No Time to Lose

Facing the Future of Louisiana and the Crisis of Coastal Land Loss

The Coalition to Restore Coastal Louisiana

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The Coalition to Restore Coastal Louisiana

The Coalition is an organization dedicated to the stewardship of one of the world's greatest natural, cultural, and economic treasures—the bays, wetlands, and estuaries of coastal Louisiana. The Coalition is made up of a wide spectrum of organizations and individuals—conservationists, businesses, local governments, landowners, civic organizations, religious groups, commercial and recreational fishers, scientists, teachers, and concerned individuals.

The Coalition was incorporated as a not-for-profit corporation in 1988 and has been certified as a tax-exempt charitable organization by the Internal Revenue Service.

Coalition to Restore Coastal Louisiana

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Cover photograph by Julia Sims

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Introduction

Are these the shadows of the things that will be or are they shadows of the things that may be, only? Men's courses will foreshadow certain ends, to which, if persevered in, they must lead. But, if the courses be departed from, the ends will change. Say it is thus with what you show me!

Charles Dickens's *A Christmas Carol*

Charles Dickens's London is a long way from coastal Louisiana. Even so, the question Dickens poses describes the choice confronting Louisiana citizens. The state's coastal wetlands and barrier islands are eroding so rapidly that, within just a few decades, south Louisiana may cease to be a viable place to live, work, and house infrastructure. Is this scenario the shadow of things that will be or the shadow of things that may be? That depends on how much we care about saving our coast.

Louisiana's coastal restoration work began in earnest with the passage of Act 6 in 1989 and the Breaux Act in 1990. Since then, a foundation has been laid for a new era of coastal stewardship. More than 80 restoration projects have been authorized, a set of restoration strategies has been developed, and the Coast 2050 initiative has been undertaken by a group of state and federal agencies with the input of many affected constituencies. Without a substantial expansion of their scope and scale, best estimates are that current coastal restoration efforts will prevent only 22% of the land loss that is projected to occur between now and the year 2050.

Fortunately, there are technically sound methods—endorsed by the Breaux Act partners and members of the Coast 2050 effort—to significantly increase this percentage. Some estimates suggest that a comprehensive restoration program could restore and maintain at least 98% of the coastal land that exists today, and could possibly achieve a net gain in acreage. These methods are founded on the principle that river water, sediments, and nutrients originally built the wetlands centuries ago, and these resources can rebuild wetlands today. By restoring as many natural water and sediment flow patterns through coastal wetlands as is practically achievable, we can curb the rate of coastal land loss.

This approach will cost billions of dollars. It will also require unprecedented levels of planning and cooperation among government, citizens, and businesses. It is time to decide if we will embrace these challenges to secure endangered communities or continue old patterns and lose coastal Louisiana as we know it.

Coast 2050

The Coast 2050 initiative was launched as a joint State/Federal effort in 1997 at the urging of the Coalition and others to arrive at an overall vision and strategic plan for coastal restoration in Louisiana. Coast 2050 sought input from local governments and the public for the development of a consensus-based restoration plan in partnership with state and federal agencies. Regional ecosystem restoration strategies and habitat objectives that were judged to be technically sound and publically acceptable were developed for the entire coastal zone of Louisiana. The Coast 2050 plan, adopted in January 1999, combines elements of previous restoration plans as wells as new initiatives based on the most up to date information and technologies.

Coast 2050: Towards A Sustainable Coastal Louisiana, Louisiana Coastal Wetlands Conservation Task Force, Wetlands Conservation and Restoration Authority, December 1998.

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If we choose to save our coast, five fundamental principles must govern our restoration policies:

1. Coastal restoration efforts must be expanded. The Breaux Act process has accomplished its mission, but it was never intended to be the entire, or even the largest, source of restoration work. The gains made by the Breaux Act should serve as the cornerstone of a truly comprehensive effort; they should not be remembered as a valiant shot over the shoulder in an otherwise full tilt retreat from the coast.

2. Louisiana and the nation must be prepared to invest the money necessary to fully restore and maintain Louisiana's coast. Because national financial support is unlikely to arrive until our state has demonstrated its own firm commitment, Louisiana must become a full financial partner in the restoration effort.

3. Ecological values cannot be the sole driving force behind the restoration and stewardship of the coast. We must recognize the vital role played by barrier shorelines and coastal wetlands in the economic, cultural, and physical well being of coastal communities and infrastructure. Indeed, the survival of metropolitan New Orleans is linked to wetlands and barrier islands as much as to levees and pumping stations.

4. The term "coastal restoration" does not refer to a process of recreating all of the wetland acreage that existed in the past. Rather, it describes an attempt to restore a sustainable balance to the landscape using a combination of natural forces and human engineering. In effect, the term calls for re-establishing the processes that once built and sustained the coast. Although the coast will continue to be dynamic, it need not continue to collapse.

5. Restoration is not a substitute for protection of existing wetlands and barrier shorelines from human impacts. Likewise, protection is not a substitute for restoration. Effective stewardship requires dedication to each of these critical, and interrelated, components.

In preparing this report every effort was made to use the most up to date information available. Information was compiled from published and unpublished information, recent modeling by Louisiana State University using data from the U.S. Army Corps of Engineers, and information collected by state and federal restoration, planning, and management programs.

Chapter 1: The Party is Over

An Historical Look at Louisiana's Wetlands

Most people have heard tales about hurricane parties, where friends gather with food and drink to ride out the storm. Whether true or not, those stories reflect a mentality of *laissez les bon temps roulez* (let the good times roll) that can no longer hold for Louisiana. In the light of the challenges facing Louisiana and the nation on the state's coast, an attitude of "live and let tomorrow take care of itself" cannot be reconciled with any meaningful notion of stewardship.

Living in south Louisiana demands that residents accommodate the landscape. Seventy percent of Louisiana's citizens live in the 18,000 square mile coastal zone, an area bounded by the Mississippi River delta to the east and the Chenier Plain to the west. But little more than one-third of this area (about 7,000 square miles in 1990) is land.[1] Of this land, less than 10% is more than three feet above sea level. Only where five salt domes rise above the surrounding wetlands, do natural elevations exceed 35 feet above mean sea level. Although it affords scant dry land for homes, roads, and businesses, the region contains 25% of the nation's coastal wetlands and accounts for 40% of all salt marshes in the lower 48 states.

1. Dunbar et al., 1992.

Figure 1. Map of coastal Louisiana

Change, sometimes on a dramatic scale, is a given in this part of the country where the Mississippi River, hurricanes, and tides have always shaped the low-lying landscape. In fact, the wetlands need periodic floods for the continued survival of their vegetation, fisheries, and wildlife.

Not surprisingly, this unique region imparts a strong sense of place to the people who live here. French speaking Cajuns, Canary Islanders, Austrians, Yugoslavians, Chinese, Germans, Greeks, Irish, Latin Americans, African-Americans, Native Americans, Vietnamese, and Italians have all created ethnic pockets in south Louisiana. Over the past 280 years, their livelihoods have evolved from farming and fisheries to focus today on international trade and the petro-chemical industry.

Throughout this evolution, coastal residents have enjoyed the benefits and wrestled with the challenges of living in a changing landscape. On one hand, they took advantage of the natural resources supplied by the Mississippi River and the coastal wetlands. Fish, shellfish, oil, gas, timber, tourism—the region seemed to provide endless ways to make a living. On the other hand, residents fought against the constraints imposed by the ecosystem, building levees to guard against flooding, draining wetlands to expand usable land, digging canals to expand drainage and navigation networks, and for access and transport of timber, oil, and gas.

When the first levees were introduced, few people realized that the wetlands needed floods to survive, and the connection between healthy wetlands and thriving coastal communities was not recognized. In recent years, however, those connections have become clear. The ways we have managed and used the coast—ranging from the construction of levees and canals and the introduction of destructive herbivores such as the nutria—have combined with the natural forces of subsidence and erosion to create a coastal crisis. *Since the 1930's, more than one million acres have disappeared, an area greater than the size of Rhode Island. Another 25 to 35 square miles of land is being lost every year.*

A century of navigation, mineral mining, and oil and gas activity have left the coast cross-cut by canals and spoil banks.

With this knowledge has come the responsibility to sustain our communities and infrastructure in ways that are compatible with a healthy marsh and a healthy coast. Such coexistence is possible; the technology exists to sustain our coast and our communities. Unfortunately, the very largesse of the ecosystem has lulled us into a false sense of security, allowing us to postpone corrective action while we live off the jobs and resources conferred by the coast's seemingly

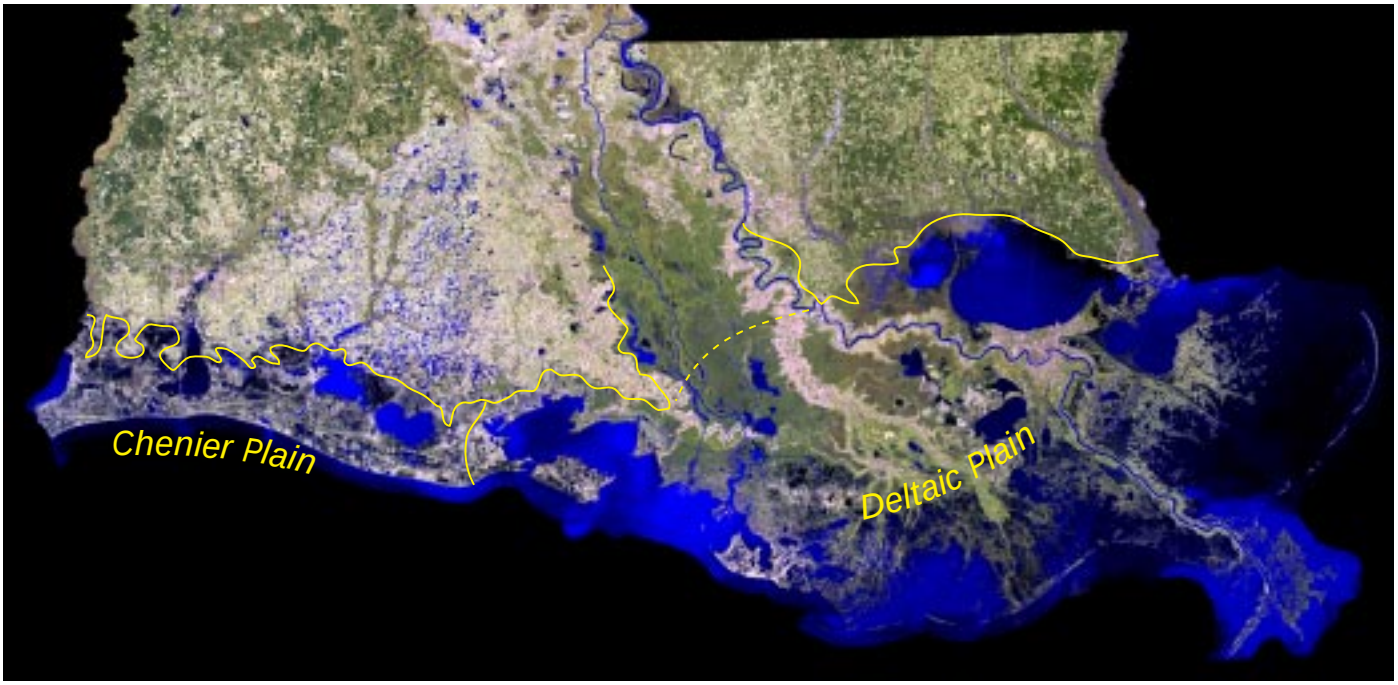
endless abundance. Like guests at a hurricane party that should have ended long ago, we see the danger signs and know that our long-term survival requires us to take action. But in the short-term, we haven't quite found the will to change the status quo.

The area at risk includes two distinct ecosystems: the Deltaic Plain and the Chenier Plain. Examining the history of human interaction with each of these ecosystems illustrates how our current situation evolved.

The Deltaic Plain

The Deltaic Plain extends northward 300 river miles, from the Gulf of Mexico to the Old River Control Structure north of New Roads, Louisiana. From east to west it stretches from the Mississippi state line, through the Atchafalaya River, to Freshwater Bayou. Its landscape reflects the cyclic nature of delta building during the past 7,000 years. Every 1,000 years or so, the river changed its course to follow a shorter route to the Gulf. Deprived of sediment, the wetlands near the old course would begin to deteriorate. Tidal channels would develop, salt water would move inland, swamps would become marsh, and marsh would become open Gulf water.

Until humans intervened, the river's spring floods left behind layers of sediment that helped build swamps and marshes. When these floods disrupted settlements along the river banks, residents built levees which in turn disrupted the natural processes that had created thousands of square miles of deltaic wetlands. As the settlers' levees lengthened and grew higher, natural outlets like Bayous Manchac, Plaquemine, and Lafourche were bottled up, largely eliminating sediment and fresh water flow in those areas.



Louisiana Oil Spill Coordinator's Office/
Coalition to Restore Coastal Louisiana

Figure 2. Satellite image of coastal Louisiana with the Deltaic and Chenier plains depicted.

Early settlers, and the people and companies who followed them, also dredged canals through wetlands for drainage and cut channels for commerce—measures that made more of the Deltaic Plain habitable, but that eventually tilted the balance toward wetland destruction.

Today, some sediment still moves into the marshes south of Venice in Plaquemines Parish, and along the margins of Atchafalaya and Four League Bays. Mud stirred up by hurricanes and winter cold fronts is also carried into shallow bays and adjacent wetlands from the Gulf, a process that is critical for maintaining saline and brackish marshes.[5] However, in many places canals, artificial banks, and levees prevent water and sediment from reaching wetland plants.[6] Examples of this process are the high levees bordering the Mississippi River, built by the federal government to facilitate navigation and protect communities from river floods, which channel most of the river's sediment off the continental shelf and deep into the Gulf.

In addition to sediment loss, the interior basins of the Deltaic Plain receive much less fresh water than in the past. Consequently, the once abundant swamps and freshwater marshes are being replaced by open water at alarming rates.[7] Scientists estimate that the Deltaic Plain is losing 23 square miles per year.[8]

The Chenier Plain

The narrow band of the Chenier Plain begins at Vermilion Bay and extends west into Texas.

Like the Deltaic Plain's mud flats, the Chenier Plain was built by the cycles of the Mississippi River. When the river followed a westward path, it deposited a great deal of mud on shore, forming mudflats that were later stabilized by marsh plants. Oak trees (chenes in French) grew on these beach ridges, giving the region its name. As the river switched channels and occupied an eastern path, this westward flow of mud lessened. When the Mississippi River moved to the east, this western coastline eroded; waves swept the shell and sand into the chenier beach ridges that are inhabited today.

Settlers used the higher natural levees of the Deltaic Plain to raise sugar cane and build cities. Settlers in the Chenier Plain, by contrast, used the beach ridges for living space and agriculture. The region's limited population focused on fishing, trapping, farming, and raising cattle. In more recent years, employment has centered on recreation and offshore oil industries.

Rises in Relative Sea Level Add to Impact

In the Mississippi River's Deltaic Plain, land settles or subsides at different rates, depending on the underlying deposits laid down in the past.[2] As a result, relative sea level rises at varying rates.

At the mouth of the Mississippi River, for instance, relative sea level rise approaches one inch per year, while the rest of the Deltaic Plain probably experiences about 0.5 inch per year.[3] These estimates include the 0.04 to 0.08 inches per year true sea level increase recorded during the past 50 years worldwide.[4] Most of this relative sea level rise, however, is due to the sinking of deltaic land (see note below). Together, sinking land and true sea level rise allow salt water to invade, killing marsh plants and eventually converting the land to open water.

NOTE: Relative sea level rise includes the effects of two factors: (1) land sinking, and (2) sea level rising. True sea level rise is the amount of rise caused only by higher water

2. Penland et al., 1989.
3. Ramsay, 1991; Turner, 1987.
4. Gornitz et al., 1982.
5. Reed, 1991; Cahoon, et al., 1995.
6. Turner, 1987.
7. DeLaune et al., 1983; Nyman et al., 1993
8. Britsch and Dunbar, 1993.

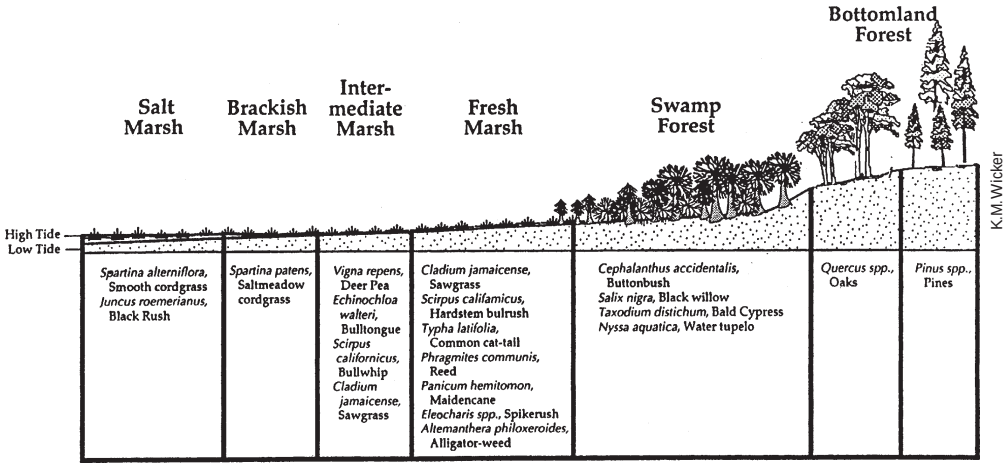
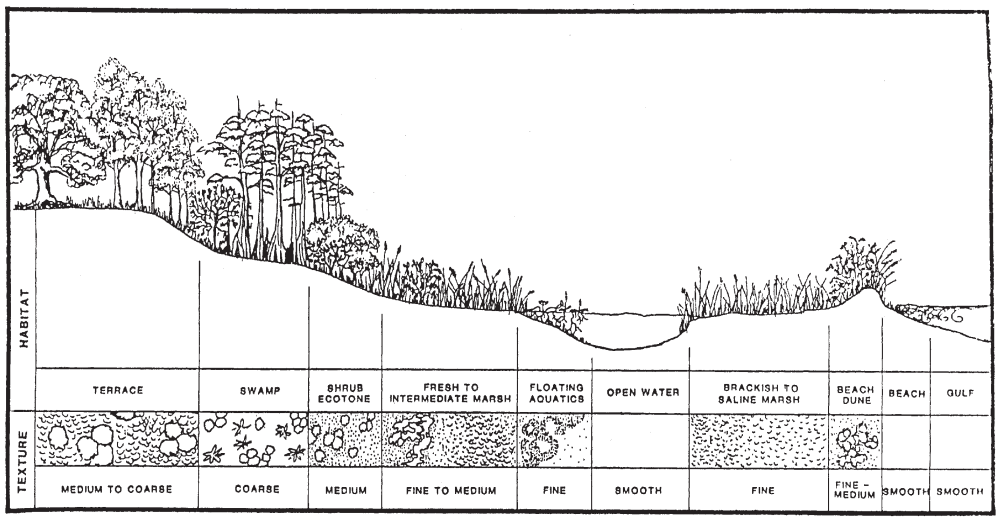


Figure 3. Cross section of Deltaic Plain habitat types.



Coastal Restoration Task Force

Figure 4. Cross section of Chenier Plain habitats.

Marshes, located behind chenier ridges in a zone that was protected from Gulf waves and water, offered habitat to ducks, geese, and fur-bearing animals. Although three rivers passed through the cheniers, limited salt water reached the marshes, and the area behind the cheniers remained a fresh water system for centuries.

In time, efforts to open and maintain navigation channels to the Gulf disrupted the Chenier Plain's stable wetland system. Dredged ship channels allowed salt water into previously isolated freshwater marshes, particularly during hurricanes. From the 1950's to the 1960's, vast expanses of freshwater marshes in the western part of the Chenier Plain converted to open water. In more inland areas to the east, marshes bordering large lakes flooded and eroded as water levels and wave energies increased. Today, the eastern end of the Chenier Plain is again gaining land mass as the Atchafalaya River deposits sediments that form the basis for new land.[9] The western part of the Chenier Plain shoreline receives no such infusion of sediment. *All told, the entire chenier coast is losing land at a rate of 7.7 square miles per year.*[10]

Together, the Chenier and Deltaic Plains are losing an average 30.7 square miles a year.

9. McBride and Byrnes, 1995; Huh et al., 1991; Kemp and Wells, 1986.

10. Britsch and Dunbar, 1993.

Chapter 2: The American Atlantis

50 and 100 Year Projections of Land Loss

The legend of Atlantis—an advanced civilization that sank beneath the sea thousands of years ago—may be a myth, but it has a haunting familiarity for those who live in south Louisiana. Like Atlantis, Louisiana south of I-10 is slowly sinking into the sea, and the region's infrastructure, economy, and way of life are disappearing with it.

This assessment is supported by new computer projections that offer a sobering glimpse of how coastal Louisiana will look in the next century if we fail to implement a full scale coastal restoration program.

These projections extrapolate from historical land loss rates, using a conservative approach that does not figure in potential sea level rise from global climate change. The projections show that Gulf waters will be one foot deeper at the Louisiana coast by the year 2050 and two feet deeper by the year 2090. Because 90% of the coast is less than three feet above sea level, an extra one or two feet will have a drastic effect. Current estimates predict that nearly 640,000 acres, an area nearly the size of Rhode Island, will be under water by the year 2050.[1]

The projections tell us that in 50 years, integral parts of south Louisiana will be open water. This land is not only an important habitat for fish and wildlife; it provides an indispensable storm buffer for cities, towns, transportation routes, and energy infrastructure. In addition, most of this land is privately owned and provides revenues for local tax bases.

Two important points about the projections should be noted. First, they do not present a worst case scenario. The assumptions underlying the figures are so conservative that the maps may actually show the best scenario that can be expected.

Projections by the U.N. Intergovernmental Panel on Climate Change state that global sea-level could rise twice as much as the localized relative sea-level rise shown in these models.

Second, these predictions outline what will happen *if we do not change our present course*. Unlike the fabled residents of Atlantis, we have the technology to save a substantial part of the coast—and possibly achieve a net gain over our current acreage—if we implement a program of full scale coastal restoration.

1. Louisiana Coastal Wetlands Conservation and Restoration Task Force and the Louisiana Wetlands Conservation and Restoration Authority, 1998.

About the Land Loss Projections

The projections were developed by Louisiana State University and the U.S. Army Corps of Engineers. The projections incorporate the best available historical land loss data (between 1974 and 1990), as well as the best current predictions of benefits that will be realized from coastal restoration projects currently underway or authorized. In the resulting maps, red shows land to be lost, and black shows land to be gained from restoration projects.

The projections only consider historical rates of sea level rise and subsidence. They do not take into account possible increases in sea level rise due to global climate change. This decision was made not because the authors doubt that global climate change exists, but because the report team wanted to use information that could be locally verified. By choosing to use such an approach, however, the projections run the risk of painting a more optimistic picture than is truly warranted.

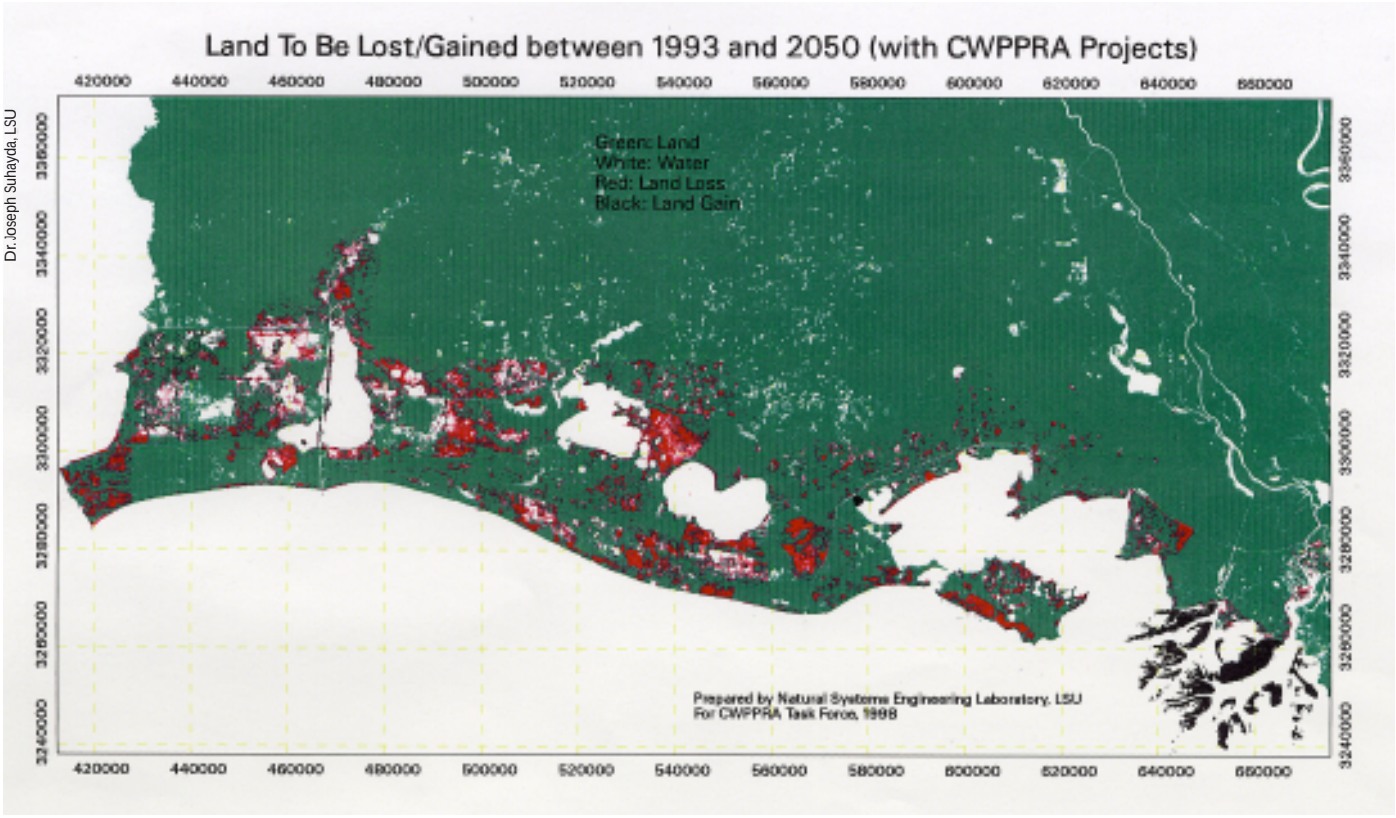


Figure 5. Projected land loss (and gain), chenier coast and Atchafalaya delta, to year 2050.

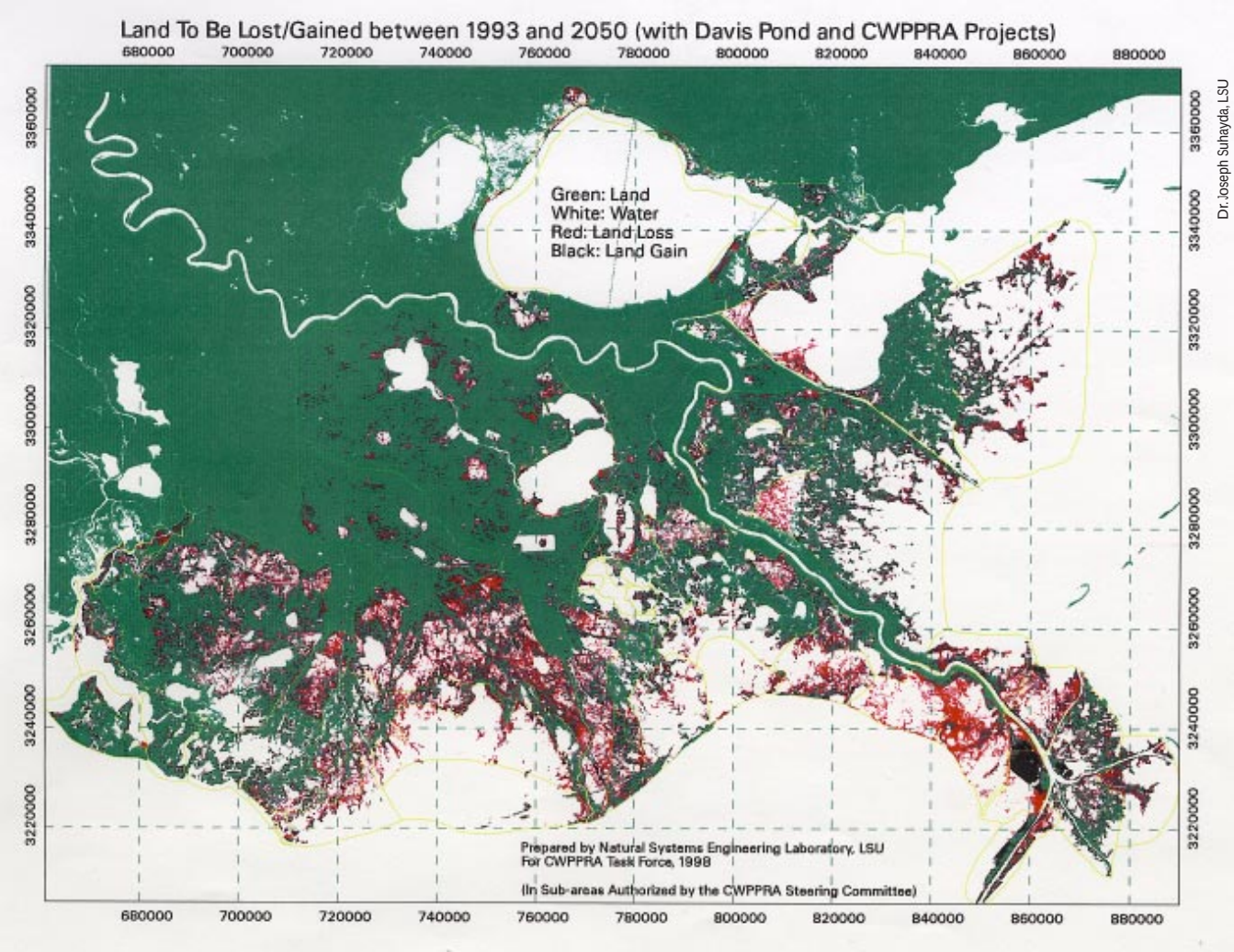


Figure 6. Projected land loss (and gain), eastern Deltaic plain, to year 2050.

Chapter 3: Costly Consequences

Why Everyone Pays When Louisiana Loses Wetlands

Compared to the Great Lakes, the Florida Everglades, the Brazilian rain forest, or even Walden Pond, Louisiana's disappearing coast has received little national attention. Perhaps that is because the land is eroding gradually, without the dramatic losses of life and property associated with traditional catastrophes. But even if its effects do not yet resemble those of an earthquake or a killer storm, the loss of Louisiana's wetlands is a national calamity. Louisianians will face disastrous consequences as communities, jobs, and entire industries are reconfigured and abandoned. Commerce and communities throughout the U.S. will incur billions in unforeseen costs. In short, the nation is facing an ecosystem collapse in south Louisiana, and the cost of inaction is high.

Oil and Gas Infrastructure at the Breaking Point

Summary

The United States depends on the oil and gas shipped through and produced in Louisiana's coastal zone. The digging of a vast network of canals to facilitate the extraction of these minerals has contributed significantly to the deterioration of the state's coastal wetlands.[1] However, because wetlands and barrier islands protect billions of dollars worth of oil and gas infrastructure from wave and storm damage, this disappearing land is a key part of the nation's energy system. If we do not change our present course and stop Louisiana's land loss, citizens, government, and especially private industry will pay a high price.

- The land-based support center for Gulf of Mexico oil and gas exploration will become open water. Billion dollar facilities will have to be rebuilt in Mississippi, Texas, or further inland in Louisiana.
- Private oil and gas producers will face unprecedented liability risks as more intense wave action increases chances of oil spills, ship collisions with exposed pipelines, and fisheries contamination from pollution associated with malfunctioning wells.
- Louisiana could lose 55,000 jobs and billions of dollars of spin-off revenue.

1. Penland et al., 1996.

What We Could Lose

No other issue demonstrates the nation's dependence on Louisiana wetlands like oil and gas. Businesses pull approximately 17% of the nation's oil and 25% of the nation's natural gas from Gulf waters. This represents hundreds of millions of barrels of oil and billions of cubic feet of natural gas.

Given the vagaries of Louisiana's oil and gas industry, some prefer not to use the word "boom" to describe the recent upswing in offshore oil and gas production that occurred in the mid 1990's. Semantics aside, the numbers show that a world wide rush is on for the hydrocarbons trapped under Gulf waters. Even when recent declines in oil prices are considered, technological innovations have lowered exploration costs and expanded ten-fold the amount of reserves that can be extracted by a single well. Ninety-three deep water drilling prospects have been identified in the Gulf as of October, 1997; 11 of these prospects were identified in the first eight months of 1997.[2]

No matter how abundant the offshore reserves might be, they are worthless unless they can be processed on shore. As of 1997, there were more than 20,000 miles of pipelines in federal offshore lands and thousands more inland, many of which make landfall on Louisiana's barrier islands and wetland shorelines. In addition to serving as pipeline anchor points, wetlands protect pipelines from waves and insure that the lines stay buried and in place.

Wetlands also shelter the ports and waterways used by the oil and gas industry to conduct daily business. Construction crews use navigable waterways such as Bayous Boeuf, Black, Chene, and Lafourche, the Atchafalaya River, and especially the Houma Navigation Canal as routes for shipping pipes, platforms, and other large equipment to the Gulf. Port Fouchon and Morgan City have experienced unparalleled industrial growth in recent years as support centers for the oil and gas industry. Louisiana's wetlands and barrier islands protect all of this infrastructure from storm and wave damage.

Coalition to Restore Coastal Louisiana

Canals and spoil banks create barriers to natural water flows and drainage.

Even Louisiana's offshore port, the Louisiana Offshore Oil Port (LOOP), depends on onshore infrastructure that is protected by wetlands. Without this protection, the nation would lose an essential trade and navigation center that would affect commerce throughout the world.

The lure of mineral fortunes attracted a record number of bids ($1.2 billion) at the 1997 federal offshore lease auction in New Orleans. That is a small figure compared to the billions of dollars

2. Falgout, 1997.

in new investment being funneled through enterprises on Louisiana's coast. For example, one company has just completed construction of a $35 million facility at Port Fouchon and is about to build another.

Market analysts predict that a high level of exploration could last 10 years, but only if growing industries can secure dependable infrastructure for transporting people, equipment, oil, water, and natural gas to and from production sites. Wetlands and barrier islands are the key to protecting this infrastructure and the economic powerhouse that has taken up residence on Louisiana's doorstep.

The success of Louisiana's oil and gas industry contributes billions to the state and national economy each year. Offshore producing companies paid an estimated $2.4 billion—nearly $1,000 for every person living in the state—to vendors and contractors in 165 different Louisiana communities during 1992. Nearly 4000 vendors serving offshore operations employ an estimated 55,000 people, and this number is increasing rapidly.[3] In addition, more than 30,000 people are employed offshore.

The Threat

As wetlands and barrier islands erode, oil and gas infrastructure will be exposed to open water and increasingly susceptible to storm damage. For example, Highway 1 south of Golden Meadow is on the verge of crumbling under the strain of the thousands of trucks that pass over it each month, not to mention the high tides and floods that regularly render it impassable. This highway is the only road into Port Fouchon, a facility that is scheduled to provide logistical support to 75% of the deep water drilling prospects in the Gulf. With its Gulf coast location and deep water access, Port Fouchon is well situated to provide these services. But without a fully functioning highway that allows secure transport to and from its facilities, Port Fouchon will be unable to meet the needs of the offshore industry.

More than 3000 oil and gas wells and production facilities are buffered from open water conditions by marshes and barrier islands.

Aside from the daily wear and tear imposed by coastal erosion, random events like hurricanes also threaten oil and gas investments. In 1992 Hurricane Andrew damaged 40 to 50 oil and gas platforms in what had once been protected bays behind the barrier islands. At the time of the storm, these barrier islands, though somewhat eroded, were still intact. If the barrier islands erode

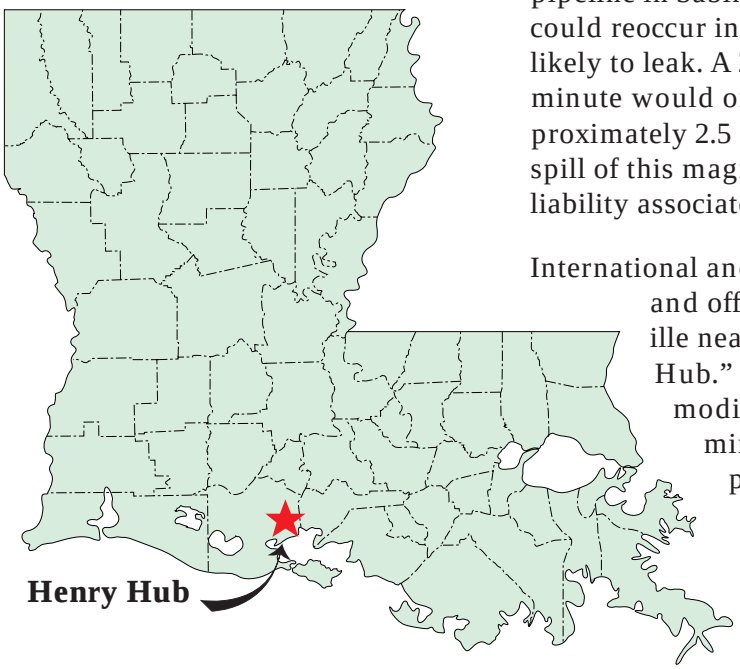
3. McKenzie and Davis, 1994.

entirely in the next 50 years as is projected, platforms, pipelines, and wells will be damaged or destroyed in increasing numbers.

The problems associated with oil production facilities offer an example of the risks involved. Over 58% of the region's production wells are located in coastal parishes; most of the wells are already more than 50 years old. These wells were designed to maximize oil and gas production and not to withstand the rigors of the open water conditions they could face in the next few decades.

Can wells built according to traditional specifications withstand the environmental pressures that may be in store for the region? Although some wells are more vulnerable than others, all would be threatened by a Category 4 or 5 hurricane, particularly if the winds were sustained inland. With more than 30,000 wells at risk within the 25-parish coastal area, environmental liability becomes an issue. The coastal region is a major fishery, and owners of these wells must consider whether damaged wells could spur lawsuits and charges of poor stewardship.

High pressure pipelines offer other safety and liability problems. As wetlands disappear, and pipelines are exposed to more waves and storms, it becomes increasingly likely that the lines will pose a danger to passing ships. This unfortunate scenario occurred in 1988 when 12 men burned to death after their ship struck an exposed pipeline in Sabine Pass. The trends suggest that this kind of accident could reoccur in coming years. Exposed pipelines are also more likely to leak. A 24-inch pipeline that carries 1000 barrels of oil per minute would only have to be broken for one hour to dump approximately 2.5 million gallons of oil into the wetlands. Although a spill of this magnitude is unlikely, the environmental damage and liability associated with such an incident make it worth considering.



International and national markets face risks as well. Many onshore and offshore pipelines meet southeast of the city of Abbeville near Henry, Louisiana, at a point called the "Henry Hub." This gauging station serves as the industry's commodity marker, and national market prices are determined every day based on how much natural gas passes through the "Hub." If this system is disrupted because of hurricane damage or flooding—even for just a few days—the futures market and refinery industry will react, causing widely fluctuating prices that will affect economies world-wide.

What Is the Pricetag for Maintaining the Status Quo?

If projections for future land loss in Louisiana come to pass, what is now the land-based support center for the Gulf of Mexico's oil and gas industry will become open water. New anchor points will have to be created for the vast network of pipelines. Ports, construction sites, and transportation routes will have to be rebuilt in Mississippi or Texas—an effort that will cost billions of dollars.

Private firms will face a choice: either upgrade wells, rebury pipelines, and fortify oil platforms to meet open water conditions, or allow costly investments to deteriorate and possible disruptions in operations and increased liability for damage caused by spills and public relations problems associated with damaged equipment. Since many firms that operate in coastal waters make sound environmental management a cornerstone of their corporate images, this choice will test their commitment to true long-term stewardship. Just reburying pipelines alone will cost hundreds of millions of dollars.[4] But this cost pales in comparison to the price of an oil spill cleanup, a task that will be increasingly necessary as exposed pipelines rupture and leak. Texaco's 1997 spill in Lake Barre cost the company $10 million in two weeks, not counting $1 million in pipeline repair costs.[5]

If the oil and gas industry is forced to forsake Louisiana for regions where its infrastructure is better protected, our state could lose at least 55,000 jobs and billions of dollars in spin-off revenues.

Shipping Takes a Blow: Ports and Navigation Channels at the Mercy of the Waves

Summary

Louisiana's wetlands and barrier islands protect navigation channels, anchorages, and waterways from winds and waves. *If we do not change our present course*, the state's nationally important port system is at risk.

- 155 miles of waterways will be exposed to open water in 50 years.
- Billions of taxpayer dollars will have to be spent on increased dredging and maintenance costs.
- A key national port system will be impaired, and businesses throughout the country could lose their preferred links to European and Pacific Rim markets.

What We Lose

Louisiana's easy-going reputation doesn't reflect the bustling activity of the state's port system, a group of facilities that allows the U.S. to compete in world markets. Four shipping facilities—the Port of New Orleans, the Port of South Louisiana, the Port of Greater Baton Rouge, and the Port of Lake Charles—together handle 20.4% of the nation's foreign waterborne commerce.[6] The tonnage handled by ports between Baton Rouge and New Orleans is the largest in the world.

4. Holder, 1997.

5. Straatmann, 1997.
6. Duffy, 1996.

Forty-one percent of the markets in America's heartland depend on the international trade conducted in coastal Louisiana.[7] In 1994, ports in Minneapolis alone exported more than 70 million tons of food and farm products and imported 59 million tons of petroleum and petroleum products (13.6% of U.S. waterborne imports) through facilities on the lower Mississippi River.[8]

The Baton Rouge-New Orleans port complex serves the eastern part of the country as well. For example, coal terminals along the Mississippi River handle the majority of steam coal exported from the U.S.[9]

Louisiana also operates the only superport in the contiguous U.S. The Louisiana Offshore Oil Port (LOOP) handled over 300 million barrels of crude oil from 279 tankers during 1996. About 13% of the nation's daily crude oil imports enter through this port, which has pipeline connections to 30% of the U.S. refining capacity.[10]

In the first six months of 1996, exports moving through Louisiana increased 9%, giving the state the third largest year-to-year gain in exports. From January through September, 1996 Louisiana exported $16.62 billion worth of goods, including

- $9.3 billion in agricultural products
- $1.4 billion in food and related products
- $2.4 billion in chemicals
- $816 million in petroleum and coal
- $374 million in industrial machinery
- $284 million in paper and related products[11]

The state's shipping industry delivers substantial benefits to local citizens. Louisiana ports provide more than 94,000 jobs.[12] Of these, 51,000 jobs representing $1 billion in earnings stay in the New Orleans metropolitan area.[13] In 1994, the Port of New Orleans alone generated more than $125 million in state and local taxes, and $4.5 billion to the local economy. The port's facilities are worth more than $700 million.

7. Davis, M., 1997.
8. Duffy, 1996; Port of New Orleans, 1996.
9. Port of New Orleans, 1996.
10. Office of Planning and Budget, 1997.
11. Sayre, 1997.
12. Office of Planning and Budget, 1997.
13. Port of New Orleans, 1998.

International commerce thrives in Louisiana because of several advantages, all of them protected by coastal wetlands and barrier islands. These advantages include:

- A protected anchorage 230 river miles inland (the Port of Baton Rouge) shelters vessels from hurricane storm surges.
- Large tracts of land, abundant natural gas, and freshwater provide industries with the space and resources to grow.
- Railroads, interstate highways, and an east to west canal system reduce shipping time and costs.

The Threat

The history of two waterways—the Gulf Intracoastal Waterway (GIWW) and the Mississippi River Gulf Outlet (MRGO)—illustrates the importance of the natural protection offered by wetlands and barrier islands, and the consequences of disregarding that protection.

As an east-west connector of international ports, the GIWW has been a work in progress for over a century. In its first incarnation, the project was dug out of natural bayous, lakes, and bays. But the project's builders soon learned that dredging channels in these open waters caused problems. Storms not only churned the lakes and bays until they became too rough for barge traffic, but waves and currents filled the channel with sediment. Maintenance dredging became a costly, perpetual requirement.

The waterway needed a better location, and in 1942, the U.S. Army Corps of Engineers moved segments of the project to the wetlands along the northern edge of the marshes.[14] There the Corps could dredge into the older Pleistocene sediments and avoid open lakes and bays.[15] In essence, the Corps was using the wetlands' ability to buffer storm surges and tides in order to protect its new navigation channel.

The new location was a success. Completed in 1949, the GIWW carries barges of crude oil, petroleum, bulk cargoes, and miscellaneous items along a 12-foot deep channel protected from the storms, waves, and winds of the Gulf of Mexico. In 1994, vessels navigating the GIWW between the Harvey Canal in New Orleans and the Sabine River in Texas carried more than 67 millions tons of goods, including 36.1 million tons of petroleum and petroleum products, 12.8 million tons of chemicals, and 1.9 million tons of food and farm products.

14. U.S. Senate, 1946.

15. Gould and Morgan, 1962.

Louisiana Oil Spill Coordinator's Office/
Coalition to Restore Coastal Louisiana

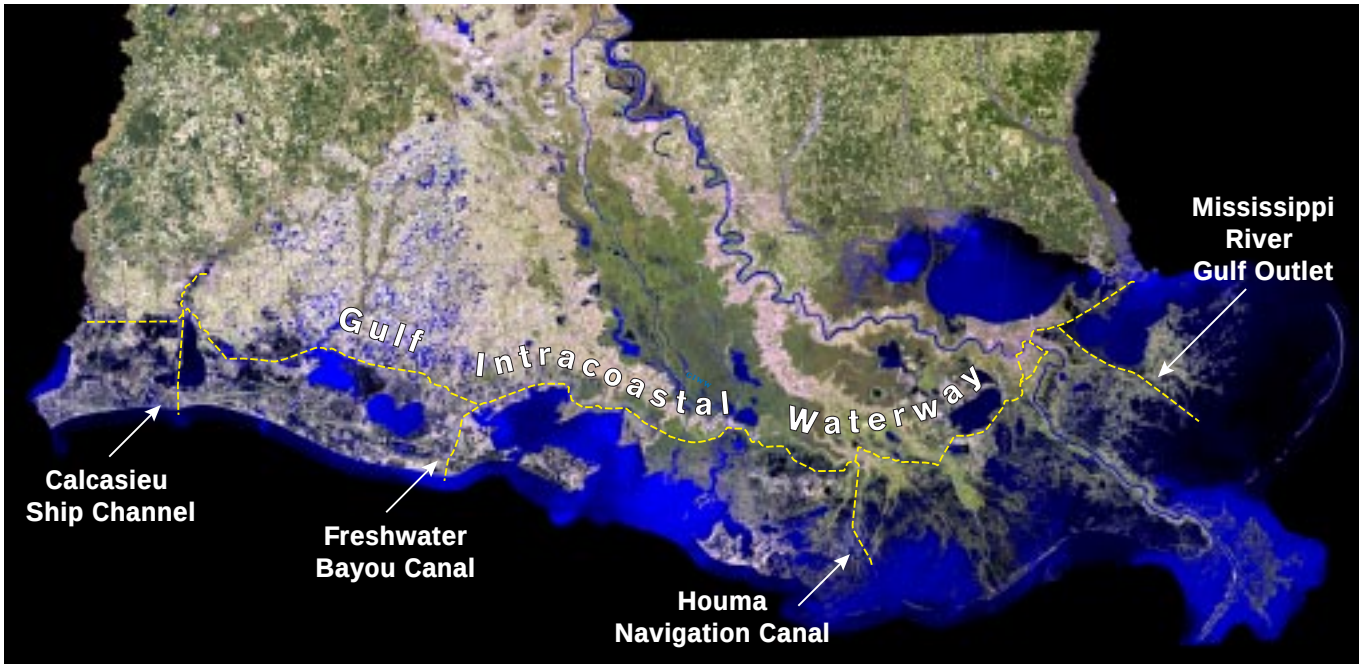


Figure 7. Coastal waterways.

The MRGO depends on wetlands protection as well. In the 1920's and 30's officials began searching for a direct inland route to the Gulf that avoided dangerous delta sands, river currents, and spring floods. In 1963, the Corps opened a new channel through the wetlands of St. Bernard Parish because the vegetation offered natural protection from wind, waves, and storms. During the next 30 years, the MRGO itself became a source of land loss and saltwater intrusion.

Maintenance dredging has always been a necessity, particularly in areas such as Breton Sound where the channel crosses open water. In these areas, the Corps annually removes about seven cubic yards of material for every cubic yard of material removed from more sheltered wetland areas.[16] As a result of increasing erosion, the main channel has widened from 500 to 2000 feet. With economic returns remaining minimal, and concerns growing over an eventual hurricane strike in St. Bernard Parish, a consensus is building for closing the MRGO.[17]

16. Howard et al., 1984.

17. Schleifstein and Darce, 1998.

The GIWW, MRGO, and other navigation channels are sheltered within the wetlands to reduce dredging costs. If these wetlands disappear during the next 50 years, the waterways will be exposed to the same kinds of winds, waves, and currents that forced the Corps to relocate the GIWW in 1942. Inland waterways could then merge with lakes or the Gulf of Mexico, mandating more frequent maintenance dredging, modification of barge handling procedures, more risk from rough weather, and greater protection of port infrastructure. In all, 155 miles of waterways could be exposed to open water in 50 years, if current projections hold.[18]

The growth of Louisiana's port system will also be limited by land loss. As container ships grow in size and require ever larger facilities, the Port of New Orleans is eager to obtain more capacity closer to the mouth of the Mississippi River.[19] The Port of New Orleans is considering construction of a new facility in this region called the Millennium Port. But as wetlands erode, the river's mouth will quickly become an exposed peninsula. Without the protection of wetlands, any new facility will be more vulnerable to storm damage. A jeopardized coast thus threatens our nation's ability to compete in the global economy.

What Is the Pricetag for Maintaining the Status Quo?

Since 1996, $112.5 million has been appropriated from the state's Transportation Trust Fund for improvements to port infrastructure.[20] Unfortunately, this sum cannot begin to address the problems that coastal erosion will impose on state ports. Maintaining 155 miles of waterways in open water conditions will cost billions of dollars. These funds will have to be supplied by taxpayers, as the federal government replaces the functions once performed for free by wetlands.

If a national mandate for supporting Louisiana's port system cannot be galvanized, the navigation routes will become inoperative. At that point, not only will port communities feel the loss of thousands of jobs and millions of dollars in revenue, but the nation will feel immediate effects.

- Midwest farmers will lose their preferred link to European and Pacific Rim markets.
- Automobile dealers will pay more for imported cars.
- As shipping costs rise, the price of gasoline and diesel fuel will increase.

18. *Louisiana Coastal Wetlands Conservation and Restoration Task Force, 1993.*
19. Darce, 1998.
20. Office of Planning and Budget, 1997.

Empty Nurseries: The Growing Threat to Fisheries

Summary

Louisiana's wetlands provide critical habitat and food resources for some of our nation's premiere recreational and commercial fisheries. Barrier islands and wetlands form natural barriers that slow the movement of fresh and ocean waters into the estuaries, thus producing environments of different salinities. This pattern of salinity gradients within an estuary is the foundation for sustaining biological productivity. Wetlands are also natural filters of sewage and other pollutants. As wetlands disappear, the potential for pollutants reaching and impacting our fisheries increases. *If we do not change our present course* and stop Louisiana's wetlands and barrier island losses, a significant part of our nation's fisheries are at great risk.

VOLUME

(figures are in millions of pounds)

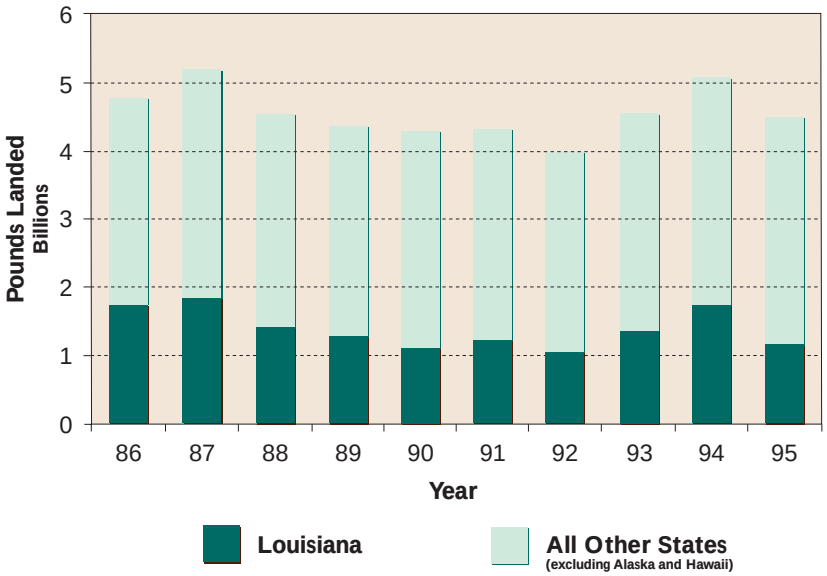
Port	1998
Dutch Harbor, AK	597.1
Reedville, VA	509.0
Kodiak, AK	357.6
Empire-Venice, LA	**328.0**
Seattle,WA	312.8
Cameron, LA	**257.4**
Intercoastal City, LA	**206.7**
Pascagoula-Moss Point, MS	193.2
Morgan City-Berwick,LA	**158.6**
Los Angeles, CA	145.3

National Marine Fisheries Service

What We Could Lose

Thanks to Louisiana's barrier islands and coastal marsh, the state's commercial and recreational fisheries are among the nation's best.

- Louisiana's commercial fisheries are the most bountiful of the lower 48 states,[21] providing 25 to 35% of the nation's total catch.
- Louisiana's catch is first or second in dollar value in the lower 48 states; $290,576,000 was paid directly to the commercial fishers at the dock in 1995.[22]
- Louisiana is first in annual harvest of men haden, oysters, and crabs. The state is also a top producer of shrimp.
- Barrier islands and wetlands buffer inland waters from wind-generated rough seas. A significant part of Louisiana's fishing fleet is shallow draft vessels built for harvesting in inland waters. As these natural wind barriers are lost much of Louisiana's fishing fleet is at risk.
- Louisiana offers some of the best recreational saltwater fishing in North America.



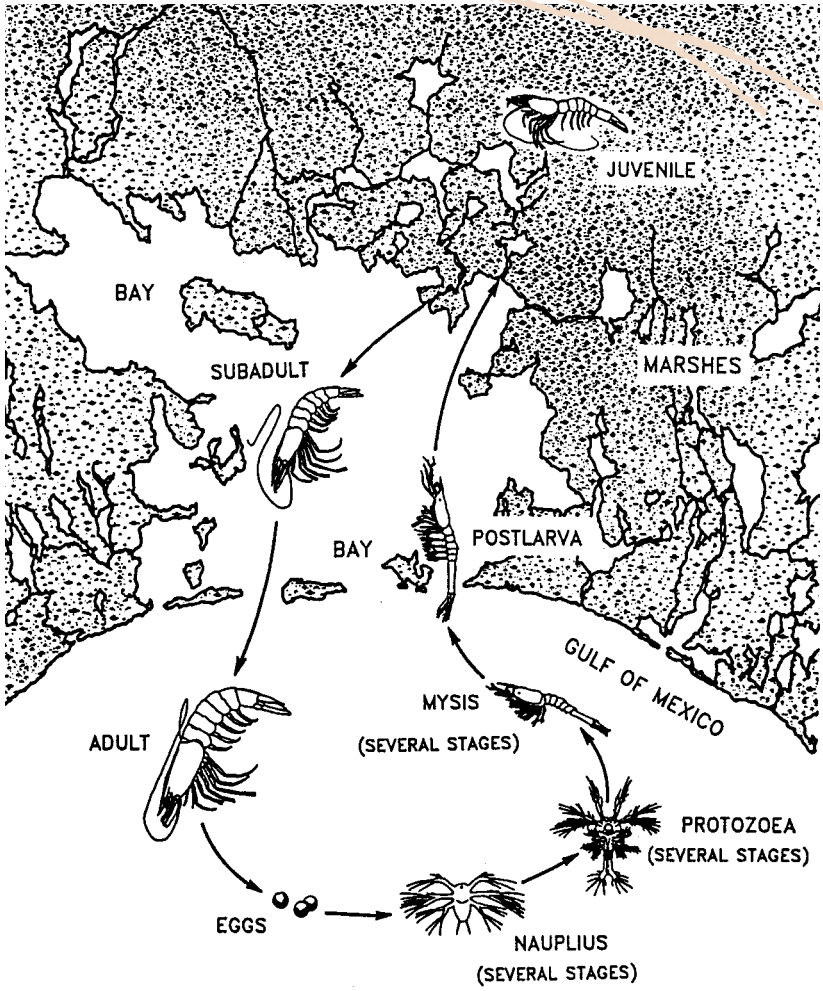
National Marine Fisheries Service

Figure 8. U.S. commercial fisheries landings in the contiguous 48 states and at the top 10 ports in the nation.

21. National Marine Fisheries Service, 1997. 22. Ibid.

Louisiana's fisheries abundance is generated by the several million acres of coastal marsh that is used as a nursery by young fish and shellfish. Most of the land that supports emergent vegetation is broken up by an intricate, open-water network of small to expansive shallow areas (mostly less than two feet deep), shallow channels, and canals. Reference to Louisiana's coastal marsh thus includes both the land supporting emergent vegetation and the open-water network within it. This marsh runs in a continuous band, up to 60 miles wide, from Texas to Mississippi (see Figure 1). Most of it functions as an estuarine nursery. Because the tidal range is only about a foot, fish and crustaceans using the open water areas are seldom forced to leave them at low tide.

Most of the coastal aquatic species sought by Louisiana sport and commercial fishers are estuarine and wetlands dependent during all or part of their life. Shrimp are a good example of this. The eggs are shed in the Gulf of Mexico, hatch, and the larvae begin to drift shoreward with the currents. They enter the large open-water bays and the larvae or small juveniles drift or swim far into the marsh, their primary nursery. There they grow rapidly and in a few weeks or months begin to move gulfward as juveniles or subadults. Many other species of more ecological than sport or commercial importance such as cocahoe minnows, bay anchovies, and fiddler crabs, spend most, if not all, of their life cycles in the marsh. Most members of this group serve as a food source for the economically important species.



Michelle Lagory

Figure 9. Life cycle of shrimp of the southern U.S. Atlantic and northern Gulf of Mexico. Although fish undergo fewer morphological changes, these life cycle movements are characteristic of most economically important estuarine-dependent species in this area.

Scientists used a trap system to continuously monitor the movement of species through the only outlet to an 87-acre marsh pond in southwestern Louisiana. The system allowed larvae and small juveniles to enter the pond, but captured all organisms leaving the pond that were too large to pass through 1/4-inch wire mesh. In the two-year study, more than 100 species of fishes and crustaceans, and over 11 million individual organisms were taken. Five commercial species accounted for over eight million of the animals captured (figure 10).

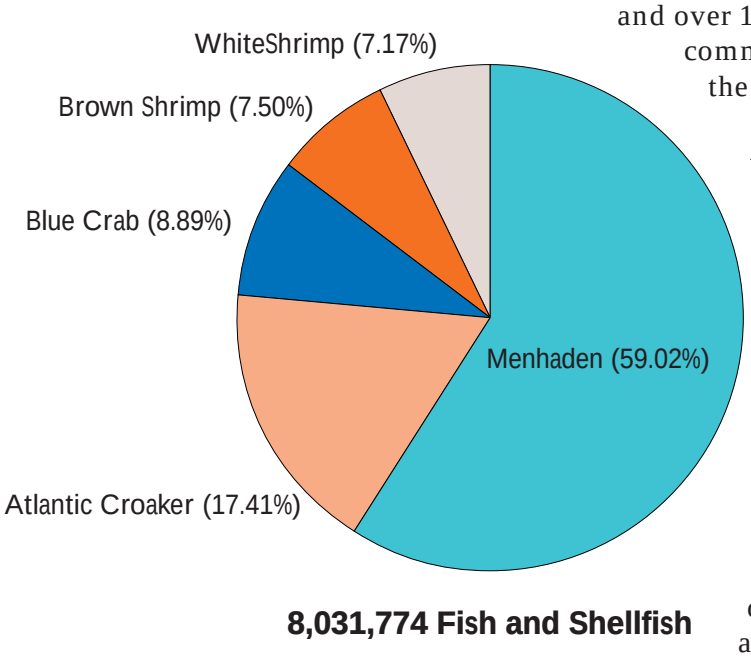


Figure 10. The five most abundant commercial fish and shellfish taken.[23]

Another commercial species inhabiting the estuary is the oyster. Louisiana annually produces approximately 25% of the nation's oysters, ranking it first in oyster production. The oyster requires a specific combination of environmental conditions for survival and growth. The inability of the adult oyster to move, combined with its specific environmental needs, makes it useful as an indicator of change within an estuary. When all other environmental conditions are met, the prevailing salinity within Louisiana's estuaries becomes the determinant for subtidal oyster survival. The oyster requires between 25 and 50% of ocean salinity. Waters are too fresh for growth and reproduction when salinities are consistently below 25% of ocean-strength water, while salinities greater than 50% ocean water introduce predators and disease that can quickly decimate an oyster population. For oysters to survive in commercial numbers to supply the nation, there is a need to maintain a balance between fresh and salt waters.

Louisiana's wetlands and barrier islands moderate the effects of encroaching ocean salinities from the Gulf of Mexico and the outpouring of fresh waters from the head of estuaries. Louisiana's Barataria-Terrebonne estuary is a good example of how an intermediate salinity is important to oyster survival. The most productive oyster zone in this region reaches all the way to the coast where barrier beaches and interior wetlands are present, but regresses inland where barrier islands, barrier beaches, and interior wetlands have eroded, thus allowing high-salinity ocean water to move inland.[24] In addition, freshwater introduced from the northern areas of the basins by precipitation and bayou discharge is filtered by the wetlands, thereby removing pollutants before reaching the oyster beds.

23. Herke et al., 1992.

24. Melancon et al., 1994.

Recreational fishing is very important to Louisiana; in fiscal year 1996-97, a total of 296,959 residents and 40,859 non-residents purchased recreational fishing licenses allowing them to fish in salt water. (Residents under 16 and over 59 do not need a license.) As used by economists, the term "total economic effect" means the total economic ripple effect created by successive rounds of retailer, manufacturer, and other expenditures. In 1996, Louisiana saltwater recreational fishing had a total economic effect of $944,000,000 (figure 11). The top five species taken by these anglers are all estuarine-dependent. The total economic effect of commercial saltwater fishing in Louisiana in 1996 was even higher—$2,604,500,000.

The top four groups in Louisiana's salt water commercial catch, in descending order of dollar value are: shrimp, menhaden, oysters, and blue crabs. Some say that since menhaden are not used for human consumption in the U.S., a decrease in their landings results in no loss to them. But many of these same people probably eat a fair amount of chicken, pork, beef, and dairy products. What they probably don't realize is that the menhaden catch helps keep the price down on these food products.

Nearly a billion pounds of menhaden are landed annually in Louisiana for conversion into fish meal, oil, and solubles. Annual production amounts to about 400 million pounds of meal and solubles. They are relatively inexpensive, nutrient-rich ingredients for poultry, hog, mink, cattle, aquaculture, and pet feeds. Thus, decreased menhaden landings will result in consumers paying higher prices for these products. The oil is used in cooking and baking fats, margarine, paint, and water resistant coatings. Also, the meal and oil constitute a significant portion of total U.S. fisheries export volume. Decreased menhaden landings thus will hurt the U.S. trade balance.

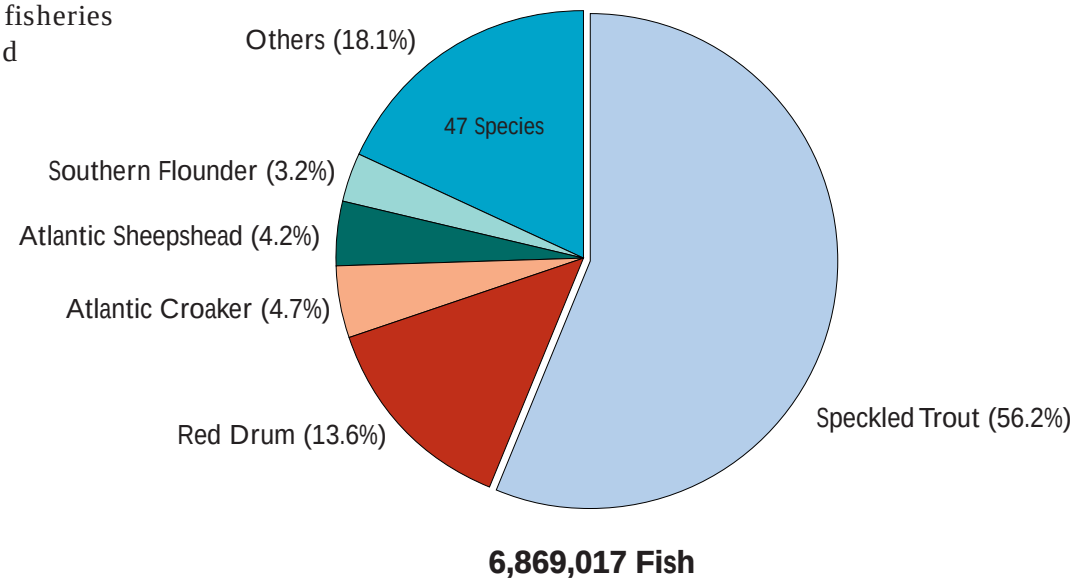


Figure 11. Top 5 recreational species in coastal Louisiana.[25]

25. Southwick Associates, 1997;
Louisiana Department of Wildlife and Fisheries, 1996.

The Threat

Putting a cumulative dollar value on lost fisheries production due to wetland loss over the next 50 years is complicated by the nature of the aquatic food web. Louisiana's coastal aquatic productivity is intricately tied to production of detritus in the wetlands. Detritus originates mostly from the decomposition of marsh vegetation after it dies annually. The detritus is fed on by microorganisms, which are fed on by zooplankton, which are fed on by small fishes and crustaceans, and so on up the food web.

A deteriorating marsh results in an increase in the land / water interface, thereby increasing detrital export to the water. This increased export of detritus stimulates fisheries production. However, this effect will be temporary because marsh acreage is decreasing. The process is analogous to having sufficient capital in the bank. As long as the capital is not withdrawn, it is possible to live off the interest. Greater annual income can be temporarily obtained by withdrawing the interest and some of the capital. But this decreases future annual interest. If continued, income eventually crashes. Most fisheries scientists believe that Louisiana's fisheries production will also crash if marsh loss continues. Because the exact time this will happen is unknown, an estimate of the *cumulative* economic loss cannot be made. However, a reasonable estimate can be made of the *annual* loss that will occur in 2050 compared to the present (see side bar).

What is the Pricetag for Maintaining the Status Quo?

Since nearly all Louisiana commercial species use the marsh at some stage of their life cycle, the assumption is made that fisheries loss will be proportional to marsh loss. Approximately 20% of the marsh is predicted to be lost by 2050; thus, the total annual economic effect of commercial fisheries losses in 2050 is estimated at 20% of $2.6 billion, or $520 million. Using the same rationale for recreational fisheries, the total economic effect loss in 2050 would be 20% of $944 million, or $189 million. All of these estimates are given in 1995 dollars and do not account for inflation.

Looking only at the economic loss ignores the great loss of high protein biomass. Compared to present production, this is estimated to be in the neighborhood of 220 million pounds / year in 2050, a terrible loss to a protein-hungry world.

The United State's coastal fisheries are renewable resources. Coastal wetlands provide the foundation for nurturing and sustaining the commercial and recreational fishery resources of the Gulf of Mexico, and especially Louisiana. Louisiana is experiencing the greatest rate and magnitude of wetlands loss in the nation. As the renewable wetlands disappear, so too will our renewable coastal fisheries.

Shrimp and Crab Landings

A marsh pond study[23] found average production values of 40.7 pounds/acre for shrimp, and 70.4 pounds/acre for crabs. The average price paid at the dock for the period 1993-1995 was $1.76/pound for shrimp and $0.63/pound for crabs. Therefore, the dockside value per acre was (40.7 x $1.76) + (70.4 x $0.63) = $115.98.

The predicted loss of about 500,000 acres of marsh by 2050 thus results in a potential annual loss of $58 million for shrimp and crab landings at the dock. This converts to a total economic effect loss of $499 million.

Production values associated with this study are probably conservative, given the study location in southwest Louisiana. The fishery in this region is considered less productive than fisheries located near the Mississippi delta. In addition, shrimp and crab larvae had to travel at least 15 miles to reach the study site.

Because of the many factors involved, it is impossible to make a precise estimate of the annual monetary loss to the fisheries in 2050 due to marsh loss. Nevertheless, the estimates in this report give an indication of the probable magnitude of this loss.

Nowhere to Hide: Weakened Wetlands Increase the Chances of Widespread Destruction by Storms

Summary

Wetlands and barrier islands form a natural buffer zone that absorbs storm surges and blunts the force of high winds. If we do not change our present course and rebuild this buffer zone, severe flooding will endanger all long-term investments in south Louisiana.

- Fifty-five miles of hurricane protection levees will be exposed to open water conditions.
- Storm surges could reach Houma, Lake Charles, Laplace, and New Orleans
- Towns and cities like Leeville, Houma, and Morgan City will become shorefront towns, forcing either a widespread relocation and abandonment of coastal communities or a massive levee construction effort that would cost billions of dollars.

What We Could Lose

Wetlands have been protecting Louisiana communities from the brunt of hurricanes for centuries. How do fragile, low-lying wetlands diffuse the fury of a massive storm? When hurricanes pass over wetlands, friction is created, which in turn reduces the storms' wind speeds. Wetlands also absorb hurricane storm surges, softening and shrinking the wall of water that slams inland during a hurricane.[26] Scientists estimate that every 2.7 miles of wetlands absorb one foot of storm surge, creating a natural buffer zone that has saved many a coastal home from destruction.[27]

When wetlands protect our communities from storms, taxpayers and businesses save substantial amounts of money. According to one estimate, the loss of a one-mile strip of coastal wetlands would increase annual property damages by $186 per acre lost.[28] Other estimates have placed the wetlands' storm protection value between $208 and $904 per acre of wetland lost.[29] Using these figures, the 2.5 million acres of wetlands that line our coast today have storm protection values of between $520 million and $2.2 billion.

26. Mitch and Gosselink, 1993; Reed, 1995.
27. U.S. Army Corps of Engineers, 1961.
28. *Industrial Economics, Incorporated*, 1996.
29. Costanza et al., 1989.

While homeowners are not always aware of these savings, engineers and planners routinely take wetlands' storm buffering capacities into account when designing levees and other public works projects. For example, the St. Charles Parish Lakefront Levee Alinement was proposed in 1983 with a budget item of $11,000,000 for slope protection.[30] The project was originally to have been located on the shore of Lake Pontchartrain, an unprotected and therefore expensive site. In the end, the project was situated behind almost four miles of wetlands. Because the project's designers could count on this vegetative barrier to reduce the impacts of storm surges, they were able to avoid spending the $11 million on slope protection and levee height that would have been necessary at the original site.

The Threat

The protective buffer of the wetlands is fast disappearing. As the barrier islands and wetlands erode, south Louisiana communities may soon be left to bear the direct brunt of storms they were not built to withstand.

The dangers posed by hurricane winds are well known. But the effects of high winds are changing with the coast's changing hydrology. As water replaces more and more wetlands, hurricanes not only meet with less resistance, they encounter more shallow water, which the storms convert into deadly waves. Although it was only a Category 1 storm, 1997's Hurricane Danny caused considerable damage because its winds picked up water from bays and drove it inland in both northward and southward directions. This resulted in widespread flooding (see "The Local Angle").

Nine out of every ten storm fatalities are caused by storm surges, which can be 50 miles wide and up to 18 feet high.[31] Emergency management experts are particularly worried about the effects of storm surges in southern Louisiana. According to LSU computer models, a storm surge could occur almost anywhere south of I-10. Barrier island and wetland loss are the main reasons for this increased vulnerability, but other geological features play a role as well.

Constance Beach, Louisiana. A harbinger of things to come.

- Louisiana's coast is flat and low, which allows surges to move inland easily.
- Open water in bayous, bays, and tidal lakes offers no resistance to storms.
- The shallow water that bounds Louisiana's coast is more easily whipped into a storm surge than is deeper water.[32]

30. U.S. Army Corps of Engineers, 1983.
31. Anderson, 1997.
32. Ibid.

The coast is not the only place that is in danger of being inundated by storm surges. The hurricane models developed by LSU show powerful surges occurring as far inland as the north shore of Lake Pontchartrain—an area traditionally regarded as a safe place to wait out severe storms.

In 1994, the American Red Cross decided that it would no longer operate hurricane evacuation shelters where computer model studies define inundation zones for Category 4 storms. Because the models predict that most of the area south of I-10 will flood during a Category 4 or Category 5 storm, the Red Cross pullout affects all shelters south of I-10 and I-12, although certain exceptions may be necessary.[33] According to Red Cross officials, the pullout decision was reached because the organization could not guarantee the safety of its workers or the people seeking shelter in typical Red Cross safe houses.

In September, 1997 the Salvation Army offered to fill the void left by the Red Cross and operate shelters of last resort in 23 parishes. Even so, the Red Cross decision sends an ominous message to coastal residents: there is no safe place in coastal Louisiana to wait out a strong storm. Said Robert Bracamontes, director of the St. Bernard Office of Emergency Preparedness, "When a powerful hurricane hits, shelters or no shelters, levees or no levees, you need to get out of Dodge. No system can withstand that threat."[34]

Routine cold fronts and high tides already cause more frequent and severe flooding in coastal communities. For example, in April 1997, a series of thunderstorms brought on widespread flooding in the Terrebonne Parish communities of Pointe-aux-Chenes and Montegut. Although local parish officials categorized the storms as typical of the season, parish crews had to add two feet to the Pointe-aux-Chenes levee top to forestall more damage. Said Claude Hebert, Terrebonne Parish Emergency Preparation Coordinator, "This had nothing to do with any kind of rainfall. Can you imagine what would have happened if we had a hurricane behind this?"[35]

Residents of flood prone urban areas count on levees to keep out water during major storms. But the facts show that this confidence is misplaced. According to a National Weather Service report, levees do a very good job of protecting communities in minimal hurricanes, but most levees in south Louisiana would be overtopped from a direct strike by a slow moving, dangerous hurricane.[36]

33. American Red Cross, 1992.
34. Pompilio, 1997.
35. Reinecke, 1997.
36. Anderson, 1997.

Even this minimal level of protection is at risk. If barrier islands and wetlands erode in the coming decades as projected, 55 miles of hurricane protection levees designed for inland, low-energy conditions will be exposed to the direct impact of open water.[37] Since Louisiana's existing drainage systems and levees cannot withstand a direct assault from a major storm, communities may have to confront hurricanes without protection.

What is the Pricetag of Maintaining the Status Quo?

Protecting cities like New Orleans, Houma, Morgan City, Thibodaux, and Lake Charles from flooding will require more than the hundreds of millions of dollars already dedicated to levee and pump projects, especially since the new systems may be overwhelmed by direct exposure to Gulf winds and waves in 50 years. We must be prepared either to spend billions on higher levees that only marginally compensate for lost wetlands, or end our commitment to south Louisiana communities as places where people can invest for the long haul.

Louisianians have a tradition of leaving the coastal zone in the wake of devastating storms. The state's history records many examples of settlement retreat when residents opted, or were forced, to move to safer areas after flooding or damaging hurricanes. After 1992's Hurricane Andrew, for instance, many people left their coastal homes and moved to Houma and other cities. If current land loss projections are accurate, this relocation mindset will be employed again and again as coastal communities become shorefront towns. The economic and cultural costs of widespread relocation is difficult to calculate, but it could easily be in the billions of dollars.

Coalition to Restore Coastal Louisiana

The road to Isle de Jean Charles, now frequently closed to passage.

A Safety Net with Holes: Provisional Insurance Coverage Becomes the Norm

Summary

Insurance is a mainstay of living, working, and building businesses in Louisiana's coastal zone. But as wetlands and barrier islands erode, storm damage costs are rising. Insurance companies have seen the writing on the wall and are moving to protect their interests. *If we do not change our present course,* citizens will have to absorb more of the costs and the risks of living and working in south Louisiana.

37. Louisiana Coastal Wetlands Conservation and Restoration Task Force, 1993.

- Insurance coverage for wind damage may be discontinued.
- Deductibles could increase by as much as 20% by the year 2000. In the coming decades, these costs are predicted to rise even more.
- Large insurance companies will stop issuing new policies in the coastal zone and more citizens and businesses will be forced to use high priced risk pools sponsored by the state.

What We Could Lose

Louisiana citizens depend on flood insurance. From the creation of the National Flood Insurance Act in 1968 through the aftermath of Hurricane Andrew and into the present, insurance has provided a safety net for most coastal investments. Without it, economic development in south Louisiana would be hamstrung after a disaster, and it would take years to fully recover.

Louisiana now ranks second among the 50 states in the number of flood insurance policy holders. As of December 31, 1997, Louisiana residents held approximately 9% of the flood policies in the country. Over 88% of Louisiana's policies (294,527) apply to property in the 25 coastal parishes, with 65% of those policies (216,154) concentrated in the five New Orleans area parishes.

As would be expected in one of the nation's most flood prone regions, many claims are issued on these policies. In 1990, Jefferson, Orleans, and St. Bernard Parishes ranked first, second, and eighth, respectively, in the nation for repeat flood claims. Flood insurance claims paid between 1978 and 1997 amounted to $904 million for the five metropolitan New Orleans parishes alone.

The Threat

Fewer than 4000 people live on the Louisiana shoreline. Grand Isle, Louisiana's only inhabited barrier island (1,033 flood insurance policies as of December 31, 1997), and Cameron Parish's barrier beach communities of Constance Beach, Holly Beach, Rutherford Beach, and Johnson Bayou (1,426 flood insurance policies as of December 31, 1997) are the only Louisiana communities directly exposed to the fury of Gulf storms.[39]

The Terminology of Flood Insurance

Most of the Louisiana coastal zone is in a Coastal Special Flood Hazard Area, defined by the Federal Emergency Management Agency (FEMA) as the combination of the A-Zone and V-Zone.

The A-Zone is the area likely to be inundated by a 1% flood, but not likely to experience direct wave action. The 1% refers to the statistical chance of this event occurring in a year. The V-Zone, also called the coastal high hazard area, is the area likely to receive high velocity waters from waves at least three feet high associated with a 1% annual chance flood.[38]

38. L.R. Johnson Associates, 1992.

39. Platt et al., 1987; Platt et al. 1992.

Dr. Joseph Suhayda, LSU

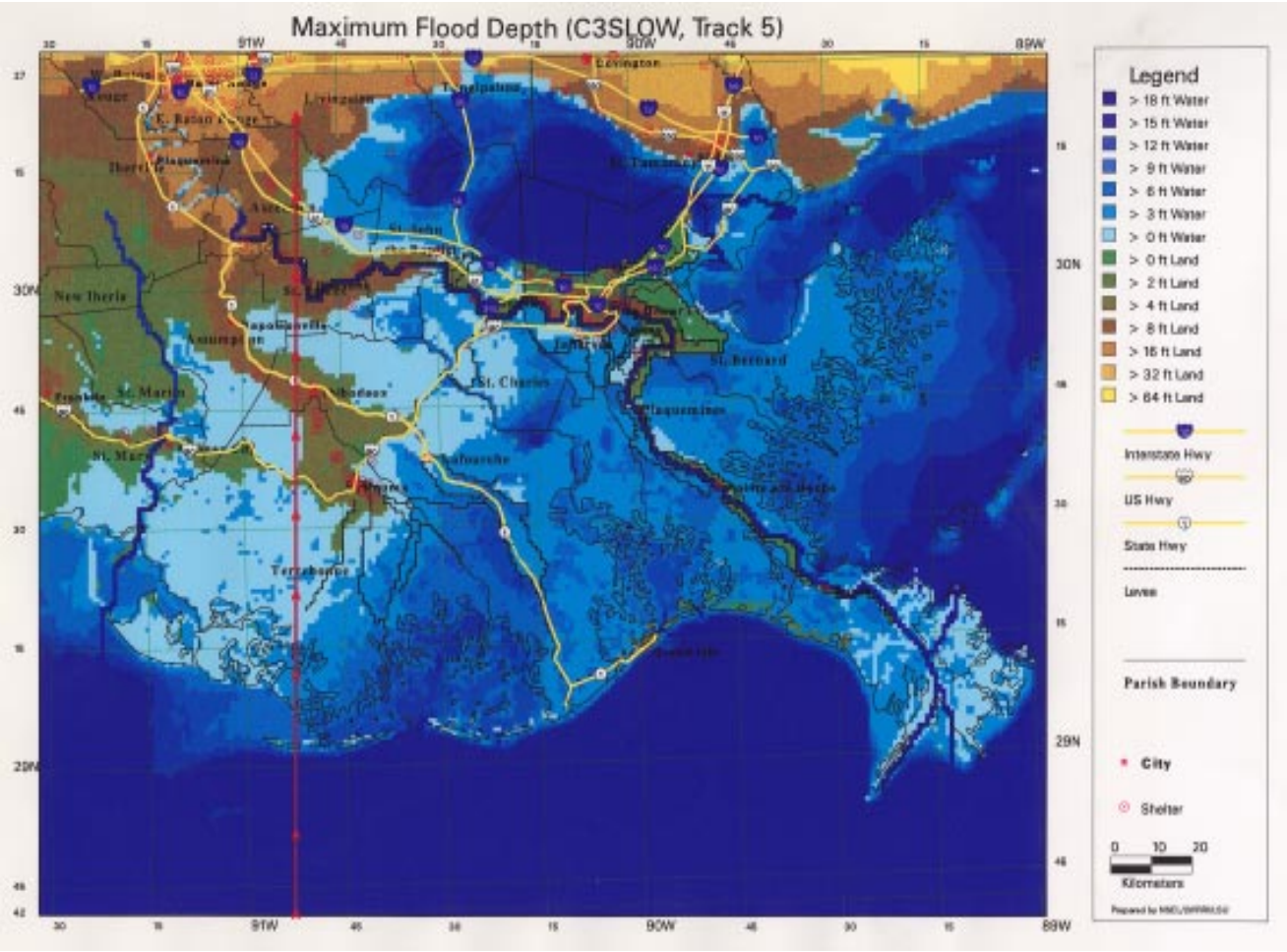


Figure 12. Projected flooding from a slow Category 3 hurricane. (Storm track shown in red)

Unfortunately, all residents of south Louisiana need flood insurance. Modeling data from LSU show that almost all land south of I-10 and I-12 could experience hurricane storm surges. And if the wetlands and barrier islands erode over the next 50 years as projected, more than two million people living inland in south Louisiana will be subject to more frequent and severe flooding. Because they absorb storm surges and help lower hurricane wind speeds, wetlands have historically protected south Louisiana from the full power of Gulf storms. But as we lose this natural buffer zone, areas that now receive storm surges of only two or three feet could be inundated with surges at least twice that high.

After Hurricanes Hugo, Andrew, Bertha, and Fran showed the devastation that can occur when a strong storm passes near a densely populated coast, the insurance industry started taking action. Using computer models to calculate storm scenarios, the industry began addressing what it deems "unacceptable risks" by raising premiums and/or reducing liabilities.[40]

Recent headlines tell the story.

•"Flood rates are on the rise: Louisiana to pay more for insurance."[41]

•"Insurers Wary of Homes in Louisiana. Many firms limit number of policies in parts of U.S. likely to be hit by hurricane."[42]

Federal flood insurance rating maps as well as other insurance tools must be revised to accommodate these changes.[43] With these trends in view, the catastrophic insurance market will require greater sharing of risks among the federal government, state insurance commissions, industry providers, homeowners, commercial vendors, mortgage lenders, and developers.[44]

The reaction of industry and government does not take into account the long, slow process of sea level rise. As sea level rises, higher water levels will reach previously unaffected areas and further increase both the risk and the cost of insurance.

40. *Best Week*, 1996a.
41. Grace, 1997.
42. Thomas, 1997.
43. FEMA, 1991.
44. Cox, 1994; Jennings, 1994; Goldberg, 1996.

What is the Pricetag for Maintaining the Status Quo?

Federally-sponsored flood insurance will likely remain available, though not necessarily for all properties and all areas. But affordable private insurance will not always be a given, even though banks and finance companies require a certain level of coverage before granting loans. In some instances, parish governments require insurance coverage before issuing building permits. Insurance companies have taken or are planning the following actions:

- Increase homeowner and commercial rates, in some cases by about 20%.[45] Before 1992, the standard deductible for hurricane damage in Louisiana was only $250 or $500. But since Hurricane Andrew, the Louisiana Insurance Rating Commission has granted some companies deductible increases of 1 to 5% of the insured value.

This means that Louisiana citizens who are insured with these companies must pay deductibles of between $1,000 and $5,000 for $100,000 worth of insurance or pay higher premiums. Additionally, insurers predict that by the year 2000, these higher deductibles will be a part of all hurricane damage insurance policies.[46]

- Reduce the number of new property insurance policies. In February, 1996, Allstate Insurance said it would freeze the amount of property insurance it sells in south Louisiana parishes. State Farm, which has 34% of the Louisiana market, is following suit. State Farm paid $4 billion in claims after Hurricane Andrew and is eager to limit similar losses in the future. Said a State Farm spokesman, "Our total exposure on the coast is $26 billion. If we take a direct pop, we're looking at some serious, serious stuff down there."[47]

- Discontinue policies or portions of policies, such as wind damage.[48] Although insurance companies will probably maintain basic fire, theft, and liability coverage, they may separate windstorm coverage and shift policies to a risk pool (such as Louisiana's Fair Access to Insurance Requirement Plan (FAIR) / Coastal Plan).[49] Four percent of Louisiana's homeowners are already forced to use the state-sponsored risk pool, at rates that are 15 to 30% above regular market prices.[50]

- Separate hurricane claims from other broad categories of damage[51] or shift the claims to the reinsurance market. This market is made up of companies outside the United States that sell high risk notes to insure high risk liabilities.[52] Coverage is usually limited to one hurricane per year.

45. *BestWeek* 1996a; *BestWeek* 1996e.
46. Hall, 1997.
47. Griggs, 1996.
48. *BestWeek*, 1996c; 1996d.
49. Thomas, 1997.
50. Thomas, 1997.
51. Goldberg, 1996.
52. *Bestweek*, 1996f.

Whether the entity is the federal government or a major insurance company, the trend is clear. Outside interests are taking stock of the risks they run by doing business in coastal Louisiana, and as they move to protect themselves, more costs will be shifted onto local residents. Reducing these risks provides a major justification for stopping the cycle of coastal land loss.

The Local Angle: How the Rules Are Changing in Coastal Communities

Summary

South Louisiana residents have developed a patchwork system for living with the floods, tides, and winds of their flood prone environment. But land loss is undermining many of the assumptions that make up this system. *If we do not change our present course* and stop wetland and barrier island erosion, coastal residents will lose confidence in the region as a place to live and work.

- Storm damage. The increasing ratio of water to land near the coast makes hurricanes more lethal than ever before. Traditional safe zones must be reconsidered in order to avoid widespread loss of property and life.
- Real estate. Land values are dropping as valuable freshwater marsh becomes salt marsh or open water. Private owners are losing investments, and lower property taxes are draining funds from local governments.
- Infrastructure. Land loss is damaging roads, bridges, and railways, turning these once reliable lifelines into costly liabilities.

What We Could Lose

The Bayou Country's distinct cultural identity is a national treasure. Both long-time residents and short-term visitors are quick to point out that the flavor of life in this region is unlike any other. South Louisiana is home to people of diverse ethnicities, who despite their varying traditions, are united by the nature of the land itself.

All residents who live in coastal Louisiana's storm-drenched, low lying environment must adapt to flooding, subsidence, and unpredictable winds. Over time, these adaptations have evolved into a shared set of guidelines for living in a changeable landscape. Many of these guidelines center on knowledge about how nature works: how to prepare for hurricanes, where to seek shelter from a bad storm, and when damage from high winds or floods can be expected. Other guidelines focus on setting up a household or business: how to build a home and obtain a mortgage, and how to get flood insurance. Other guidelines deal with the land itself: its worth, who owns it, and how many services local governments can support based on property tax collections.

The nature of these guidelines is not so unusual; most U.S. communities have a similar fund of knowledge. But in south Louisiana, where the boundaries between land and water are always changing and a single storm can wipe out a town, these guidelines have particular relevance. They have provided a communal framework for conducting daily life—a framework that has given this region much of its viability and character.

The Threat

As wetlands and barrier islands erode, many of the assumptions that have structured life along the coast are now being undermined. For example, much of the marsh land behind barrier islands is being replaced with open water. These new open water areas and the land surrounding them have become dangerous places during hurricanes, no matter which way the storm winds are blowing.

As hurricanes move ashore today, their northerly winds encounter more open water and fewer storm buffering wetlands. The hurricanes stir this shallow water into waves and drive the waves into the back of barrier islands and coastal ridges, endangering any homes, businesses, or boats located nearby. This backside assault is a new phenomenon; one that makes a deadly combination with the front-side winds and waves that routinely batter Gulf-facing properties during storms.

Many observers see a correlation between this new kind of wave action and the effects of Hurricane Danny, a Category 1 hurricane that occurred in 1997. The storm caused unexpectedly severe

Citrus Farmers Face the Rising Tide*

The next few years will be critical for the $3 million Louisiana citrus industry, as farmers face the effects of salt water intrusion. Farmers in Plaquemines Parish, who grow 90% of Louisiana's citrus crop, have been among the first to encounter this problem. As sea level rises, salt water infiltrates the citrus trees' roots; one study found salt water damage in 80% of the trees tested.

To save their crops, farmers who can afford them install expensive irrigation systems. The irrigation systems flush Mississippi River water among trees' roots, diluting the salt water and allowing the trees to grow normally. Farmers who can't afford this remedy are, increasingly, losing their livelihoods.[53, 54]

53. Hegeman, 1997.

54. Anonymous, 1998.

flooding and property damage. For example, one business tied up its helicopters for safe keeping in a parking lot located near Empire. As the storm moved ashore, the once sheltered lot turned into a lake, and the helicopters were flooded.

The effects of Hurricane Danny suggest that parish governments, residents, and businesses must rethink traditional methods of preparing for and weathering storms. If, as seems to be the case, the only safe harbors are located further north in areas surrounded by wetland buffers, evacuation agreements between parishes must be revamped. Fishers and farmers will have to secure their boats and livestock using more elaborate procedures than have been required in the past. And citizens will have to evacuate sooner and over a more extensive area than ever before.

Land loss is also changing the rules that govern coastal real estate investments. Freshwater marshes have the highest use value of all marsh types because they provide habitat for the most freshwater fish and game and can therefore support extensive fishing, hunting, and trapping. Decades ago, private landowners, including many large corporations, purchased thousands of acres of freshwater marsh in order to secure claims to the fish, wildlife, and subsurface oil and gas. Today, as salt water spreads further inland, freshwater marshes are converting to salt and brackish marsh, and property values are dropping.

When land degradation progresses to the point that marsh actually becomes a navigable waterway, ownership of the area (including rights to any subsurface minerals), can shift to the state. If current land loss projections hold true, thousands of acres in private holdings could be transferred to the state. This transfer of assets is not the financial windfall to the state that it might appear. The loss of private investment and the threat of lawsuits more than compensate for any fiscal gain the state might incur. Reduced property taxes also result in less parish revenue to support public services, such as schools, fire departments, road and bridge maintenance, and solid waste disposal.

Homeowners are seeing other changes in long-held assumptions about living in the coastal zone. Homes located behind barrier islands in towns like Buras, Cocodrie, Lafitte, and Fourchon have traditionally been considered more secure from storm damage. But residents are now being forced to change their definitions of what is safe and what is not. Scientists believe the coast is changing so rapidly that it is hard to specify how many homes are at risk. Even so, the federal government believes the risks have increased enough to justify stricter regulations concerning new construction in the coastal zone. The Federal Emergency Management Administration (FEMA) always required that new development in the coastal zone be elevated to heights above base flood

Wetlands Values

•Sale Value: $200-$300 per acre.[55] This is the most traditional approach to calculating wetland values. The sale value takes into consideration only the real estate price of the land itself and not any of the intrinsic benefits that the land confers to the public.

•Use Value: fresh marsh = $70 per acre, brackish marsh = $60 per acre, salt marsh = $50 per acre.[56] This approach is applied uniformly across the coast to determine tax assessments. It describes the tangible profitability of the land surface gained through fishing, hunting, trapping, and aquaculture. Subsurface oil and gas are not considered in this value.

•Public Value: $4,300 per acre.[57] This approach considers all of the values that wetlands give the public such as: preventing storm damage to residences and businesses; supporting fisheries, eco-tourism, and other resource based industries; and sheltering navigation channels.

55. U.S. Fish and Wildlife Service, 1994.
56. Coriel and van Orsdel, 1996.
57. Costanza et al., 1989.

elevation. The required elevations are now higher than ever, and FEMA holds all coastal parishes accountable for enforcing the regulations.

Officials in Cameron Parish complied with the new regulations by enacting an ordinance that requires new development to be built between 11 and 20 feet above sea level. If parish officials had not done so, FEMA would have made the entire parish ineligible for national flood insurance as well as federal disaster relief in the event of an emergency.

The parish enforces the ordinance by requiring proof of elevation as part of building permits, discontinuing electricity service to homes that are found to be out of compliance, and preventing homeowners who do not comply from purchasing national flood insurance.[58] Although some long time coastal residents choose not to purchase flood insurance, new homeowners are required to purchase a policy before they can obtain a mortgage. And private insurance is becoming more expensive and more difficult to obtain as insurance companies seek to cut their losses in high risk areas like coastal Louisiana (see, "A Safety Net with Holes").

Land loss will also further weaken the coastal transportation systems that had once been considered reliable. With the wetlands and barrier islands disappearing, highways, bridges, and railroads will be directly exposed to high energy waves. To understand the effect this will have, one need only compare two adjacent sections of coastal highway. Highway 82 west of Holly Beach runs along an exposed chenier and beach ridge and requires constant reconstruction. East of Holly Beach, the road is in better repair because it is protected by wetlands and a beach.

Continued land loss may render U.S. Highway 90 between New Orleans and Raceland unusable. The same applies to Louisiana 1 south of Golden Meadow, a roadway that is often washed out by floods and high tides.[59] In all, 27 miles of railroad and 100 miles of highways will be exposed to open water if more comprehensive coastal restoration programs are not implemented.

Perhaps the biggest losers in the coastal land loss crisis are local governments, since they depend on funds supplied by property taxes. Local tax assessments of marsh lands are based on the land's use, with freshwater marsh having the highest value and saltwater marsh the lowest.[60] In many areas where freshwater marsh has converted to salt marsh, landowners are asking that their property taxes be lowered to reflect the decrease in their land's value. A few landowners have even filed suit over this issue. The situation prompted the Louisiana Tax Commission to lower marsh land use values in 1996, shrinking the coffers of local governments.

58. Horne, 1997.
59. LA 1 Coalition, 1997.
60. Coriel and Van Orsdel, 1996.

What is the pricetag for maintaining the status quo?

Local governments will lose millions of dollars in revenues as land values continue to drop. The new wetland use values implemented in 1996 reduced the assessments of salt marsh from $7 an acre to $5 an acre. In Cameron Parish alone, this change caused a $250,000 drop in tax collections.[61] For a parish of only 9,200 people, this required a tax increase of $27 per person, just to maintain current services. In parishes where erosion rates are higher, the amounts of lost revenue are correspondingly greater. Lafourche and Terrebonne Parishes each lost $700,000 in assessed values of wetlands in 1996, with greater losses predicted in the coming years.[62]

Moreover, 25 years from now open water could inundate thousands more acres of wetlands, and landowners will probably abandon their real estate investments in droves. Whether or not ownership of the parcels reverts automatically to the state, these open water areas will still represent black holes for parish tax rolls. In a scenario that could be viewed as the coastal equivalent of urban blight, abandoned open water areas will drain funds from parish governments not only because they will supply no tax revenue, but also because they will require taxpayer-funded services such as liability insurance, patrolling, and posting of no trespassing signs. If the abandoned areas are not maintained, adjacent property owners will see their property values diminish, and a cascade of land devaluation could spread throughout coastal parishes.

Shoring up the coastal zone's transportation system would require billions of dollars in public works projects. For example, the federal government already expects to spend $23 million building and replacing bridges in Terrebonne Parish, and the estimated cost of emergency repairs to Louisiana Highway 1 south of Golden Meadow is $63,050,000. Making the highway from Fourchon to Golden Meadow safe and fully usable would cost approximately $266,000,000.[63] All of these repairs are needed today, but if coastal erosion continues at present rates, more repairs, on a larger scale, will be needed in the next 50 years.

Economics alone cannot describe how land loss will damage south Louisiana's quality of life. As storm damage increases, land values drop, and infrastructure depreciates, the region will cease to be a viable place to live and work. Unless swift action is taken to restore wetlands and barrier islands, 50 years from now many coastal communities could either be abandoned or left as outposts—a dismal and costly legacy to pass on to future generations.

Highway 82, the only east-west highway in lower southwestern Louisiana. Once set back from the Gulf, it is now in danger of being breached. The chenier highway rests on the last ridge between the Gulf and a vast marsh plain.

61. Neal, 1997.
62. Bonvillian, 1997.
63. LA 1 Coalition, 1997.

Case Study: The Threat to New Orleans

Summary

All communities in Louisiana south of I-10 are threatened by coastal erosion, but New Orleans's potential losses are especially high. The assets that make the city a great metropolis—its unique cultural heritage, industry and shipping facilities, complex transportation systems, and vast private property holdings—are imperiled by low-lying geography that leaves the area vulnerable to flooding. Because New Orleans could lose more assets on a greater scale than other coastal cities, it offers a comprehensive example of the effects all south Louisiana residents can expect in the next 50 years if we do not change our present course.

- Widespread life and property loss during hurricanes
- Increased property losses in severe rainstorms
- Hazardous hurricane evacuations
- Intensified storm surges along some levees
- Billions of dollars in additional expenditures to improve hurricane protection, storm drainage, and transportation infrastructure

What We Could Lose

New Orleans lies at the center of a nearly 2,600 square mile metropolitan area containing 1.2 million people and five parishes: Orleans, Jefferson, Plaquemines, St. Bernard, and St. Tammany. Taxable real estate and property in the region are assessed at more than $5 billion, and fair market value of these assets exceeds $40 billion. Port activities, oil and gas production, tourism, and health care services anchor an economy that is projected to grow slowly in the coming years.

New Orleans, A city bounded by water.

The Mississippi River divides Orleans, Jefferson, and Plaquemines Parishes into east and west banks. Although the river, along with Lake Pontchartrain, smaller channels, and nearby wetlands provide the means for economic prosperity, these resources represent a double edged sword. No other major city in the country is surrounded with quite so many flood prone lowlands and waterbodies—features that make New Orleans a virtual island.

Moreover, at least 45% of the metropolitan core is at or below sea level. New Orleans proper forms a saucer shape with elevations varying from ten feet below mean sea level in developed areas to 15 feet above sea level along the natural ridges of the Mississippi River. Parts of St. Tammany Parish are 200 feet above mean sea level, but its heavily populated coastal areas are low lying and therefore vulnerable to high water.

The surrounding waterbodies combined with low elevations and heavy rainfall—an average of 61 inches per year with variations of 50%—have made water and drainage management necessities in New Orleans since the early 1700's. Ditches or canals once circled each city block, and landowners forfeited their property if they did not enclose their land in "palisades."[64] Levees were built as early as 1719 to ward off river floods. In 1770 Governor O'Reilly decided that every family settling in the province should be given land if they agreed to build a levee within three years to protect their property.[65] This policy guaranteed that Louisiana's lowlands would be drained and established the region's tradition of daily, intensive drainage.

This tradition continues today in New Orleans's elaborate drainage system. About 520 miles of levees and floodwalls, 270 floodgates, and 92 pumping stations connected to thousands of miles of drainage canals and pipes have been constructed around New Orleans. Along the Mississippi River, approximately 180 miles of levees and floodwalls with an average height of 20 feet prevent overbank flooding. Pumps continually remove surface runoff and groundwater seepage. Engineers also control high water levels in the Mississippi River through diversion floodgates located upstream.

The Threat

Although New Orleans drainage system is world renowned, it has serious flaws. The levees and floodwalls were built to stop water from coming into the area, but they also prevent water from flowing out. Excess rain and flood water must therefore be pumped by machines, which are only designed to handle the short-term, high water levels of a ten-year rainfall. (A "ten-year rainfall" is defined as the peak rainfall expected on average once every ten years. This peak level equals 3.5, 6.3, and 7.7 inches of rain in one, six, and 12 hours respectively.) Long-term high water levels, which can occur during storms and high tides, not only overwhelm the pumps' capacities, but they can also destroy the pumping machinery itself. Pumps aside, many of the area's canals and street drains can only handle the lower volume of a one to two-year rainfall.

Sustained southerly winds can already cause tides and water levels to rise by two to three feet—at least one foot above normal. A ten-year tidal event, which can occur without a hurricane, increases tidal changes by about four feet east of the Mississippi River and three feet west of the river. These high tides reduce pumping efficiency by between 9 and 25%, depending on the station's location.

64. deVilliers, 1920.

65. Martin, 1882.

If wetlands and barrier islands erode as projected, two things will happen in the next 50 years: (1) New Orleans will, in effect, be a Gulf coast city, with the Gulf of Mexico just a few miles from the French Quarter; and (2) the city will lose the wetland buffer that now protects it from many effects of flooding. As a result, severe floods will occur more frequently, and the strain on the area's already overtaxed drainage system will increase. Hurricanes pose the most frightening threat, especially since New Orleans sits on a wide, gently sloping continental shelf—a geographic feature that promotes large storm surges.

- In 1965, the eye of Hurricane Betsy passed about 50 miles west of New Orleans. Tidal water surged into Plaquemines, St. Bernard and Orleans Parishes, causing $2 billion in damages and 81 deaths.[66]

- In 1985, Hurricane Juan caused higher tides than Hurricane Betsy (the maximum on record at some gauges) because of its almost stationary, five day attack. The west bank of Jefferson Parish sustained the worst damage from Juan; storm surges there caused $52 million in damages.

After Hurricane Betsy, work began on a billion dollar hurricane protection system around the south shore of Lake Pontchartrain. When it is completed in 2002, this system should in theory be able to shelter the city from a Category 3 hurricane storm surge. But, in reality, whether or not a surge overtops the levees depends on the storm. A slow moving storm moving up the middle of the state would overwhelm the hurricane protection levees because its counterclockwise motion would whip up water from either the Gulf or Lake Pontchartrain and push it into the city limits. The risk increases if water levels in the Mississippi River and nearby lakes and wetlands are already high.

According to the Director of Emergency Management for the City of New Orleans, a storm of this kind could put 20 feet of water in the French Quarter. LSU's storm surge models show that a hurricane could push an 18-foot storm surge into Lake Pontchartrain, and that this wall of water could be topped with ten-foot waves.

None of the seawalls or levees on either side of the lake could handle this level of storm surge. Personnel at the state Office of Emergency Preparedness stress that a quick influx of water from overtopped levees will cause widespread loss of life, stating "If you don't evacuate New Orleans, the best thing you can do is tie a tag around your toe so we can identify your body."[67]

66. Anderson, 1997.

67. Ibid.

The Times Picayune

Figure 13. Evacuation of New Orleans from Hurricane Georges, 1998 (Picture courtesy of The Times Picayune).

What Is the Pricetag for Maintaining the Status Quo?

Unfortunately, storm surge heights will only increase as more wetlands are lost and the Gulf reaches closer to New Orleans. As mentioned in Chapter 2, sea level rise is projected to rise a minimum of one foot in the next 50 years, inundating many more acres of storm buffering wetlands. Even if New Orleans is lucky and a severe storm doesn't hit for several decades, flooding, exacerbated by wetland loss, will still present enormous risks to property.

A portion of the West Bank, bounded by the Mississippi River and the Harvey Canal, is a 22,500 acre urban area with substandard hurricane protection and 34,362 structures[68] valued at more than $3 billion. The projected future of this area illustrates the potential effects from a 100-year hurricane combined with continued land loss. Some structures that in 1991 would flood only in a 100-year hurricane would begin to flood in 2040 with a less severe 50-year storm. In 2040, a 100-year hurricane hitting this portion of the West Bank would produce an average increase of two feet of floodwater due to levee overtopping and rainfall.

(Note: these estimates are based on US Army Corps of Engineers sea level rise estimates of .25 feet and .45 feet of subsidence in the next 50 years.)

Damage to residential structures increases by 50% when the depth of water flooding rises from one to three feet above floor level. This projection suggests that total flood damages to structures, their contents, and vehicles during a 100-year hurricane could increase by 280% in this area of the West Bank within the next 50 years.

For instance, in 1991, the West Bank would theoretically have experienced $629 million in flood damages from a 100-year hurricane. In 2040, damages could increase to $1.8 billion, an increase of $50,155 per acre of urbanized area. Applying the same figure to the East Bank of Orleans and Jefferson Parishes results in increased damages totaling $4.3 billion in 2040 from a 100-year hurricane. Actual losses would be lower, however, since levees on New Orleans's East Bank currently are built to a higher standard than those on the West Bank.

Hurricanes are not the only source of costly flooding. In 1995, a severe rainstorm caused $3 billion in flood damages in metropolitan New Orleans. The disaster was exacerbated by high tides in the coastal community of Slidell where it took more than two days to pump out the floodwater.

68. U.S. Army Corps of Engineers, 1994.

The Times Picayune

Figure 14. New Orleans flooding from Tropical Storm Francis, 1998.

Whether the source is a major hurricane or a heavy downpour, increased flooding means more costs for taxpayers. In Orleans and Jefferson Parishes, flood damages to structures, contents, and vehicles associated with a ten-year rainstorm already total approximately $250 million, and the capital costs associated with the metro area's hurricane protection system is almost $1 billion. In the next 50 years, millions more dollars will have to be spent to offset higher water levels brought on by wetland and barrier island loss. Upgrading levees and sea walls to withstand more intense flooding would cost billions of dollars. Other infrastructure costs include the following:

- Most port facilities are outside flood control structures. The wharves located in tidal areas along the Industrial Canal and Mississippi River Gulf Outlet are only 10 feet high and could easily be covered by high water. Raising these wharves will entail expensive upgrades and equipment replacements.
- Roadways in coastal St. Tammany Parish can be washed out by increases in Lake Pontchartrain's water level. South of the lake, roads can be covered by high water from the lake as well as from surrounding wetlands. For example, in 1992, water from heavy rain and high tides in Lake Pontchartrain inundated Interstate Highway 10 near the Bayou Sauvage Wildlife Refuge in eastern New Orleans. The severe flooding left only the road's shoulders open, in part because Interstate 10 had already sunk 2.5 feet from its original elevation. Raising the road above floodstage will cost an estimated $3.5 million.

Other vulnerable roadways south of Lake Pontchartrain include sections of U.S. 90, the Lafitte-Larose Highway, and La. Highways 46 and 300 in lower St. Bernard Parish. The estimated cost of raising these roadways to withstand current water levels is $93 million. Building the roadways high enough to withstand the water levels projected for the next century will cost millions more.

Hurricane evacuation routes present another problem. Although evacuating New Orleans in the event of a hurricane is clearly essential, some of the major evacuation routes are flood prone or easily congested with traffic. To improve these deficiencies will cost at least $1.2 billion.

- High water already threatens many low bridges in the metropolitan area. Since some bridges that cross major drainage canals are below the height of nearby flood control structures, they must be closed and sandbagged when water levels rise in the canals. These bridges must also be raised when floodwalls and levees are raised. For example, work is underway to raise by four feet the bridges crossing the London Avenue and Orleans Avenue canals in Orleans Parish, at a cost of $2 million per bridge. The I-10 and I-610 bridges over the 17th Street Canal at the Orleans-Jefferson boundary are scheduled for the same improvement at an estimated cost of $10 million. If coastal land loss projections become a reality, these improvements will be just the first step in a costly series of construction projects aimed at keeping New Orleans's transportation network high and dry.

- The deficiencies of current evacuation routes were demonstrated in September 1998. Rain and high tides from Tropical Storm Frances flooded the low-lying underpass near Metarie Road on Interstate 10, the city's major evacuation route. Traffic was stopped at this underpass for hours. As Hurricane Georges approached and evacuation looked imminent, the earlier flooding of the underpass had state and local officials scrambling for a short-term solution. As a long-term answer, an overpass is estimated to cost $100 million.

- Still flooded from Topical Storm Frances two weeks earlier, U.S. Highway 190 between Raceland and DesAllemands had to be pumped and sandbagged for Hurricane Georges. Tidal surge from Frances had also blocked miles of U.S. Highway 61 at the Interstate 310 interchange. Most of the hundreds of thousands of Hurricane Georges evacuees bypassed both of the floodprone U.S. highways in favor of Interstate 10. With residents piled onto I-10 bumper-to-bumper, major traffic jams occurred. Luckily, residents had more time to make it out of the area because Georges slowed down and produced relatively dry weather on its western side. Rising water from a faster, wetter hurricane would cut off New Orleans' few evacuation routes much earlier, stranding thousands of people.

Chapter 4: The Next Step—Ours to Choose

It is decision time for anyone with a stake in the future of coastal Louisiana—anyone who uses Gulf oil and gas, eats our state's seafood, relies on Louisiana shipping routes to import and export goods from overseas, or benefits from the storm protection provided by our coastal wetlands. The scope of current land loss is great enough to affect everyone in our state and nation—not just residents of the bayou country.

What, then, are our alternatives? Can we still save our coast? The answer is yes, if we shift our approach and begin to work with river floods and ocean tides instead of against them. We have spent nearly 300 years trying to conquer the natural forces that built this region. Now, scientists and engineers tell us, we must adapt to these forces and use them to build and nourish coastal land.

The Breaux Act provided the framework for this new approach, and the results of that 10-year effort are noteworthy: working partnerships have been created, plans for substantially reducing future land loss have been developed, and more than 80 restoration projects are on line. We must now build on these successes.

The most aggressive restoration strategies predict that we can achieve a net gain of the coastal land acreage which exists today in Louisiana. Saving this amount of land will require the following bold steps:

- Expand the pace and scope of restoration projects;
- Provide adequate support and staffing for an expanded Breaux Act process;
- Make Louisiana a full financial partner in the restoration and stewardship of the state's coastal system;
- Increase the role of science and modeling in the development, selection, and evaluation of restoration projects.

Coastal Louisiana... a vast but threatened treasure.

Step 1: Expand the pace and scope of restoration projects

Recent modeling, coupled with lessons learned in the last ten years of Louisiana's coastal restoration effort, have taught us that we must restore entire landscapes, not small parcels of land. In keeping with this landscape-based approach, science has shown that river diversion projects—like Caenarvon and Davis Pond—do more to slow land loss than any other kind of restoration activity.

No single type of project will restore our coast. Rather, diversions, barrier shoreline projects, and interior hydrologic restoration efforts must be used together to mirror the natural river processes that originally built and sustained the wetlands. It is also important to recognize that restoration efforts alone cannot solve the problem. We must reconcile the diverse activities that take place in southeast Louisiana with the need for long-term stewardship.

Action Steps:

- Reintroduce river water and sediments into basins east of the Atchafalaya River. Create a distributary channel of the Mississippi River that will form a new mini-delta in the lower Barataria-Terrebonne system.
- Re-establish sheet flow in selected coastal areas, in ways that support the long-term viability of communities, infrastructure, and investments.
- Use Gulf-borne sediments from the Mississippi and Atchafalaya Rivers to stabilize the chenier coast, while maintaining, to the greatest degree practicable, the traditional estuarine characteristics of the bays west of the Atchafalaya River.
- Re-establish functional barrier islands and shorelines to reduce tidal erosion and provide storm buffers.
- Integrate flood protection, restoration plans, and development planning to identify and communicate real-world expectations of where and how development should take place. It is time to stop placing people and structures in harms way.

What is Sheet Flow and Why Is It Important?

Sheet flow is a technical term to describe the way rivers flood. When unleveed rivers overflow their banks, the water spreads out in thin sheets over a broad area. This movement of water allows sediment and nutrients to be deposited gradually over a large tract of land. Wetlands cannot survive without the sediments and nutrients distributed by sheet flow.

Unfortunately, what is good for wetlands is not always good for human communities. After the great flood of 1927, the Mississippi River was largely bottled up by levees expressly to prevent sheet flow. No river water overflows the river banks today. Instead, the river is channeled in one swift stream nearly to the Gulf of Mexico. As the river water plunges into the Gulf, it empties most of its sediment over the continental shelf.

Of course, we cannot return to the days of destructive Mississippi River flooding. But we can allow sheet flow to occur selectively—in targeted areas where healthy wetlands will provide storm buffers and economic opportunities for south Louisiana communities.

Step 2: Provide dedicated staff support and broaden public input for the Breaux Act process

The Breaux Act Task Force, made up of five federal agencies and a representative of the Governor's Office, has done a laudable job since its formation in 1990. However, it must adapt to meet the challenges ahead.

Presently, the relationship between the Task Force, its members, and program committees lacks clear lines of authority and accountability. There is no readily accessible source of information about the program, and no one to coordinate the implementation of the Task Force's directives. Perhaps as a result, the public's role in the process has been shrinking steadily, despite the creation of a Citizen Participation Group in 1991.

Other coastal restoration efforts in the U.S. have solved these problems by creating a small office that oversees daily administration of the restoration initiative. A similar office could be created in Louisiana without any changes in the Breaux Act.

Action Step:

- Create a dedicated management office for Breaux Act activities. Hire a team of three people (executive director, outreach coordinator, and administrative support person) responsible for moving the Breaux Act process forward, coordinating all wetland restoration activities (including WRDA, section 404, and section 1135), and facilitating communication among Task Force members and the public on matters dealing with restoration, protection, and use of the coast.

The cost of such a staff would be largely offset by savings in time and money for current members of the Breaux Act Task Force. Having a staff would also allow the U.S. Army Corps of Engineers to allocate more of its Breaux Act dollars to actual restoration work, rather than to general program administration.

- Reconstitute Citizens Participation Groups to re-energize public involvement in the restoration process, and to directly advise the Wetlands Task Force on matters of policy, priority, and the effectiveness of the Breaux Act effort.

Step 3: Make Louisiana a full financial partner in the restoration and stewardship of the state's coastal system

In 1989, Louisiana created a coastal restoration program financed by a constitutionally created trust fund. The state's leadership and monetary commitment paved the way for federal passage of the Breaux Act.

Since that time, however, Louisiana has fallen behind. Oil and gas revenues earmarked for the trust fund have declined in the 1990s, generating only about $5 million per year. For every dollar the federal government spends on coastal restoration in Louisiana, the state spends only 15 cents. By contrast, coastal restoration programs in California and Florida match every federal dollar with a dollar of state funds. Louisiana must commit more money to its restoration effort, or we will not attract the federal funds necessary to complete the job.

Action Steps:

- Secure a larger share of revenue from federal outer continental shelf (OCS) oil and gas activity. For more than 50 years, Louisiana has borne the environmental brunt of supporting the OCS oil and gas industry, while reaping few direct financial benefits. In 1995, for example, the federal government received $2.8 billion from OCS mineral revenues. Louisiana received only $16 million. By correcting this disparity, the state can better address the impacts of offshore activity on its coastal ecosystems.
- Re-evaluate the tax and fiscal policies of the state to ensure a bigger slice of the pie for coastal restoration. The ultimate responsibility for financing coastal restoration lies with Louisiana's citizens and government. Our present spending policies do not meet this responsibility. The state must commit hard dollars to coastal restoration each year, instead of creating piecemeal taxes or temporary cash sources. Such a commitment can only be made as part of a reform effort aimed at fiscal security and tax equity.

Step 4: Expand the role of science and modeling in the development, selection, and evaluation of restoration projects

Common sense dictates that plans and projects be based on the best available science. Participants in the Breaux Act process have worked hard to place this credo at the center of Louisiana's coastal restoration effort, but advances still need to be made. For example, most projects are still evaluated on an individual basis, rather than as components of an entire watershed restoration strategy. In addition, direct wetlands benefits remains a key criterion for judging the merits of a project, even though some types of projects are inherently easier to evaluate this way than others. Computer models can now predict patterns of coastal change as well as project impacts. Nevertheless, Louisiana does not use modeling to develop, modify, or evaluate coastal restoration efforts.

Coastal restoration is a changing field, and the professional judgement of those charged with designing and selecting projects must be informed by more than their past experience. As more complex projects are considered, we must make greater use of emerging science and modeling data so that public funds can be invested wisely.

Action steps:

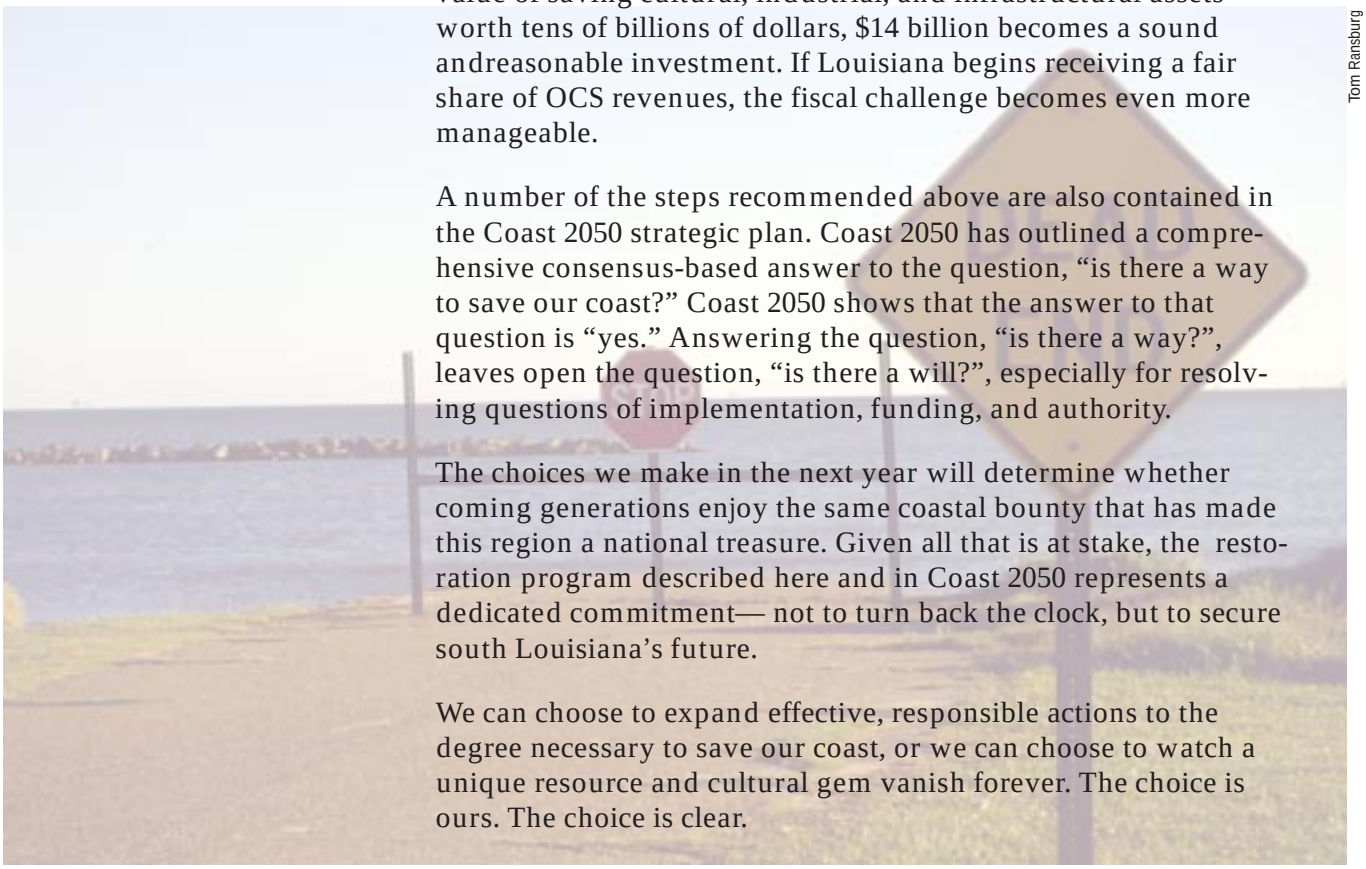
- Implement the concept of a university-based modeling center in Louisiana that could draw from expertise in the public, private, and academic sectors.
- Make project monitoring information widely available. Projects pursued under the Breaux Act must be monitored for up to 20 years. For the information gathered to be of optimal value, it should be made available for public inspection, comment, and use. Expand the practice of publishing regular reports and posting monitoring reports on the Internet would create a valuable feedback loop that would expand our knowledge base and bolster confidence in the overall restoration effort.
- Create a science and technology advisory board to help review restoration plans, projects, and monitoring reports. To date, the role of non-governmental science and technical experts has been limited. A broader role is required if we are to apply the best science to our coastal restoration efforts. The proposed advisory board would comply with the Federal Advisory Committee Act, and its members would represent a range of scientific disciplines and diverse geographic regions. The committee would examine how Louisiana could best use scientific advances in restoration work being done in places like the Florida Everglades.

- Conduct peer reviews of selected projects to ensure high performance. Peer reviews would consider qualitative and operational aspects of the projects in addition to the technical aspects covered by monitoring protocols. In fact, these reviews would ensure that monitoring protocols are kept up to date. The science and technology advisory committee mentioned above would help structure the reviews, and the Breaux Act staff would coordinate the overall effort.

Summary

Work on the scale suggested above has been undertaken before, as witnessed by the levees and canals that now dominate south Louisiana's landscape. Experience has shown these projects to be major tasks, akin to the effort undertaken after World War II to build the national interstate highway system. Like the highway system, Louisiana's coastal restoration effort will be expensive, have widespread impacts, and bring enormous benefits. Inevitably, some communities and users will be disproportionately affected by the coastal restoration effort. These problems must be identified and addressed now, so they can be managed fairly.

The cost of saving Louisiana's coast is estimated to be about $14 billion, to be spread over roughly twenty years.[69] This pricetag must be viewed in a realistic context. When one considers the value of saving cultural, industrial, and infrastructural assets worth tens of billions of dollars, $14 billion becomes a sound andreasonable investment. If Louisiana begins receiving a fair share of OCS revenues, the fiscal challenge becomes even more manageable.



Tom Ransburg

A number of the steps recommended above are also contained in the Coast 2050 strategic plan. Coast 2050 has outlined a comprehensive consensus-based answer to the question, "is there a way to save our coast?" Coast 2050 shows that the answer to that question is "yes." Answering the question, "is there a way?", leaves open the question, "is there a will?", especially for resolving questions of implementation, funding, and authority.

The choices we make in the next year will determine whether coming generations enjoy the same coastal bounty that has made this region a national treasure. Given all that is at stake, the restoration program described here and in Coast 2050 represents a dedicated commitment— not to turn back the clock, but to secure south Louisiana's future.

We can choose to expand effective, responsible actions to the degree necessary to save our coast, or we can choose to watch a unique resource and cultural gem vanish forever. The choice is ours. The choice is clear.

69. Louisiana Coastal Wetlands Conservation and Restoration Task Force and the Louisiana Wetlands Conservation and Restoration Authority, 1998.

Bibliography

American Red Cross 1992 Guidelines for Hurricane Evacuation Shelter Selection. ARC 4496. July.

Anderson, B. 1997 Storms could swamp state coast. Baton Rouge: The Advocate. June 27. pp. 1B and 2B.

Anonymous 1814 Expedition to Barataria, La. New Orleans: The Louisiana Gazette. October 11, p. 2, col. 4.

Anonymous 1850 Country correspondence of the delta. New Orleans Daily Delta. February 11, p. 1, col. 4.

Anonymous 1856 Last Island inundated: shocking loss of life. New Orleans: The Daily Picayune. August 14, p.2, col. 2.

Anonymous 1893 A Graphic Picture of Poor Cheniere Caminada. The Weekly Thibodaux Sentinel. October 10, Thibodaux, La.: Nicholls State University Archives. (typed copy).

Anonymous 1893 Cheniere's priest tells sad story. The Weekly Thibodaux Sentinel. October 14, Thibodaux, La.: Nicholls State University Archives.

Anonymous 1998 Salty Winds, Water Don't Mix with Citrus. New Orleans: The Times-Picayune. October 16.

BestWeek 1996a Nationwide to Reduce New Policies on Coast. Insurance News & Analysis. Property / Casualty Edition. Release 42. October 14. pp. 4&5.

BestWeek 1996b Nationwide's New Plan Limits Florida Exposure. Insurance News & Analysis. Property / Casualty Edition. Release 43. October 21. pp. 5&6.

BestWeek 1996c Florida Cuts Rate Hike For Allstate, Freezes Rate. Insurance News & Analysis. Property / Casualty Edition. Release 31. August 5. pp. 4&5.

BestWeek 1996d State Farm Amends Florida Cancellations. Insurance News & Analysis. Property / Casualty Edition. Release 42. October 14. pp. 5&6.

BestWeek 1996e Nationwide Seeks Hearing on Florida Rate Increase. Insurance News & Analysis. Property / Casualty Edition. Release 42. October 7. p. 4.

BestWeek 1996f Hurricane Risk Hits Capital Markets In Innovative USAA Reinsurance Deal. Insurance News & Analysis. Property / Casualty Edition. Release 32. August 5. pp. 1-2.

Boesch, D.F., M.N. Josselyn, A.J. Mehata, J.T. Morris, W.K. Nuttle, C.A. Simensted, and D.J.P. Swift 1994 Scientific Assessment of Coastal Wetland Loss, Restoration and Management in Louisiana. Journal of Coastal Research Special Issue No. 20. 103 p.

Bonnot, P. 1932. The California shrimp industry. Fisheries Bulletin Number 38. Sacramento: Division of Fish and Game of California, Bureau of Commercial Fisheries.

Bovillian, G. 1997 Personal Communication. Assessor, Terrebonne Parish September.

Braud, D., L. Handley, B. Territo, D. Davis, H. Peele 1995 Louisiana Oil Spill Contingency Plan Map. Prepared for the Louisiana Oil Spill Coordinators Office / Office of the Governor. Oversize. 1:500.000.

Briggs, G. 1968. Sedimentation in Breton Sound and the Effects of the Mississippi River-Gulf Outlet. Transactions, Gulf Coast Association of Geological Societies, 18:304-319.

Britch, L.D. and J.B. Dunbar 1993 Land Loss Rates: Louisiana Coastal Plain. Journal of Coastal Research, 9:324-338.

Cahoon, D.R, D.J. Reed, J.W. Day, Jr., G.D. Steyer, R.M. Boumans, J.C. Lynch, D. McNally, and N. Latif 1995 The influence of Hurricane Andrew on Sediment Distribution in Louisiana Coastal Marshes. Journal of Coastal Research, Special Issue No. 21, pp. 280-294.

Centaur Associates, Inc. 1986. Indicators of the direct economic impact due to oil and gas development in the Gulf of Mexico. OCS Study / MMS 86-0015. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico Region, New Orleans, LA 210 p.

Chamberlain, O. 1942 Island Inventory. Jefferson Parish Yearly Review. pp. 50-64.

Coastal Management Division 1992 Final Assessment and Strategy for the Louisiana Coastal Management Program. Section 309, Coastal Zone Management Act. Baton Rouge, LA: Department of Natural Resources.

Cole, G. 1892a An island outing. New Orleans: The Daily Picayune. September 25. p. 12, col. 3-7.

Cole, G. 1892b The Cheniere Caminada: a visit to an old pirate village. New Orleans: The Daily Picayune. October 2. p. 2, col. 1-3.

Coreil, P. and K. Van Orsdel 1996 Per Acre Gross Revenues From Marshlands: Small Versus Large Landowners Comparisons. Baton Rouge, LA: LSU Agricultural Center - Cooperative Extension Service. Unpublished. September 10.

Costanza, R., F.H. Sklar, and J.W. Day, Jr. 1986 Modeling spatial and temporal succession in the Atchafalaya / Terrebonne marsh / estuarine complex in South Louisiana. In: D.A. Wolfe (ed.) Estuarine Variability. New York: Academic Press. pp. 387-404.

Costanza, R., S.C. Farber, and J. Maxwell 1989 Valuation and Management of Wetland Ecosystems. Ecological Economics, 1:335-361.

Cowdrey, A.E. 1977 Land's End: A History of the New Orleans District, U.S. Army Corps of Engineers and Its Lifelong Battle with the Lower Mississippi and Other Rivers Winding Their Way to the Sea. New Orleans, LA: U.S. Army Corps of Engineers. 118 p.

Cox, B. 1994 Insurers fear repeat of Hurricane Andrew loss. National Underwriters: Property & Casualty / Risk & Benefits Management. August 22. p. 3.

Darce, K. 1998 The solution some say, is a Superport. New Orleans: The Times-Picayune. March 1. p. F-1 and F-4.

Davis, D.W. 1991 Oil in the northern Gulf of Mexico. In: H.D. Smith and A. Vallega (eds.) The development of integrated sea-use management. New York: Routledge. pp. 139-152.

Davis, D.W. 1992 Canals and the Southern Louisiana Landscape. In: D.G. Janelle (ed.) Geographical Snapshots of North America. New York: The Guilford Press. pp. 375-379.

Davis, D.W. and J.L. Place 1983 The Oil and Gas Industry of Coastal Louisiana and Its Effect on Land Use and Socioeconomic Patterns. Open File Report 83-118. Reston, VA.: United States Department of the Interior, U.S. Geological Survey. 73 p.

Davis, M. 1997 Personal Communication. Executive Director, Coalition to Restore Coastal Louiaiana. Baton Rouge, LA.

DeGrummond, J. L. 1961 The Baratarians and the Battle of New Orleans. Baton Rouge, LA: Legacy Publishing Company.

Delaune, R.D., R.H. Baumann, and J.G. Gosselink 1983 Relationship Among Vertical Accretion, Apparent Sea Level Rise and Land Loss in a Louisiana Gulf Coast Marsh. Journal of Sedimentary Petrology, 53:147-157.

Detro, R. A. and D.W. Davis 1974 Louisiana marsh settlement succession: a preliminary report. Paper read before Association of American Geographers, Seattle. Unpublished Manuscript.

Deutschman, P. 1949 They Danced Till They Died. Coronet Magazine, 25(Ja):143-145.

deVilliers, M. 1920 A History of the Founding of New Orleans, 1717-1722. Louisiana Historical Quarterly, 3(2):157-251.

Duffy, G.F. 1996 Testimony of George F. Duffy, Chairman of the Governor's Task Force on Maritime Industry before the Senate Appropriations Subcommittee on Energy and Water Development on February 27.

Dunbar, J.B., L.D. Britsch, and E.B. Kemp 1992 Land Loss Rates. Report 3: Louisiana Coastal Plain. Technical Report GL-90-2. New Orleans, LA: U.S. Army Corps of Engineers, New Orleans District.

Ellis, T. H. n.d. Account of the storm on Last Island. (Typed copy, Louise Butler writings, box 5, folder 2, no. 1069, S-19-21). Baton Rouge, LA: Hill Memorial Library, South Reading Room, Louisiana State University.

Falgout, T. 1997 Personal Communication. Executive Director, Greater Lafourche Port Commission. October.

Farber, S. 1996 Welfare Loss of Wetlands Disintegration: A Louisiana Study. Contemporary Economic Policy, XIV (Ja):92-106.

Federal Emergency Management Agency 1991 Projected Impact of Relative Sea Level Rise on the National Flood Insurance Program. Washington, D.C.: Federal Insurance Administration. October. 72 p.

Federal Emergency Management Agency 1996 Federal Insurance Administration 1996 Year in Review. FEMA News Desk on the INTERNET. Updated: December 8.

Forrest, M. n.d. Wasted by Wind and Water: A Historical And Pictorial Sketch of the Gulf Disaster. Milwaukee: Art Gravure and Etching Co. 18 p.

Fortier, A. 1909 Louisiana: comprising sketches of counties, towns, events, institutions, and persons, arranged in encyclopedic form. Atlanta: Southern Historical Association. 3 vols.

François D.K. 1993 Federal offshore statistics: 1992. U.S. Department of the Interior, Minerals Management Service, Operations and Safety Management. OCS Report / MMS 93-0066. Herndon, Virginia. 155 p.

Franks, K.A. and P.F. Lambert 1982 Early Louisiana and Arkansas Oil: A Photographic History 1901-1946. College Station: Texas A&M University Press. 241 p.

Frazier, D.E. 1967 Recent deltaic deposits of the Mississippi river: Their development and chronology. Transactions of the Gulf of Coast Association of Geological Societies, 17:287-315.

Gilbert, W. 1814 Letter describing Jean Lafitte's base at Cat Island. (Gilbert [Walker] Letter). Louisiana State University: Hill Memorial Library, South Reading Room.

Goldberg, S. 1996 Perspectives of an Insurance Company. In: Hurricane Preparedness: Facing the Reality of More and Bigger Storms. The 18th Annual National Hurricane Conference, Orlando, Florida. Compiled by Lawrence S. Tait, National Hurricane Conference, Tallahassee, Fla. pp. 45-49.

Gornitz, V., S. Lebedeff, and J. Hanson 1982 Global Sea-Level Trend in the Past Century. Science, 215:1611-1614.

Gould, H.R. and J.P. Morgan 1962 Field Trip No. 9. Coastal Louisiana Swamps and Marshlands. IN: E.H. Rainwater and R.P. Zingula (eds.) Geology of the Gulf Coast and Central Texas and Guidebook of Excursions. Houston: Houston Geological Society. pp. 287-341.

Grace, S. 1997 Flood Rates on the Rise. New Orleans: The Times-Picayune Section B. January 6. p. B-1 and B-2.

Griggs, T. 1996 Property Insurance freeze looms. Baton Rouge: The Advocate. February 20. pp. 1C and 2C.

Grill, G. 1996 Louisiana Department of Transportation and Development. September 12.

Griggs, T. 1996a Incentives drive bids for Offshore Leases in Gulf to Record Number. Baton Rouge, LA: The Sunday Advocate, April 28. p. 1H.

Griggs, T. 1996b Louisiana now the place to drill as companies tap the Austin Chalk. Baton Rouge, LA: The Sunday Advocate, April 28. p. 1H.

Hall, J. 1997 Storm's ill wind is still blowing. New Orleans: The Times-Picayune. September 4. pp. C-1 and C-3.

Hegeman, R. 1997 Saltwater intrusion threatens Louisiana's citrus. New Orleans: The Times-Picayune. November 9. p. A-43.

Herke, W.H., E.E. Knudsen, P.A. Knudsen, and B.D. Rogers 1992 Effects of Semi-impoundment of Louisiana Marsh on Fish and Crustaceans Nursery Use and Export. North American Journal of Fisheries Management, 12:151-160.

Holder, S. 1997 Personal Communication. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico Region, New Orleans, Louisiana. October.

Horne, T. 1997 Personal Communication. Parish Administrator, Cameron Parish, LA.

Howard, P.C., T.J. Duenckel, S.M. Gagliano, G.J. Gasperecz, and J.C. Leslie 1984 The Mississippi River Gulf Outlet: A Study of Bank Stabilization. Baton Rouge, LA: Coastal Management Section, Department of Natural Resources. (December).

Huh, O.K., H.H. Roberts, L.J. Rouse, and D.A. Rickman 1991 Fine-grain Sediment Transport and Deposition in the Atchafalaya and Chenier Plain Sedimentary System. In: Kraus, Gingrich, and Kriebel (eds.). Coastal Sediments '91. Seattle, WA: American Civil Engineers. 1:817-830.

Industrial Economics, Incorporated. 1996 Economic Value Assessment for the Barataria-Terrebonne Estuarine System. BTNEP Publication 26. Thibodaux, LA: Barataria-Terrebonne National Estuary Program. (March).

International Oil Scouts Association 1994 International Oil and Gas Development, Yearbook (Review of 1993 Production). Austin, Texas: Mason Map Service, Inc. 64:736-781.

Jennings, J. 1994 Catastrophic market said to require greater risk-sharing. National Underwriters: Property & Casualty / Risk & Benefits Management. June 20. p. 29.

Jordon, D. S. 1887 The fisheries of the Pacific coast: the fisheries of San Francisco county. in Fisheries and fishery industries of the United States. Washington, D.C.: U.S. Government Printing Office. pp. 612-618.

Kemp, G.P. and J.T. Wells 1987 Observations of Shallow-Water Waves Over a Fluid Mud Bottom: Implications to Sediment Transport. In: N.C. Kraus (ed.) Coastal Sediments '87. Proceedings of a Special Conference. American Society of Civil Engineers. New Orleans, LA. May 12-14. 1:363-378.

Keown, M.P., E.A. Dardeau, Jr., and E.M. Causey 1986 Historic Trends in the Sediment Flow Regime of the Mississippi River. Water Resources Research, 22:1555-1564.

Kolb, C.R. and J.R. Van Lopik 1958 Geology of the Mississippi River Deltaic Plain, Southeastern Louisiana. Technical Reports 3-483 and 3-484. Vicksburg, MS: U.S. Army Corps of Engineers Waterways Experiment Station.

Larson, D.K., D. Davis, R. Detro, P. Dumond, E. Liebow, R. Motschall, D. Sorensen, and W. Guidroz. 1980 Mississippi Deltaic Plain Region ecological characterization: a socioeconomic study. Vol. 1. Synthesis papers. Washington, D.C.: U.S. Fish and Wildlife Service, Office of Biological Services. FWS / OBS-79 / 05. 368 p.

L.R. Johnson Associates 1992 Floodplain Management in the United States: An Assessment Report. Volume 2: Full Report. Prepared for the Federal Interagency Floodplain Management Task Force. FIA-18 / June 1992. p. C-1, Glossary

Lenski, J. 1943 Changing Times Along the Bayou. Jefferson Parish Yearly Review. pp. 94-104.

Louisiana Coastal Wetlands Conservation and Restoration Task Force 1993 Coastal Wetlands Planning, Protection, and Restoration Act: Louisiana Coastal Wetlands Restoration Plan. Main report and environmental impact statement. Baton Rouge, LA.

Louisiana Coastal Wetlands Conservation and Restoration Task Force and the Wetlands Conservation and Restoration Authority 1998 Coast 2050: Toward a Sustainable Coastal Louisiana. Baton Rouge, LA. December. 161 p.

Louisiana Department of Wildlife and Fisheries 1996 Recreational Licenses Sold. Baton Rouge, LA: Office of Marine Fisheries.

LA 1 Coalition 1997 Highway Improvement Proposal. Thibodaux, LA 17 p.

Louisiana Tax Commission 1996 Twenty-Seventh Biennial Report. 1994-1995. Baton Rouge, LA.

Maestri, W. 1999 Jefferson Parish Department of Emergency Management. January 6.

Martin, F. 1882 The History of Louisiana from the Earliest Period. New Orleans: J.A. Gresham. Reprinted in 1975 by Pelican Publishing Co., Gretna, LA. 469 p.

McBride, R.A. and M.R. Byrnes 1995 A Megascale Systems Approach for Shoreline Change Analysis and Coastal Management Along the Northern Gulf of Mexico. Gulf Coast Association of Geological Societies, Transactions, 45:405-414

McKenzie, L.S., III and D.W. Davis 1994 Louisiana Gulf of Mexico outer continental shelf offshore oil and gas activity impacts. Baton Rouge, Louisiana. Louisiana Mid-Continent Oil and Gas Association. 112 p.

McKenzie, L.S., III, P.J. Zander, M.T.C. Johnson, B. Baldwin, and D.W. Davis 1993 Socioeconomic impacts of declining outer continental shelf oil and gas activities in the Gulf of Mexico. OCS Study MMS 93-0028. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico Region, New Orleans, Louisiana. 240 p.

Melancon, Jr., E., T. Soniat, V. Cheramie, M. Lagarde, R. Dugas, and J. Barris 1994 The Oyster Resource Zones Within Louisiana's Barataria and Terrebonne Estuaries. Barataria-Terrebonne National Estuary Program. BTNEP Publication-15. September.

Mitsch, W.J. and J.G. Gosselink 1993 Wetlands. New York: Van Nostrand Reinhold. Second Edition. 722 p.

Morse, W.D. n.d. The Birth of Jennings. Jennings, LA: Jennings Chamber of Commerce. 149 p.

National Marine Fisheries Service 1997 Commercial Fishery Landings. NOAA Habitat Connections. 1:4

Neal, K. 1997 Personal communication. September.

Nyman, J.A., R.H. Chabreck, R.D. DeLaune, and W.H. Patrick, Jr. 1993 Submergence, Saltwater Intrusion, and Managed Gulf Coast Marshes. In: O. Magoon (ed.) Proceedings of Coastal Zone '93. Eighth Symposium on Coastal and Ocean Management. New Orleans. American Shore and Beach Preservation Association and American Society of Civil Engineers. pp. 1690-1704.

Office of Planning and Budget 1997 State of the State 1996. State of Louisiana. Baton Rouge, LA: Division of Administration. 117 p.

Office of Technology Assessment 1984 WETLANDS. Their Use and Regulation. OTA-O-206. Washington, D.C.: U.S. Congress. March. 208 p.

Padgett, H. R. 1960 The Marine Shell Fisheries of Louisiana. Ph.D. Dissertation. Baton Rouge: Louisiana State University.

Penland, S., I.A. Mendelssohn, L. Wayne, and L.D. Britch 1996 Natural and Human Causes of Coastal Land Loss in Louisiana. Baton Rouge, LA: Coastal Studies Institute, Wetlands Biogeochemistry Institute, Louisiana State University.

Penland, S., K.E. Ramsey, R.A. McBride, T.F. Moslow, and K.A. Westphal 1989 Relative Sea-Level Rise and Subsidence in Louisiana and the Gulf of Mexico: 1908-1988. Coastal Geology Technical Report 3. Baton Rouge, LA: Louisiana Geological Survey.

Platt, R.H., H.C.Miller, T. Beatley, J.Melville, and B.G. Mathenia 1992 Coastal Erosion. Has Retreat Sounded? Program on Environment and Behavior Monograph No. 53. University of Colorado: Institute of Behavioral Science. 195 p.

Platt, R.H., S.G. Pelczarski, B.K.R. Burbank (eds.) 1987 Cities on the Beach. Management Issues of Developed Coastal Barriers. University of Chicago Department of Geography Research Paper No. 224. 324 p.

Pompilio, N. 1997 Void filled as accord on shelters is reached. New Orleans: The Times-Picayune. September 8.

Port of New Orleans 1996 Superior Service Along the Inland Waterway. IN: 1996-1997 Annual Directory. Board of Commissioners Port of New Orleans. pp. 26-28.

Port of New Orleans 199- Port Facts. Board of Commissioners of the Port of New Orleans.

Ramsay, K.E. 1991 Rates of Relative Sea-Level Change in the Northern Gulf of Mexico. Coastal Depositional Systems in the Gulf of Mexico. Society of Economic Paleontologists and Mineralogists Foundation. Twelfth Annual Research Conference. pp. 204-208.

Reed, D.J. 1991 Sediment Deposition in Louisiana Coastal Marshes. Coastal Depositional Systems in the Gulf of Mexico. Society of Economic Paleontologists and Mineralogists Foundation. Twelfth Annual Research Conference. pp. 211-214.

Reed, D.J. (ed.) 1995 Status and Trends of Hydrologic Modification, Reduction in Sediment Availability, and Habitat Loss / Modification in the Barataria-Terrebonne Estuarine System. Publication #20. Thibodaux, LA: Barataria-Terrebonne National Estuary Program.

Reinecke, F. 1997 Tidal flooding hits coast of parish. Houma: Houma Courier. April 6. pp. 1A and 11A.

Sampsell, L. D. 1893 The Recent Storm on the Gulf Coast. Frank Leslie's Weekly, 26:269-270.

Sayre, A. 1997 Louisiana exports increase 9 percent. Baton Rouge, LA: The Advocate. February 8.

Schlatre, M. 1937 The Last Island Disaster of August 10, 1856, A Personal Narrative on One of the Survivors. Louisiana Historical Quarterly, 20(3):1-50.

Schleifstein, M. and Keith Darce 1998 Goodbye MR-GO? New Orleans: The Times-Picayune. October 18. pp. A-1, A-10, and A-11.

Schneider, G.P. 1952 The History and Future of Flood Control. Chicago: American Society of Civil Engineers, Waterways Division. 98 p.

Seydlitz, R. and S. Laska. 1994 Social and Economic Impacts of Petroleum "Boom and Bust" Cycles. OCS Study / MMS 94-0016. U.S. Department of Interior, Minerals Management Service, Gulf of Mexico OCS Regional Office, New Orleans, Louisiana. 131 p.

Silas, U. 1890 Last Island. The Weekly Thibodaux Sentinel. August 9 (typed copy). Thibodaux, La.: Nicholls State University Archives.

Sklar, F.H, R. Costanza, and J.W. Day, Jr. 1985 Dynamic Spatial Simulation Modelling Of Coastal Wetland Habitat Succession. Ecological Models, 29:.261-281.

Southwick Associates 1997 The Economic Benefits of Fisheries, Wildlife and Boating Resources in the State of Louisiana. Report prepared for the Louisiana Department of Wildlife and Fisheries, Baton Rouge, LA. 21 p.

Sterns, S. 1887 Fisheries of the Gulf of Mexico: The Fishery Interests of Louisiana. In: Fisheries and Fishery Industries of the United States. Washington, D.C.: U.S. Government Printing Office. pp. 575-582.

Straatmann, L. 1997 Personal communication. Texaco, Inc. October 7.

Suhayda, J. 1996 Computer modelling of the Louisiana coastal wetlands projected land loss (and gain) to year 2050. Louisiana State University. Prepared for the Coalition to Restore Coastal Louisiana.

Tabberer, D.K., W. Hagg, M. Coquat, and C.L. Cordes 1985 Pipeline impacts on wetlands final environmental assessment. OCS EIS / EA 85-0092. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Regional Office, New Orleans, Louisiana. 41 p.

Thomas, G. 1997 Insurers Wary of Homes in LA. New Orleans: The Times-Picayune Real Estate Section. January 11. pp. 1, 12-13.

Turner, R. and D.R. Cahoon 1987 Causes of Wetland Loss in the Coastal Central Gulf of Mexico. Vol. 1, Executive Summary. New Orleans: Minerals Management Service. OCS / MMS87-0119.

Turner, R. E. 1987 Relationship Between Canal and Levee Density and Coastal Land Loss in Louisiana. Biological Report 85 (14). Washington, D.C.: U.S. Fish and Wildlife Service. 58 p.

Turner, R.E. 1977 Intertidal vegetation and commercial yields of penaeid shrimp. Transactions of the American Fisheries Society, 106:411-416.

Turner, R.E. and D.F. Boesch 1987 Aquatic animal production and wetland relationships: insights gleaned following wetland loss or gain. In: D. Hook (ed.) The Ecology and Management of Wetlands. Beckenham, Kent, U.K.: Croom Helm, Ltd. pp. 25-39.

U.S. Army Corps of Engineers. 1994. West Bank of the Mississippi River in the Vicinity of New Orleans, Louisiana (East of the Harvey Canal). Feasibility Report and Environmental Impact Statement. New Orleans District Office.

U.S. Army Corps of Engineers 1994 Waterborne Commerce of the United States, Calander Year 1994. Part 2. Waterways and Harbors Gulf Coast, Mississippi River System, and Antilles. SRSC-SCUS-94-2. Water Rersource Support Center.

U.S. Army Corps of Engineers 1983 Lake Pontchartrain, Louisiana, and Vicinity Hurricane Protection Project. Reevaluation Study. Appendix A, Section IV, Detailed Cost Estimates New Orleans District. p. 4.

U.S. Army Corps of Engineers 1961 Interim Survey Report. Mississippi River Delta at and Below New Orleans, Louisiana. New Orleans District. December 29. p. A-11.

U.S. Army Corps of Engineers 1924 Annual Report of the Chief. Intracoastal Waterway from Vermilion Bay to Schooner Bayou, Louisiana.

U.S. Congress 1990 Louisiana Coastal Wetlands Planning, Protection and Restoration Act of 1990 (PL101-646).

U.S. Department of Commerce 1990 Bureau of Economic Analysis. BEA Regional Projections to 2040.

U.S. Department of Commerce 1990 Bureau of the Census. Population.

U.S. Fish and Wildlife Service 1950 Curing of Fishery Products. Research Report 18. United States Department of the Interior.

U.S. Fish and Wildlife Service 1994 Draft Environmental Impact Assessment for the Establishment of the Mandalay National Wildlife Refuge, Terrebonne Parish, LA. Jackson, MS: US Fish and Wildlife Service Field Office.

U.S. Department of the Interior, Minerals Management Service n.d. Working for America's energy future and a quality environment. U.S. Department of the Interior, Minerals Management Service, Washington, D.C. 15 p.

U.S. Department of the Interior, Minerals Management Service 1994 Current Facts and Figures, Minerals Management Service, Offshore Oil and Gas Operations, Gulf of Mexico OCS Region.

U.S. Senate 1946 Senate Document 231. 79th Congress, 2nd Session.

Van Pelt, A. W. 1943 The Caminada Storm: A Night of Tragedy. New Orleans: The Times-Picayune. September 26, Magazine Section, p. 8, col. 1.

Vermilion Historical Society 1983 History of Vermilion Parish, Louisiana. Abbeville, LA: The Vermilion Historical Society. 485 p.

Wicker, K.M. R.E. Emmer, D. Roberts, and J. van Beek 1989a Pipelines, Navigation Channels, and Facilities in Sensitive Coastal Habitats, An Analysis of Outer Continental Shelf Impacts, Coastal Gulf of Mexico. Volume 1: Technical narrative. OCS Report / MMS 89-0051. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Regional Office, New Orleans, LA. 470 p.

Wicker, K.M. R.E. Emmer, D. Roberts, and J. van Beek 1989b Pipelines, Navigation Channels, and Facilities in Sensitive Coastal Habitats, An Analysis of Outer Continental Shelf Impacts, Coastal Gulf of Mexico. Volume 2: Atlas of Physical, Cultural, and Biological Parameters. OCS Report MMS 89-0052. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Regional Office, New Orleans, LA. 83 p.

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