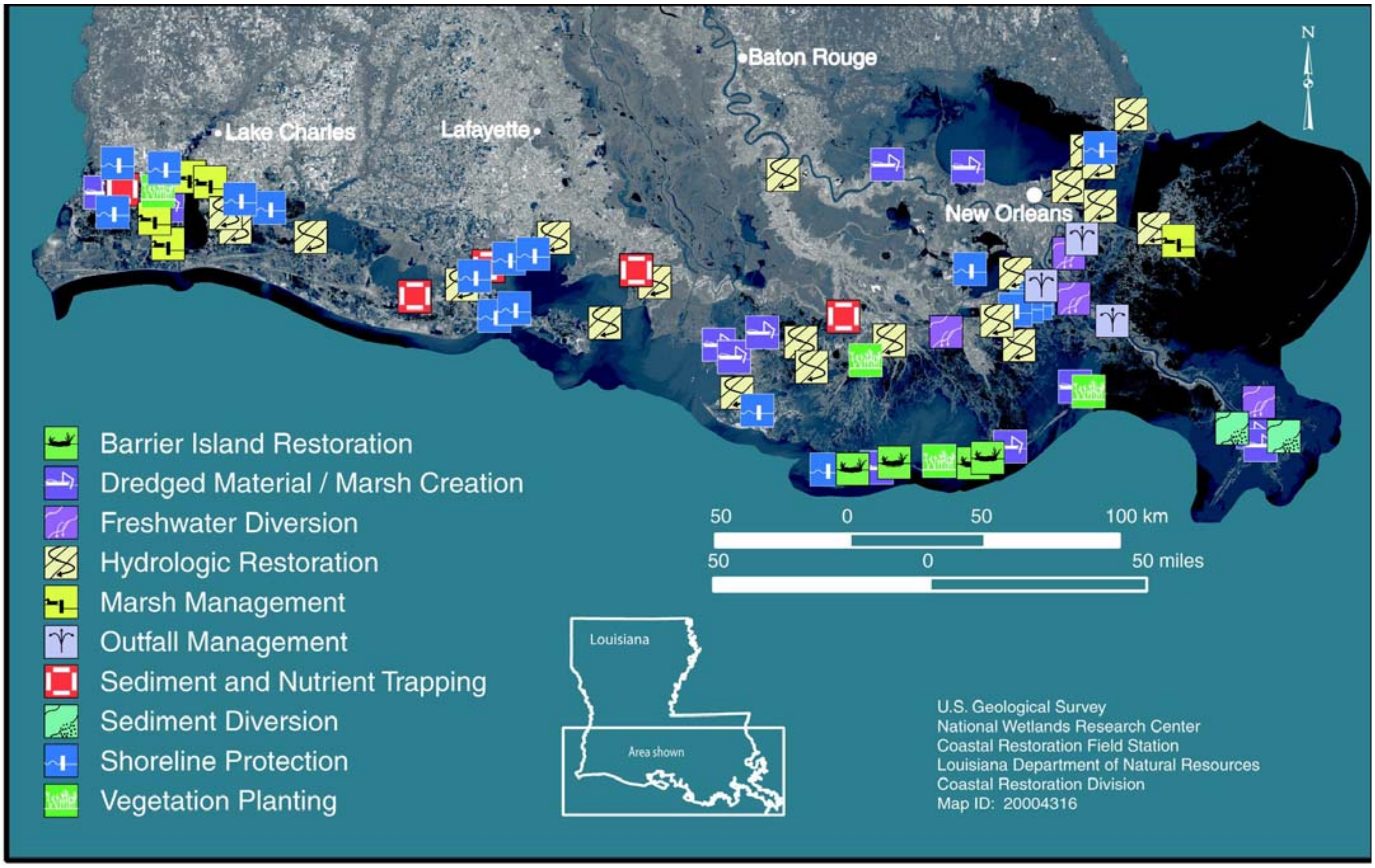



***Figure 4.2*** *Locations of Breaux Act projects authorized on priority project lists 1-8, classified by project type, across the coast (excluding deauthorized projects).*

Force meets quarterly, has held at least three public meetings per year since 1992 to present information to and obtain input from the public concerning coastal restoration projects, and in compliance with the Breaux Act, has submitted annual priority lists of restoration projects to the U.S. Congress since 1991.

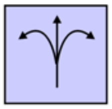
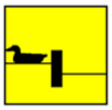
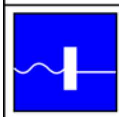
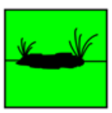
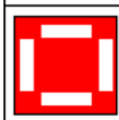
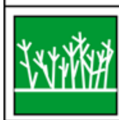
All annual priority lists are formulated with interagency and public involvement and are assessed on a number of criteria, including cost effectiveness, longevity/ sustainability, risk/uncertainty, supporting partnerships, public support, and support for the Breaux Act Restoration Plan. Environmental benefits are considered through the Wetland Value Assessment (WVA), a quantitative, habitat-based assessment developed to estimate anticipated environmental benefits for proposed restoration projects. The WVA uses historical wetland loss data and scientific models to quantify predicted changes in wetland quality and quantity that may result from a proposed restoration project. This method utilizes a community or habitat-level approach and has been developed for application to fresh/ intermediate marsh, brackish marsh, saline marsh, cypress-tupelo swamp, and bottomland hardwood forests. These WVA models evolve to incorporate recent scientific findings and Breaux Act monitoring results, and to include recommended changes from variable sensitivity tests and statistical analyses. For complete WVA procedures, please refer to the WVA methodology document (CWPPRA-EWG 1998).

## Project Implementation

Once a project has been selected for implementation by the Breaux Act Task Force and a lead agency is assigned, engineers begin site analysis, project design, and construction. Site analysis of each project includes gathering geotechnical and hydrologic information and conducting surveys and site visits. The information learned from the site analysis is used to refine plans and specifications for the project design.

Permission to access the area for construction and monitoring must be obtained from private landowners. Obtaining permission can sometimes be an arduous task, since most coastal wetlands in Louisiana are privately owned. Landowners are usually receptive to the idea of protecting and restoring their property, raising concerns only over liability issues. However, there can be many landowners for one proposed project area, necessitating multiple negotiations and contracts. Without an agreement between agencies and landowners, projects cannot be implemented. Arrangements for land rights are typically made concurrently with the project design phase. An additional concern during project design is to minimize impacts to other user-groups, such

*Table 4.1 Descriptions of project types for Breaux Act-funded restoration projects in coastal Louisiana.*

| | | |
|---|---|---|
|  | Freshwater Diversion | Freshwater diversions restore deteriorated wetland areas with the nourishment of fresh water, sediment, and nutrients. Fresh water helps to relieve areas that have suffered from saltwater intrusion, while sediment and nutrients promote the growth of new marsh in areas that are subsiding. In freshwater diversions, also called controlled diversions, fresh water is transported from an adjacent river or water body into surrounding wetlands. Gates or siphons are used to regulate the volume of water flow. |
|  | Sediment Diversion | Sediment diversions, also called uncontrolled diversions, allow nutrient- and sediment-rich freshwater to flow into surrounding wetlands. A gap (called a crevasse) is cut into the river levee and river water flows through the levee into the wetlands. Natural land-building processes promote the creation of new marsh in place of open-water areas. |
|  | Outfall Management | Outfall management projects are used to maximize the benefits of a freshwater diversion project. This technique involves regulating water levels and direction of water flow to increase the dispersion and retention time of fresh water, nutrients, and sediment in the marsh. The water flow may be regulated by a combination of gates, locks, weirs, canal plugs, and gaps cut in artificial levee banks to prevent diverted water from rapidly exiting the area. |
|  | Hydrologic Restoration | Hydrologic restoration projects address problems associated with artificially altered hydrology by reverting human-altered drainage patterns toward more natural drainage patterns. On a large scale, this technique may involve locks or gates on major navigation channels, and restoring natural ridges; on a smaller scale, it may involve blocking dredged canals or cutting gaps in artificial levee banks. |
|  | Marsh Management | Marsh management projects have historically been used to manage land for waterfowl and furbearers and more recently for migrating shorebirds. This technique involves controlling the water level and/or salinity in an impounded marsh area. A variety of structures can be employed to alter water levels and salinities in order to achieve the regrowth of desired vegetation and wildlife habitat. |
|  | Shoreline Protection | Shoreline protection projects are designed to decrease or halt shoreline erosion. Some structures, such as rock berms, are applied directly to the eroding shoreline while others, such as segmented breakwaters and wave-damping fences, are placed in the adjacent open water in order to decrease a wave's energy before it hits the shoreline and to promote the buildup of sediment. |
|  | Barrier Island Restoration | Barrier island restoration projects are designed to protect and restore Louisiana's barrier islands. These projects incorporate a variety of techniques such as placement of dredged material to increase island height and width, placement of structures such as rock breakwaters to protect the island from erosive forces, and placement of sand-trapping fences, with vegetation plantings, to build and stabilize sand dunes on barrier island beaches. |
|  | Dredged Material/ Marsh Creation | Dredged material/marsh creation projects utilize sediment that is dredged for maintenance of navigation channels and access canals, or material may be dredged specifically for marsh creation. The sediment is placed in a deteriorated wetland at specific elevations so that desired marsh plants will colonize and grow to form new marsh. |
|  | Sediment and Nutrient Trapping | Sediment and nutrient trapping projects create new land and protect nearby marshes with structures that are designed to slow water flow and promote the buildup of sediment. Examples include brush fences, such as Christmas tree fences, and shallow bay terraces, which involve dredging sediment from a bay and placing it above the water level in the form of land ridges. |
|  | Vegetation Planting | Vegetation planting projects are used alone and in conjunction with shoreline protection, stabilization of construction sites, barrier island restoration, marsh creation, terraces, and sediment and nutrient trapping. Flood-tolerant and salinity-tolerant marsh plants are planted that will hold sediments together and stabilize the soil with their roots as they become established in a new area. |

as oyster harvesters who collect oysters from adjacent water bottoms. Once permission is obtained from the landowners and the Task Force has approved the final design, construction of each project is bid through the appropriate federal or state bid process for construction. Applications for a coastal use permit, a U.S. Army Corps of Engineers Section 404 permit, and National Environmental Policy Act documentation are submitted for each restoration project. All necessary approvals and land rights must be obtained before the project is implemented.

## Project Monitoring and Evaluation

In accordance with the Breaux Act requirements for project evaluation, the Biological Monitoring Section (BMS) of the Louisiana Department of Natural Resources (LDNR) Coastal Restoration Division (CRD) cooperates with federal, state, and local agencies to monitor and scientifically assess all restoration projects. Biological monitoring begins before most projects are constructed so that conditions from both before and after the project can be compared. An appropriate reference area that can act as a comparison for each project is chosen to evaluate project effectiveness.

Monitoring personnel work with federal agency technical personnel and university scientists to develop a Monitoring Plan for each restoration project based on specific project goals and objectives. Data are collected and analyzed to evaluate each project's performance and effectiveness in meeting the project goals. All Breaux Act projects are monitored for 20 years, with the exception of demonstration projects, which are usually monitored for less than 10 years.

Monitoring protocols are documented in a quality management plan (QMP) developed by a CWPPRA subgroup from the U.S. Geological Survey's (USGS) National Wetlands Research Center, LDNR CRD, and Louisiana State University (Steyer et al. 1995). The QMP is a program-level document which sets the standards by which restoration projects are monitored and ensures consistency in data collection, handling, and evaluation, and it is a "living" document that can respond to evolving scientific knowledge, restoration technologies, and goals for the Breaux Act.

Year-to-year and seasonal variabilities (e.g., droughts, tropical storms) have hindered the ability to distinguish some project effects from environmental effects. These variabilities necessitate a monitoring approach with a high degree of flexibility to detect the effectiveness of management actions under different environmental conditions (Boesch et al. 1994).

Project monitoring results are reported in two basic types of project-specific evaluation reports: progress reports (data and summary graphics) and comprehensive reports. Progress reports are submitted frequently during the projected 20-year project design life and include sections pertaining to the project's current monitoring status, design, and results. The 3-year comprehensive reports compile all available monitoring information and are structured to include more project performance details, with greater emphasis placed on specific conclusions as to whether the project is meeting project-specific goals and objectives. Completed progress reports and comprehensive reports are available on the LDNR/CRD web site at www.saveLAwetlands.org and on the Breaux Act web site at www.lacoast.gov. A GIS-based spatial database and an Oracle-based relational database were developed to manage the tremendous amount of monitoring data being generated from this program. These databases provide critical monitoring information to restoration project planners, designers, and monitoring managers who are actively pursuing the latest available information for the evaluation of project performance and the planning and design of future projects. These data are available to other agencies, academia, and the general public by request or on the Internet through LDNR's nationally recognized SONRIS/2000 interface (Strategic On-line Natural Resources Information System at www.dnr.state.la.us). The Breaux Act's innovative approach in requiring a scientific evaluation of project effectiveness has allowed the acquisition of unprecedented data concerning restoration approaches and techniques—data which will further restoration science worldwide.

## *Existing and Ongoing Feasibility Studies*

Initially, most Breaux Act projects that were constructed were designed as small, fast-track projects that could defend against small-scale wetland loss. For example, the Boston Canal-Vermilion Bay Bank Protection project (PTV-18) used rock dikes and vegetation plantings to protect 466 acres of wetlands that were rapidly eroding (see Section V, Region 3, page 51). These types of projects are successful, are meeting their basin objectives, and have demonstrated the effectiveness of some techniques in protecting and rebuilding wetlands. However, smaller scale projects often can only address localized problems. They generally do not impact a large area and do not address large-scale wetland loss problems.

Mississippi River diversions and barrier island restoration have long been identified as key components to the success of the coastal restoration program in the Louisiana deltaic plain. The Breaux Act Task Force recognized the need for a more comprehensive understanding of the most effective ways to implement these restoration technologies for the long-term conservation of coastal wetlands. It was determined that two separate studies located within the Mississippi Delta Plain would be initiated beginning in 1995: the Barrier Shoreline Feasibility Study (BSFS), managed by LDNR and the Mississippi River Sediment, Nutrient, and Freshwater Redistribution Study (MRSNFRS), managed by the U.S. Army Corps of Engineers (USACE). The Feasibility Study Steering Committee, composed of representatives from each of the Breaux Act agencies and chaired by the USACE, was established to provide oversight and guidance for the duration of both studies.

### Barrier Shoreline Feasibility Study (BSFS)

- The first large-scale feasibility undertaken by the Breaux Act
- Initiated in 1995 by the Breaux Act Task Force at a total cost of $1.5 million
- Designed to assess and quantify wetland loss problems linked to protection provided by the barrier island formations along coastal Louisiana and to develop the most cost-effective measures to minimize future wetland loss
- Completed in 1999, the document was reviewed and approved by the Task Force in June 2000

The study area for Phase 1 is between the western end of Isles Dernieres (Raccoon Point) and Sandy Point in Plaquemines Parish (figure 4.3). This area was further divided into four barrier system subareas for investigation: (1) Isles Dernieres, (2) Timbalier Islands, (3) Caminada-Moreau headland/Grand Isle, and (4) the Plaquemines shoreline. These barrier shorelines provide the outermost protection to the Barataria-Terrebonne basins, which are currently experiencing the largest land loss rate in coastal Louisiana.

The cost of implementing the recommendations of this feasibility study to protect and preserve this portion of Louisiana's barrier shoreline is estimated to be $951 million, including a 5-year maintenance cycle for 30 years after initial construction is completed. Benefits derived from this feasibility study are two-fold: (1) the recommended plans selected by the study team for the individual subareas are consistent with Breaux Act projects already on the ground (e.g., Isles Dernieres, Timbalier Island), and (2) results are applicable to a larger scale Barataria Basin Feasibility Study (see page 19) that was authorized under the Louisiana Coastal Area, Ecosystem Restoration Authority and will serve as the first step toward implementation of the Coast 2050 Plan.

### Mississippi River Sediment, Nutrient, and Freshwater Redistribution Study (MRSNFRS)

- Initiated in June 1995 by the Breaux Act Task Force at a total cost of $3.35 million
- Designed to evaluate potential uses of sediment, nutrient, and freshwater resources from the Mississippi River to create, protect, and enhance coastal wetlands
- Draft report distributed for agency review and comment in June 2000

The study area comprises the entire Mississippi River Deltaic Plain, from the East Atchafalaya Basin Protection Levee eastward to the Louisiana-Mississippi state border, encompassing approximately 6.4 million acres (figure 4.4).

Information has been gathered on land use, habitat type, land loss, endangered and threatened species, real estate costs, and existing demands on water supplies. In addition, hydraulic, salinity, and landscape modeling of riverine impacts under multidiversion scenarios has

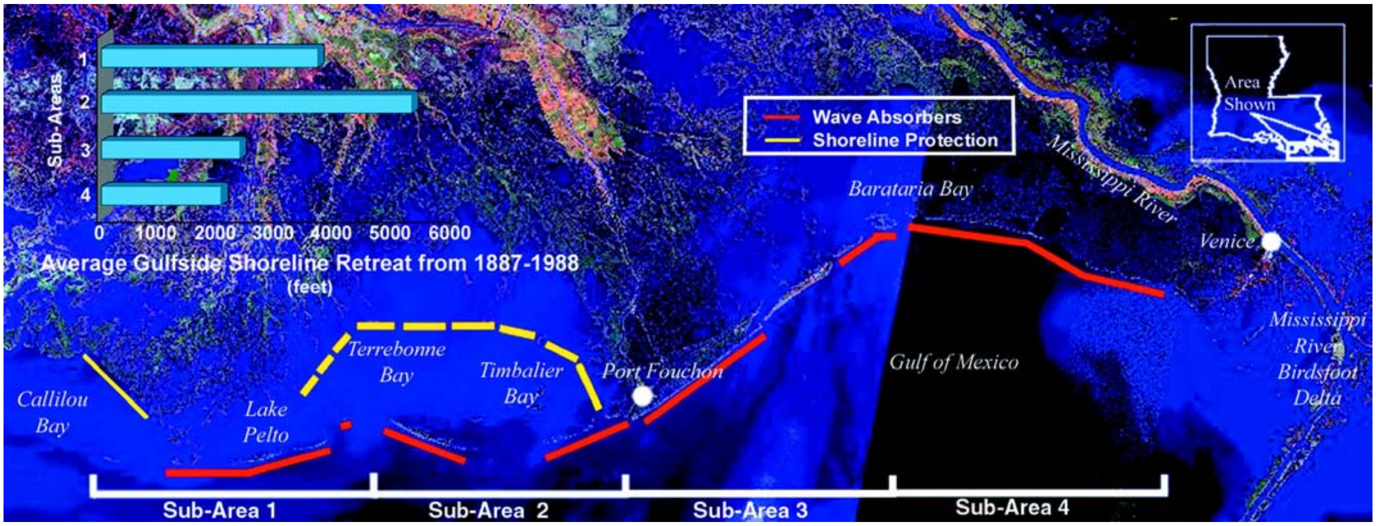



*Figure 4.3 Location of Barrier Shoreline Feasiblilty Study area and recommended action plan: subarea 1 = Isle Dernieres; subarea 2 = Timbalier Islands; subarea 3 = Caminada-Moreau Headland/Grand Isle; subarea 4 = Plaquemines Shoreline. The inset histogram represents historic gulfside shoreline retreat in linear feet from 1887 to 1988 (from Williams et al. 1992).*

been completed to determine the effects of resource reallocation (e.g., to balance the utilization of river water between multiple user groups for such purposes as navigation, drinking water, and freshwater diversions). Hydraulic model simulations have been developed to determine the combined effects of the MRSNFRS and BSFS alternatives on the Barataria basin. The Mississippi River Ship Channel Improvement reconnaissance study, which evaluated environmental enhancement of navigation feature maintenance, has also been integrated into the study. Potential benefits will be extrapolated based on selected site-specific evaluations. Final project recommendations will then be made based on the evaluation of environmental benefits versus costs for each alternative and possible combinations of alternatives.

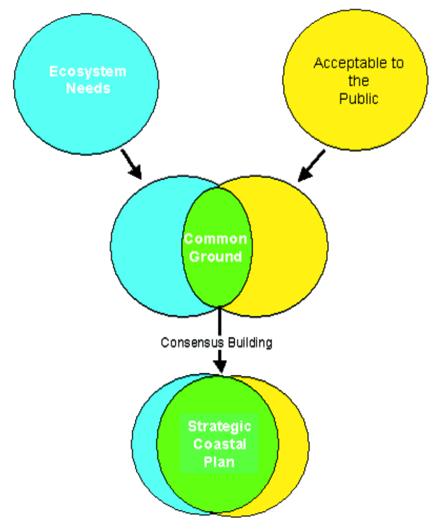
## Hydrologic Investigation of the Chenier Plain (HICP)

- Funded by Breaux Act planning monies at a cost of $250,000
- Designed to develop a more holistic understanding of Chenier Plain hydrology
- Draft report compilation is currently in progress

The Task Force also approved funding for the Hydrologic Investigation of the Chenier Plain (HICP) study to determine the role of hydrology on the stability of marshes in that area. This study was initiated to provide a better understanding of system hydrology which is essential to the implementation of future restoration strategies within the western, Chenier Plain region. Information generated through this effort is intended to serve as a cornerstone in the development of a long-term restoration framework that will guide project planning and implementation activities, new feasibility analyses, and future environmental modeling.

This project analyzed historic trends in land use and management, landscape changes over the past 50 years, water level and water control structure operation records, and spatial and temporal salinity patterns. New data collection consisted primarily of strategically collected GPS elevational survey points in marshes across the region.

There are two areas of particular concern that the study addresses: (1) clarifying the role of alterations in system hydrology in wetland loss in the Mermentau and Calcasieu-Sabine basins; and (2) determining the impacts to wetlands in the Calcasieu-Sabine Basin by the potential expansion of the Sabine-Neches Waterway.




*A model of the process for developing strategies of the Coast 2050 Plan, representing the incorporation of ideas from governmental agencies, academia, and the public.*

## Coast 2050 Feasibility Studies

- Will develop regional-scale projects in the context of the Coast 2050 Plan for review and consideration by the U.S.

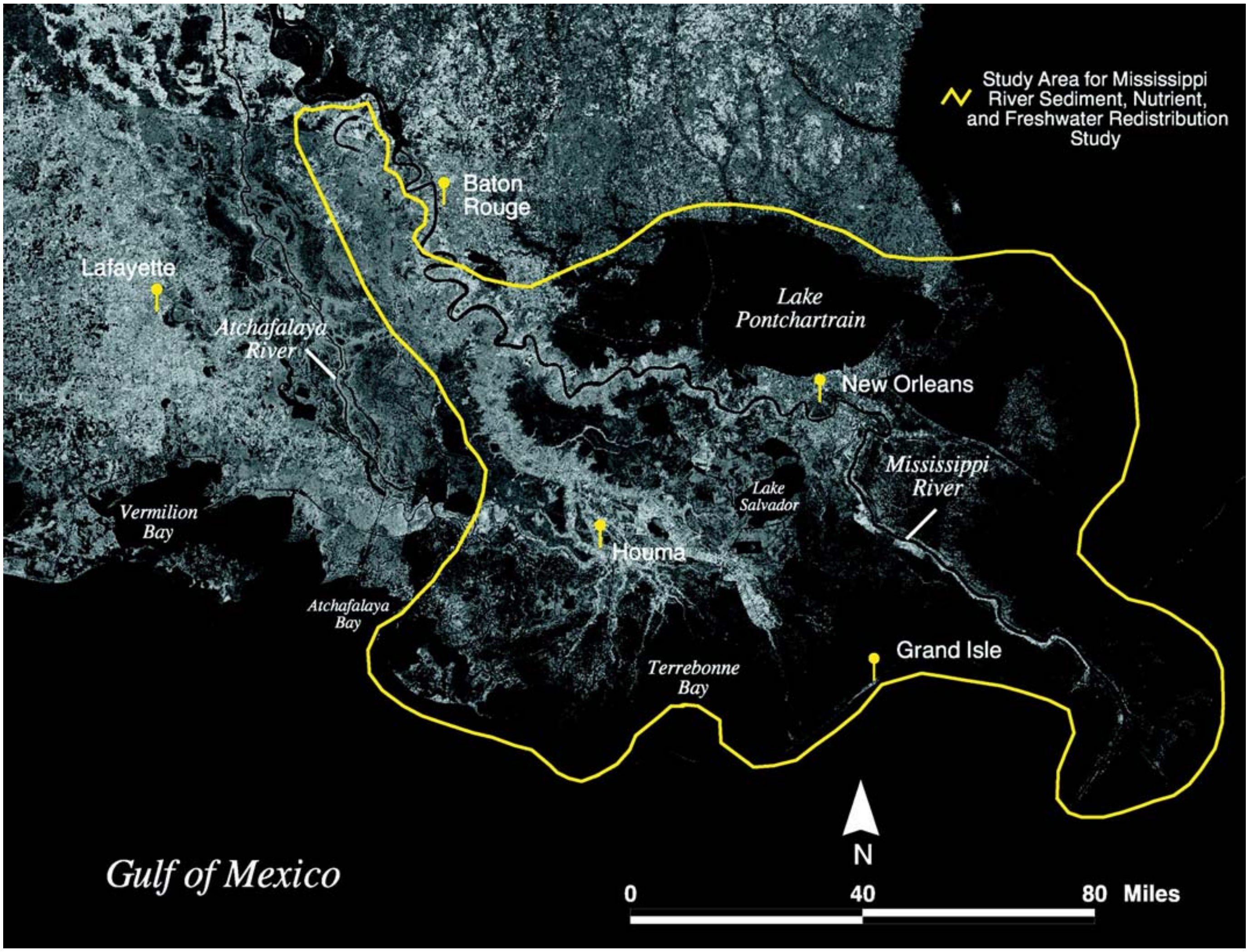



***Figure 4.4*** *The study area for the Mississippi River Sediment, Nutrient, and Freshwater Redistribution Study.*

Congress for funding under future Water Resources Development Acts

- Will target the Barataria Hydrologic Basin first in a planned sequence of feasibility studies because of its high rate of land loss and the enormous resource potential of fresh water, sediments, and nutrients offered by the adjacent Mississippi River
- Study will serve as the model for future feasibility studies as the Coast 2050 Plan is implemented across the Louisiana coast

As a follow-up to these large-scale feasibility studies, the USACE and LDNR, under the auspices of Louisiana Coastal Area, Louisiana (LCA), have cooperatively entered into a major ecosystem restoration study in the Barataria Basin that is based on Coast 2050 regional ecosystem strategies (see www.Coast2050.gov). Although this study will not be funded through the Breaux Act, results and information generated in both the MRSNFRS and BSFS will be utilized and built upon with the goal of developing future large-scale ecosystem level restoration projects. An interim large-scale Coast 2050 feasibility study, *Louisiana Coastal Area, Louisiana, Ecosystem Restoration—Barrier Island Restoration, Marsh Creation, and River Diversion—Barataria Basin Feasibility Study,* began in early 2000. It is anticipated that a total of eight future basin studies will ensue under the LCA authority over the next 10 years.

The projects selected for feasibility development were chosen from Breaux Act-funded Coast 2050 regional ecosystem strategies for the basin and include restoration of the barrier shoreline from Belle Pass to Sandy Point (consistent with the recommendations of the BSFS), marsh creation near Louisiana Highway 1 (south of Leeville) and in Caminada Bay, and a Mississippi River delta building diversion below the city of Empire. In addition, a hydro-dynamic modeling effort will be undertaken to evaluate restoration alternatives related to the input, movement, and circulation of water as described in the regional ecosystem strategies for the basin. The model is designed to predict the future with and without water-related management measures implemented in the basin, based on current conditions. An extensive amount of data already exists for this area, collected through the Barataria-Terrebonne National Estuary Program (BTNEP).

Execution of these feasibility studies marks the beginning of a new level of cooperation between the USACE and the State of Louisiana. Additionally, these feasibility studies are the first initiative to develop comprehensive wetland restoration plans based on the Breaux Act-funded Coast 2050 Plan for other funding sources such as WRDA.

## *Program Advances: The Coast 2050 Plan– The Need for Action*

In response to Louisiana Governor Foster's call for a unified effort to restore and protect Louisiana's coastal resources, a new planning initiative, Coast 2050, began in 1997. Coast 2050 is a strategic plan for the survival of Louisiana's coast through large-scale restoration. This marks a new day for ecosystem scale coastal restoration in Louisiana and reflects the growth and adaptability of the Breaux Act restoration effort. Agencies involved with implementing the Breaux Act in Louisiana have gained a wealth of experience and information on which to build the next level of coastal restoration. Agencies and stakeholders have developed strong relationships of cooperation and trust that will help smooth the transition to larger restoration efforts. The emphasis on ecosystem scale projects is a strategic step in the right direction to save Louisiana's rapidly disappearing coastal wetlands.

The Coast 2050 Plan was developed through a process of cooperation and collaboration between federal, state, and local entities, landowners, environmentalists, wetland scientists, and the public. The plan is supported by all 20 coastal parishes. Through 65 public meetings and workshops, technically sound solutions were found to meet ecosystem needs and secure public acceptance and support. For the first time, diverse groups in Louisiana have come together to develop one shared vision for the coast in one plan with a unified goal *"to sustain a coastal ecosystem that supports and protects the environment, economy and culture of southern Louisiana, and that contributes greatly to the economy and well-being of the nation."*

The Coast 2050 Plan (LCWCRTF and WRCA 1998) was finalized in December 1998 and incorporates elements of all previous wetland restoration efforts, along with new initiatives from private citizens, local governments, state and federal agency personnel, and the scientific community. Those responsible for restoration decisions in Louisiana expect and welcome the fact that the plan will be revised in the future as new knowledge becomes available, as new opportunities arise, as new restoration technology develops, and perhaps as new landscape problems occur. Addressing the collapse of Louisiana's coastal ecosystem, however, must move forward in the face of such uncertainty or it will be too late for the marshes, the swamps, the industries, and the people. A full description of the Coast 2050 process and an on-line copy of the Coast 2050 Plan can be found at www.saveLAwetlands.org/site/reports.html or www.Coast2050.gov.

## Ecosystem Management Strategies

The highly productive wetlands in coastal Louisiana were originally built through a balance of creative and erosive natural geomorphic processes. Many of the processes which create and/or maintain marsh have been interrupted by human intervention and must be reestablished to achieve sustainability of Louisiana's coastal wetlands. Reestablishment does not imply "controlling" nature but does require constructive use of the forces that formed coastal Louisiana: rivers, rainfall, and the sea. Neither does reestablishment imply a return of the coastal system to a pristine condition. The intent of ecosystem management is to design restoration strategies based on ecological principles so the future coast will have the suitable productivity, sustainability, and other desirable features of a highly valued natural system.

### *Strategic Goals*

Three strategic goals were identified which must be achieved in order to restore the coastal ecosystem to a sustainable level. The regional ecosystem strategies described subsequently are intended to accomplish these goals.

#### Goal 1: Vertical Accumulation

The natural, long-term productivity of Louisiana's coastal wetlands has occurred because, over a large area and over time measured in centuries, the ecosystem maintained itself against the natural forces (such as subsidence and erosion) that cause marsh loss. To achieve self maintenance, marshes must accumulate sediment and/or organic matter at a rate that equals or exceeds the combined effect of sea-level rise and subsidence (figure 4.5). This upward growth in the land surface is known as vertical accumulation. Delta building is one natural process of accumulation of new land. For established marshes, vertical accumulation occurs through periodic, gentle flooding and drainage that can deposit mineral sediments on the marsh surface and/or provide additional nutrients which promote healthy vegetation and high rates of organic productivity.

#### Goal 2: Estuarine Gradient

A second essential characteristic adding to the sustainability and productivity of a natural system is its diversity of habitats and the consequent diversity of fish and wildlife resources. A dynamic salinity gradient in each estuary is the fundamental driving force creating ecosystem diversity (figure 4.6). Significant freshwater input must occur at the upper end of each estuary. Flowing seaward, this fresh water gradually becomes a more saline and tidally dominated flow, terminating at the gulf end of the estuary. Each grade of water is associated with unique vegetation communities that support various fish and wildlife habitats. Many

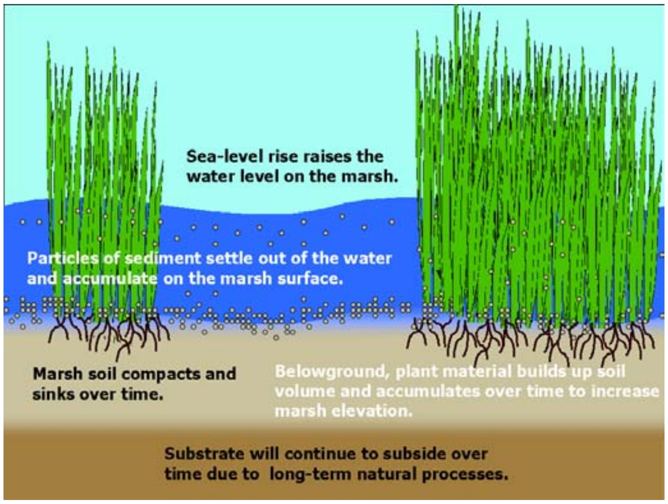



***Figure 4.5*** *Strategic Goal 1: assure vertical accumulation to achieve sustainability.*

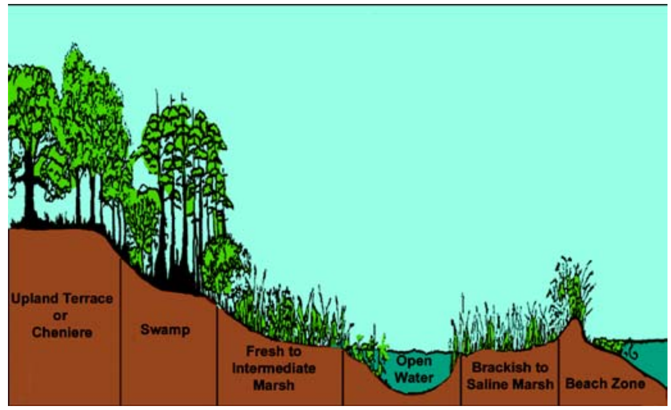



***Figure 4.6*** *Strategic Goal 2: maintain estuarine gradient to achieve diversity.*

aquatic species, such as shrimp, migrate through and depend on the salinity gradient, as different salinity regimes and vegetation types are needed at different times in their life cycles. For other species, certain salinity levels are toxic. A balance between habitat types and opportunities for exchange between these habitats is crucial.

### Goal 3: Ecosystem Linkages

Ecosystem linkages are the pathways by which energy, materials, and organisms are transferred and mixed among the ecosystem components (figure 4.7). Effective interconnections are needed to support a food chain that is diverse and highly productive. Optimal linkages require that the land forms and hydrology of the ecosystem allow for efficient exchange of energy and materials between the marshes and estuaries. In turn, this exchange is achieved by habitats that have stable edges and are naturally interspersed with other habitats, and by a hydrologic regime that maintains the natural rhythms of the coast—including tidal cycles, storms, and river floods.

## *The Strategies*

Each of these goals addresses general ecosystem processes and functions that are the building blocks of a healthy and stable coastal system. Still, there are several types of wetland systems on Louisiana's coast. Each is unique in its hydrologic regime and geologic origin, requiring different restoration tactics for each. Therefore, a set of restoration strategies, designed with respect to the goals above, was defined for each of the Coast 2050 regions. These Regional Ecosystem Strategies are the result of the Coast 2050 consensus-building process. Each strategy was selected to address not just wetland needs, but also the long-term benefits to public concerns such as communities, transportation and navigation infrastructure, and fisheries production. Regional Ecosystem Strategies identified in the Coast 2050 Plan include large-scale river diversions, maintenance of the integrity of major shorelines and land bridges, barrier island restoration and maintenance, and restoration of natural watershed drainage patterns. The same project types identified to address critical basin objectives in the 1993 CWPPRA restoration plan will carry over to address the strategic goals of the Coast 2050 Plan.

The Regional Ecosystem Strategies are outlined in the Coast 2050 Plan, available on line at www.Coast2050.gov or www.saveLAwetlands.org. Brief descriptions of the ecology of each region and the status of restoration

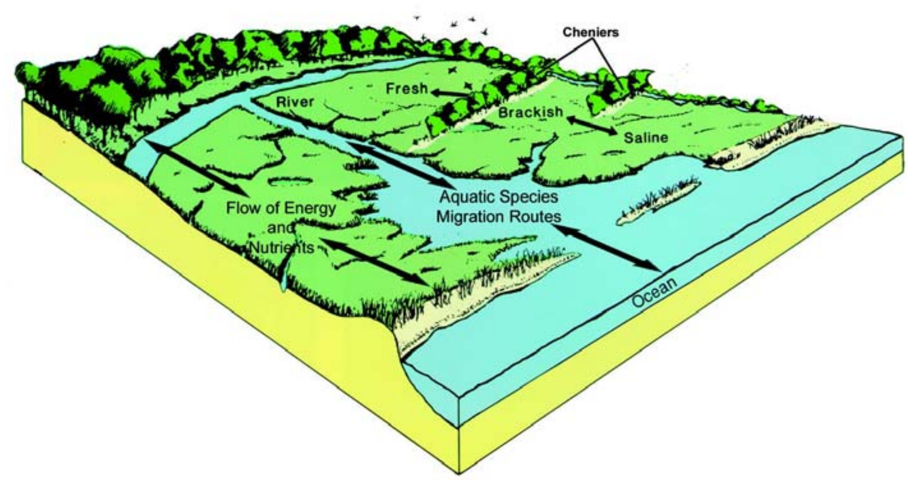



***Figure 4.7*** *Strategic Goal 3: maintain exchange and interface to achieve system linkages (adapted from Watzin and Gosselink 1992).*

projects authorized by the Breaux Act are summarized under Breaux Act Restoration Status (section V). We cannot restore the coast to a pristine condition in which only natural forces are at work, but we can use restoration techniques that mimic the natural processes of the coast to maintain a healthy, sustainable ecosystem that acts in concert with human endeavors.

## Cash Flow Management

For 9 years, restoration project selection has taken place pursuant to a policy in which the entire lifetime cost of each project was placed in escrow upon initial selection of an undeveloped project concept. This practice limited project starts and made it prohibitive to consider large-scale projects. Perhaps most importantly, it placed hundreds of millions of Breaux Act construction dollars in escrow accounts dedicated to projects that might later be found unfeasible. Given the enormous need for effective action, the amount of money set aside in this way greatly weakened the argument that the overall restoration program was significantly underfunded.

Led by the state, the Breaux Act Task Force formally adopted in 1999 a new "pay-as-you-go" policy for managing cash flow and approving restoration projects that is consistent with state fiscal policy for other public works programs. The new policy will also allow more projects to more quickly reach an advanced state of engineering design prior to final construction approval, which will increase the likelihood that each project performs as expected.

As a result of this change, within a few years more projects will be ready for construction than can be funded under the previous cash flow stream. This situation will provide a backlog of worthy projects ready for construction, which will establish healthy competition among first-rate, critical projects while bolstering the argument that the restoration program must be funded at higher levels. It will also, for the first time, allow proponents to seek funding from additional sources (outside of the Breaux Act or the State Wetlands Trust Fund) for worthy projects that have already been designed.

## *Louisiana Coastal Wetlands Conservation Plan*

In addition to coastal restoration efforts funded under Section 303 of the Breaux Act addressing wetland losses due to natural or indirect causes, Section 304 of the Breaux Act targets wetland losses resulting directly from developmental activities. Under authority of Section 304, the LDNR was designated by the Governor of Louisiana as the state agency responsible for the development of the Coastal Wetlands Conservation Plan (Conservation Plan) with the goal of achieving "no net loss of wetlands in the coastal areas of Louisiana as a result of developmental activities initiated subsequent to approval of the Conservation Plan" exclusive of any wetland gains achieved through implementation of restoration projects funded through Section 303 of that Act. The LDNR was also responsible for submittal of the Conservation Plan for approval to three federal agencies: the U.S. Department of the Army, the U.S. Fish and Wildlife Service, and the U.S. Environmental Protection Agency. The Conservation Plan was unanimously approved by the agencies and was promulgated in December 1997.

The effectiveness of the Breaux Act depends on both reactive (addressing current and historical wetland losses) and proactive (addressing future wetland losses) activities. A restoration program addressing natural and past development activities can only be successful if future development activities are also addressed. The Conservation Plan provides a nonregulatory mechanism to increase public awareness of coastal wetland loss issues, provides information to landowners to improve land management practices, increases monitoring and tracking of the impacts of developmental activities in wetland areas, increases the tracking and monitoring of mitigation projects, and increases funding of restoration activities outside of the federal Breaux Act.

Photo by Jessica Wallace

*LDNR monitoring manager Bill Boshart services data collection equipment.*