## The Ocean in Our Living Room
## "Hurricanes 2005"

Katrina, Aug 29, 2005

Rita, Sept 24, 2005

## A View from Between the Storms

Jessie Kastler, Ph.D.
Louisiana Universities Marine Consortium

July 2006
COSEE Online Institute

Katrina destroyed our roof

Rita flooded us to ~4 ft

Insured losses totaled ~$2M

We were VERY fortunate…

## Part I: Louisiana Coastal Setting

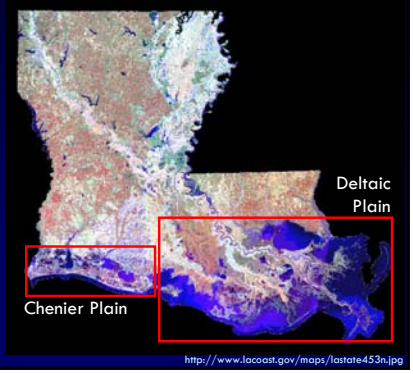
## Mississippi River Drainage Basin

The blue line outlines the watershed (or drainage basin) of the Mississippi River. The Mississippi River drains 41% of the continental US and 2 Canadian provinces.
What does the Mississippi River carry downstream from all that land?

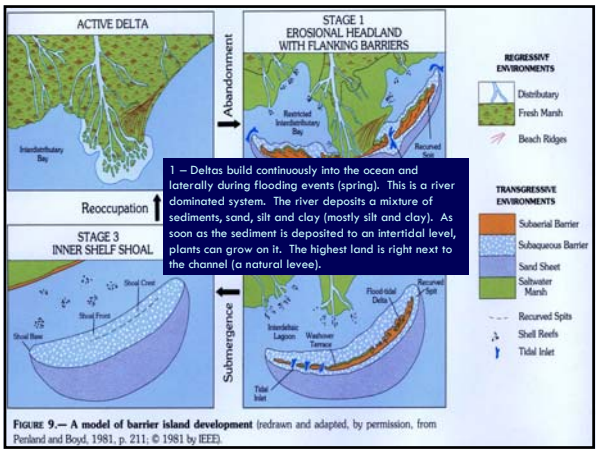
This aerial photograph shows the bird foot delta of the Mississippi River. Black is water, solid tan is upland, and broken tan is wetland. The blur around the end of the delta is sediment in the water, carried by the Mississippi River from the mid-continent to build south Louisiana.

## Louisiana and Coastal Plains

The Mississippi River built the deltaic plain AND the chenier plain as different parts of the same delta building process.

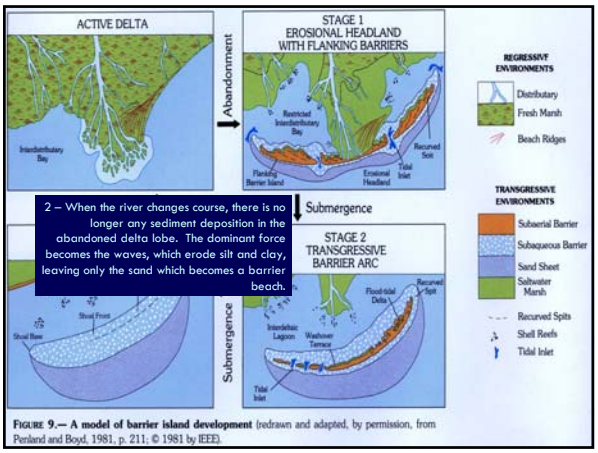



http://www.lacoast.gov/maps/lastate453n.jpg



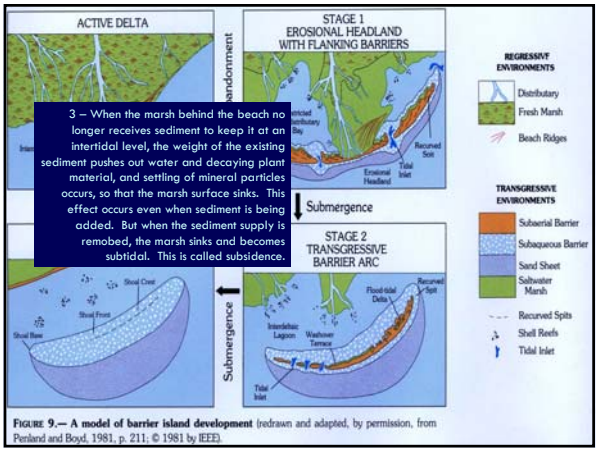

1 – Deltas build continuously into the ocean and laterally during flooding events (spring). This is a river dominated system. The river deposits a mixture of sediments, sand, silt and clay (mostly silt and clay). As soon as the sediment is deposited to an intertidal level, plants can grow on it. The highest land is right next to the channel (a natural levee).

FIGURE 9.— A model of barrier island development (redrawn and adapted, by permission, from Penland and Boyd, 1981, p. 211; © 1981 by IEEE).



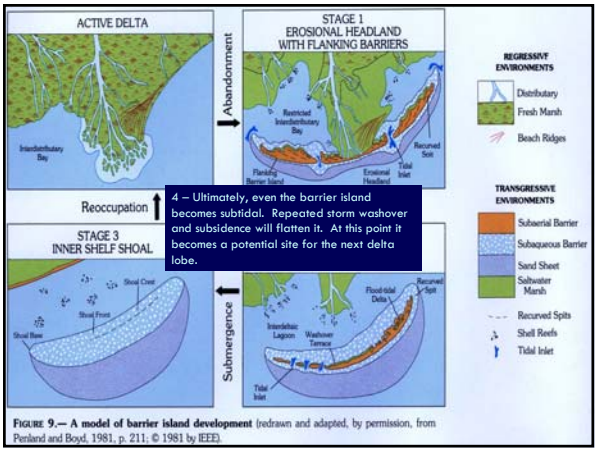

2 – When the river changes course, there is no longer any sediment deposition in the abandoned delta lobe. The dominant force becomes the waves, which erode silt and clay, leaving only the sand which becomes a barrier beach.

FIGURE 9.— A model of barrier island development (redrawn and adapted, by permission, from Penland and Boyd, 1981, p. 211; © 1981 by IEEE).



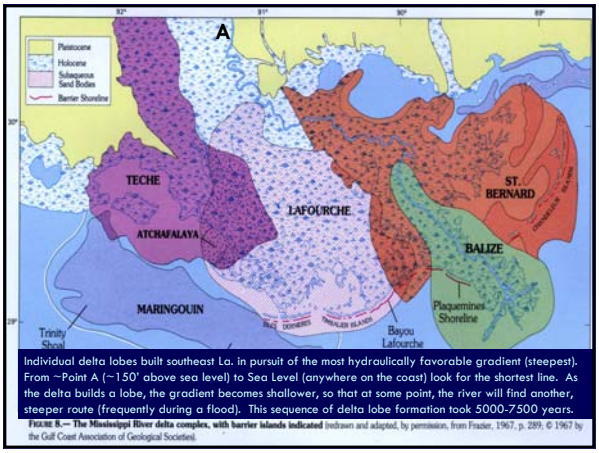

3 – When the marsh behind the beach no longer receives sediment to keep it at an intertidal level, the weight of the existing sediment pushes out water and decaying plant material, and settling of mineral particles occurs, so that the marsh surface sinks. This effect occurs even when sediment is being added. But when the sediment supply is remobed, the marsh sinks and becomes subtidal. This is called subsidence.

FIGURE 9.— A model of barrier island development (redrawn and adapted, by permission, from Penland and Boyd, 1981, p. 211; © 1981 by IEEE).



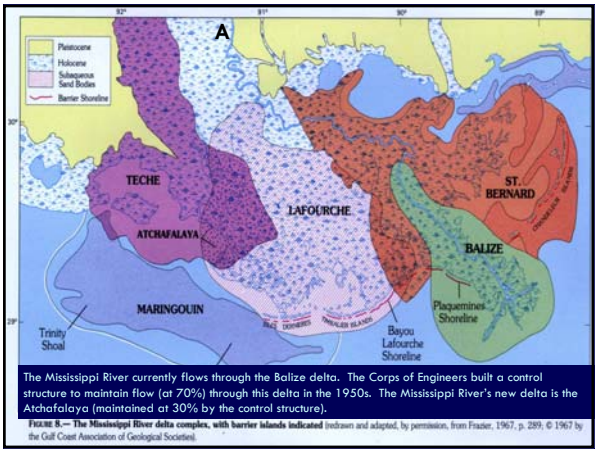

4 – Ultimately, even the barrier island becomes subtidal. Repeated storm washover and subsidence will flatten it. At this point it becomes a potential site for the next delta lobe.

FIGURE 9.— A model of barrier island development (redrawn and adapted, by permission, from Penland and Boyd, 1981, p. 211; © 1981 by IEEE).




Individual delta lobes built southeast La. in pursuit of the most hydraulically favorable gradient (steepest). From ~Point A (~150' above sea level) to Sea Level (anywhere on the coast) look for the shortest line. As the delta builds a lobe, the gradient becomes shallower, so that at some point, the river will find another, steeper route (frequently during a flood). This sequence of delta lobe formation took 5000-7500 years.

FIGURE 8.— The Mississippi River delta complex, with barrier islands indicated (redrawn and adapted, by permission, from Frazier, 1967, p. 289; © 1967 by the Gulf Coast Association of Geological Societies).




The Mississippi River currently flows through the Balize delta. The Corps of Engineers built a control structure to maintain flow (at 70%) through this delta in the 1950s. The Mississippi River's new delta is the Atchafalaya (maintained at 30% by the control structure).

FIGURE 8.— The Mississippi River delta complex, with barrier islands indicated (redrawn and adapted, by permission, from Frazier, 1967, p. 289; © 1967 by the Gulf Coast Association of Geological Societies).

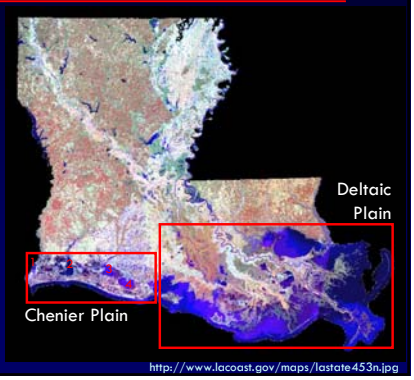
## Chenier Plain

Lakes Sabine-1, Calcasieu-2, Grand-3, and White-4 formed as bays at drowned river mouths during the Holocene rise in sea level.

The Mississippi River built the chenier plain in episodes on the western part of the continental shelf, while moving from lobe to lobe in the delta plain.

When the active lobe was in the the western part of the delta, sediment accreted in the chenier plain as fine sediment mud flats.

When the active lobe was in the eastern part of the delta, sediment eroded from the chenier plain, leaving coarse sand and shell.




http://www.lacoast.gov/maps/lastate453n.jpg

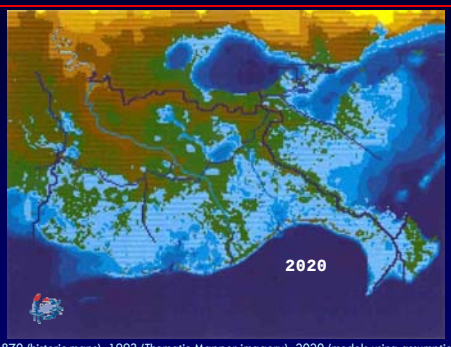
## Chenier Plain

{ Note the width of the chenier deposit beyond the drowned river bay }


These are known as cheniers. Typically they are higher in elevation and colonized by live oak; *cheniere* = place of oaks. This (roughly) shore parallel sequence of ridges is clearly visible in aerial photos. How does this compare to your own coast's geography?

http://www.lacoast.gov/maps/lastate453n.jpg

## Our Estuaries Are Threatened




1839 & 1870 (historic maps); 1993 (Thematic Mapper imagery); 2020 (models using assumptions about hurricanes and land loss rates).

Suhayda & www.btnep.org

Example of land loss in area south of LUMCON. Local residents share anecdotes of driving horse and buggy to the Isles Dernieres less than 100 years ago…

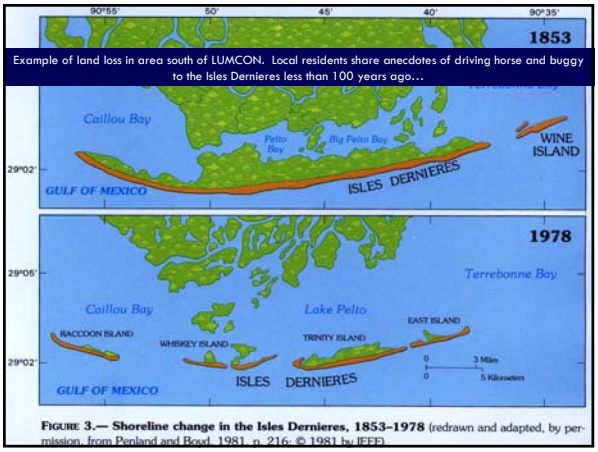



**FIGURE 3.— Shoreline change in the Isles Dernieres, 1853–1978** (redrawn and adapted, by permission, from Penland and Boyd, 1981, p. 216; © 1981 by IEEE)

## Coastal Ocean Statistics

- The Mississippi River has the world's 7th largest delta
  - with 40% of U.S. tidal marshes
  - and the largest commercial fishery in the 48 states
- From 1928-2000 Louisiana lost 1900 miles$^2$ of wetland
- 700 miles$^2$ will be lost by 2050 if no action is taken
- ~30% of loss is from natural causes: subsidence, ↑ sea level
- The rest is from canal dredging, ↓ sediment supply, oil/gas withdrawal

www.lca.gov

## Outer Continental Shelf (OCS) Leases

- Provide 25% of Natural Gas, 12% Crude Oil (domestic)
- Largest source of federal revenue after U.S. Treasury (IRS)
  www.gomr.mms.gov
- Louisiana → 50-80% GOM OCS production MMS, Congress 2005
- 3rd Natural Gas → 2nd with OCS
- 4th Crude Oil → 3rd with OCS La Mid-Continental Oil & Gas Assoc.

## Part II: Hurricane Climatology

## Hurricane Katrina
## August 29, 2005

- Max Intensity
  - 150 mph winds (5)
  - 185 mph gusts
  - 902 mb
- Landfall Intensity (So LA)
  - 140→105 mph winds (4→3)
  - 920 mb


Katrina reached its maximum intensity in the Gulf & had weakened to a category 3 storm (initial estimates categorized it as a category 4 storm) by the time it reached land in Buras, Louisiana early August 29.

http://www.ncdc.noaa.gov/oa/climate/research/2005/hurricanes05.html

## Hurricane Katrina
## August 29, 2005

A very large storm (radius 105 mi), Katrina's maximum strength was expelled in Mississippi. Louisiana received a direct hit with storm surge of > 20', but was spared the maximum storm surge, >30 observed in Mississippi.


http://www.ncdc.noaa.gov/img/climate/research/2005/katrina/katrina-satellite.gif

## Hurricane Rita
## September 24, 2005

- Max Intensity
  - 150 mph winds (5)
  - 185 mph gusts
  - 897 mb
- Landfall Intensity (swLA, swTX)
  - 120 mph winds (3)
  - 937 mb

Like Katrina, Rita had its greatest intensity while in the Gulf. It traveled west along Louisiana's coast, pushing water toward the shore with the force of a category 5 storm. By the time it hit land in southwest Louisiana/southeast Texas, Rita was a category 3.

http://www.ncdc.noaa.gov/img/climate/research/2005/rita/ritatrack-cimss.gif

## Hurricane Rita
## September 24, 2005

Rita caused an exceptionally widespread storm surge, ~20' in the vicinity of the storm. The high winds pushing ashore pushed up a surge of ~9' across south Louisiana. Rita was not as big as Katrina, but the hurricane was sustained for more than 150 miles inland, and was associated with widespread heavy rain (>6").

http://www.ncdc.noaa.gov/img/climate/research/2005/rita/rita-nnvl-pg.gif

## The Big One?

Katrina, Aug 29, 2005

Rita, Sept 24, 2005

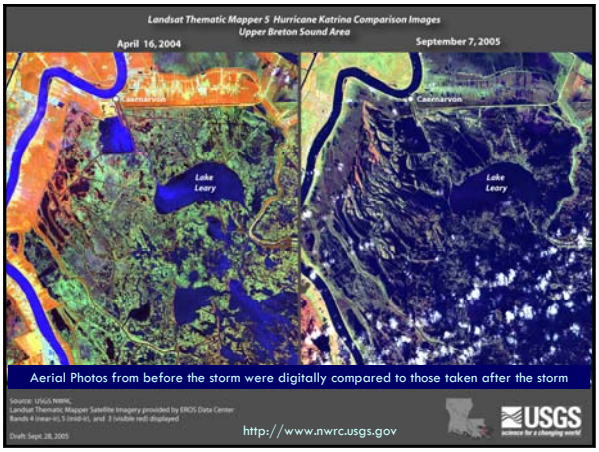
New Orleans (x) is just below Lake Pontchartrain (o)

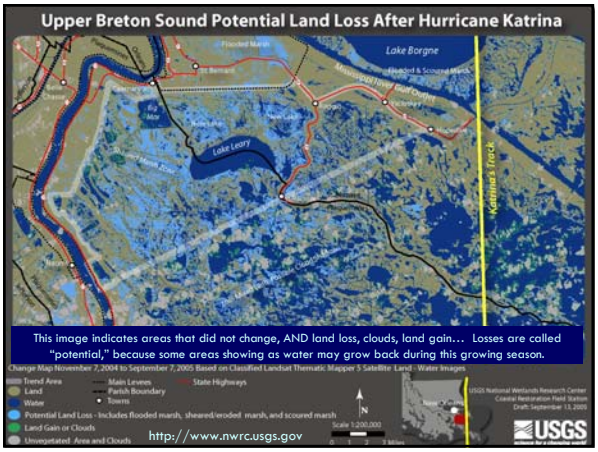
For decades scientists have warned of the danger that a major storm might hit New Orleans with catastrophic consequences. Katrina and Rita were major storms, and both had catastrophic consequences.

Keep in mind: 1) Neither came ashore as a category 5; 2) Neither had the path forecast for the feared storm. The eye of the forecast catastrophe would push across New Orleans from the southeast, first filling Lake Pontchartrain, then emptying the lake into the city. Something to consider for the future…

## Part III: Damage

## Part III: Damage – Natural Environments




## East Louisiana Marsh Damage

- **LOSS 118 mi²**
  - 40.9 mi² Breton Sound
  - 19.1 mi² Pontchartrain
  - 4.4 mi² Pearl River
  - 17.8 mi² Mississippi River
  - 17.6 mi² Barataria
  - 19.4 mi² Terrebonne

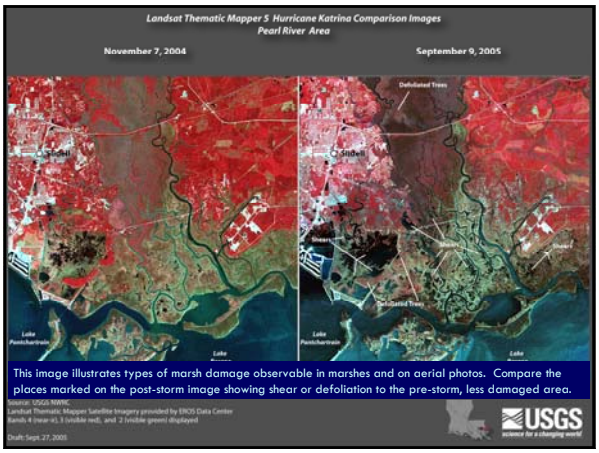
  Worst east of Mississippi River

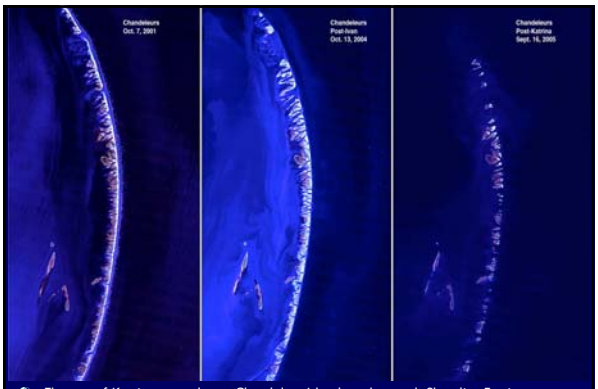
- NO LOSS Atchafalaya Delta

## East Louisiana

- Previous Louisiana coastal land loss rates

  1956 – 1978 = 40 mi²/year
  1978 – 1990 = 35 mi²/year
  1990 – 2000 = 24 mi²/year
  2000 – 2050 = 10 mi²/year
  (WITH restoration)




- The eye of Katrina passed over Chandeleur Islands and caused Shoreline Erosion
- The islands lost ~50% of area left after Hurricane Ivan, 1994

http://coastal.er.usgs.gov/hurricanes/rita/photo-comparisons/cameron.html

## West Louisiana – Hurricane Rita

- Many similar types of damage to that caused by Katrina in eastern marshes
- More prominent and longer lasting:
  Flooding: caused toxicity in marsh plants (and agricultural fields) because of the buildup of toxic salts and sulfides
- Shoreline erosion was widespread on chenier plain beaches

## West Louisiana – Hurricane Rita


9/21/05 10/07/05

Southwestern Louisiana from Sabine Lake to White Lake:
See the mud in the channels (and quite a distance from the channels, upstream). Also notice the loss of color from vegetated areas and the increase in water area close to the coast.

http://coastal.er.usgs.gov/hurricanes/rita/photo-comparisons/cameron.html

## West Louisiana – Hurricane Rita

**Holly Beach:** In the lower photograph, note the sand deposit emerging from the flood waters in a mid-island location half way between the arrows, as well as landward of the main highway along the far-left side.

http://coastal.er.usgs.gov/hurricanes/rita/photo-comparisons/cameron.html

## Oil & Hazardous Waste Spills

- Southeast Louisiana Oil Spills
  - 6 major
  - 3 medium
  - 133 minor (<10,000 barrels)
  - 191,000 barrels
- Southwest Louisiana Oil Spills
  - 2 major
  - 2 medium
  - 174 minor
  - 4,200 barrels
- USCG lead in most cases

## Oil & Hazardous Waste Spills

Numerous sites with unknown wastes = **orphan containers**
1.9 million by 1Feb06


Thousands of vessels unclaimed or unfound, potentially leaking fluids to water or soil

## Part III: Damage – Natural Resources

## Agricultural Crop Damage

- $ 7,000,000,000 Annual Revenue
- $1,600,000,000 Loss, 2005 (not counting infrastructure)

Loss of Revenue by
- Lost product
- Changes in supply/demand
- Reduced quality
- Disruption of marketing/delivery
- Increase production cost with lost agricultural infrastructure

http://agcenter.lsu.edu

## Agricultural Damage

| | |
|---|---|
| Forestry (Timber) | $ 836 M |
| Agronomic Crops (Sugarcane) | $ 358 M |
| Livestock & Forage | $ 75 M |
| Fruit, Nuts, Veggies, Honey | $ 42 M |
| Aquaculture | $ 58 M |
| Fisheries | $ 176 M |
| Hunting Leases / Fishing Charters | $ 41 M |

Timber, Sugarcane and Fisheries experienced the greatest losses in the agricultural sector

http://agcenter.lsu.edu

## Fisheries Damage (in detail)

Annual Revenue = $700M

LOSS = $234M

| | |
|---|---|
| Crawfish – west Louisiana | $ 38 M |
| Turtles | $ 6 M |
| Alligators | $ 13 M |
| AQUACULTURE | $ 58 M |
| | |
| Oysters | $ 27 M |
| Menhaden | $ 25 M |
| Shrimp – east Louisiana | $ 90 M |
| Commercial Finfish | $ 15 M |
| Crabs | $ 19 M |
| FISHERIES | $ 176 M |

http://seagrant.lsu.edu

## Fisheries Damage

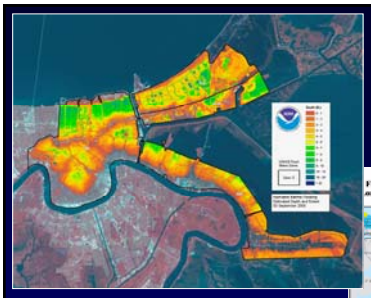
Shrimp

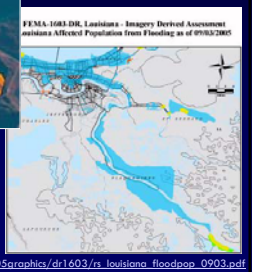
Oysters

Menhaden

Crawfish

## Part III: Damage – Social Infrastructure






- 80% New Orleans was under water
- 80% New Orleans was evacuated

http://www.gismaps.fema.gov/2005graphics/dr1603/rs_louisiana_floodpop_0903.pdf
http://www.disastercenter.com/Katrina%20Louisiana.html

## Louisiana Social Impacts

1558 People Died

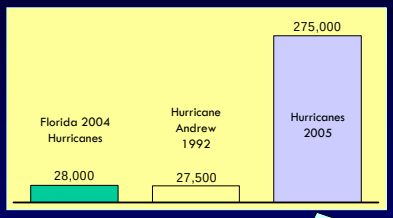
650,000 Displaced
240,000 Unemployed

40 Schools Destroyed
10 Hospitals Closed
19,000 Businesses Destroyed

$45B Insured Losses (Katrina)
$37B FEMA Loss
~$8,244 per capita; by contrast the 9/11 tragedy cost FEMA ~$483 per capita

## Housing Losses

Number of homes destroyed by major hurricanes*




**Number for Louisiana alone estimated to be over 205,000**

* Destruction is defined as a structure made uninhabitable or damaged beyond economic repair
Source: National Association of Home Builders; American Red Cross (as of 9/15/05); Insurance Information Institute

## Population Shift


From August to December 2005, Orleans Parish lost 64% (437K-158K), St Bernard Parish lost 95% (65K-3K). Lake Charles gained 15% from outlying Cameron and Calcasieu Parishes (174K-201K).

People continue to move back to New Orleans, but some areas and people will not easily be able to return.

The New York Times/James Bronzan

## Debris Generated

**Based upon Corps of Engineer Debris Models:**

- Hurricane Katrina generated an estimated **22 million tons** of debris.
  55 million cubic yards
- Hurricane Rita generated an estimated **0.5 million tons** of debris.
  1 million cubic yards


298,400 refrigerators by 1Feb06


9.7 million pounds household hazardous waste by 1Feb06

www.LDEQ.gov

## Part III: Damage – Ongoing

New Orleans Sewage & Water Board (SWB) loses 60% of treated water to leaks/thieves
- Storm broke some pipes
- Post-Storm recovery effort broke others
- anecdote from NO:
  - SWB contractor sees NO Police Station using water from fire hydrant
  - Tells the officers this is stealing water from SWB
  - Officers are contrite, but what can they do? they need water to operate

Levee Failure:
- Built and maintained by US Army Corps of Engineers (COE)
- COE report states why New Orleans flooded after Katrina:
  - 1 – The system was not integrated, there was no repetition, so failure was uncontained and spread easily once it began
  - 2 – The model hurricane used to test the levees did not represent that which NOAA (the weather service) suggested
  - 3 – Levees were unrepaired.
  - Some were lower than design height (by ~3ft) because of subsidence
  - 4 – Most failure resulted from scour (a design flaw)

From the Times Picayune www.nola.com

## Choices for Louisiana

- ~1700 –1980 Decisions dominated by needs for
  - Community Protection (levees against spring and hurricane floods)
  - Navigation (transportation to and from city, hunting/fishing areas, navigation through marshes and into river, oil & gas production)

## Choices for Louisiana

- ~1700 –1980 Decisions dominated by needs for
  - Community Protection
  - Navigation
- ~1980-2006 Decisions dominated by land loss concern
  - Coastal Restoration & Environmental Protection

## Choices for Louisiana

Some prominent coastal restoration efforts

- Barataria – Terrebonne National Estuary Program (www.btnep.org)
- Coastal Wetlands Planning, Protection, & Restoration Act of 1990 (lacoast.gov)
- Coast 2050 (www.lca.gov)
- Louisiana Coastal Area 2005 (www.lca.gov)
- Water Resources Development Act (planning)

## Choices for Louisiana

- ~1700 –1980 Decisions dominated by needs for
  - Community Protection
  - Navigation
- ~1980-2006 Decisions dominated by land loss concern
  - Coastal Restoration
- Post-Storms Decisions must consider
  - Coastal Restoration
  - Community Protection
  - Navigation (Working Group for Planning, 2006)

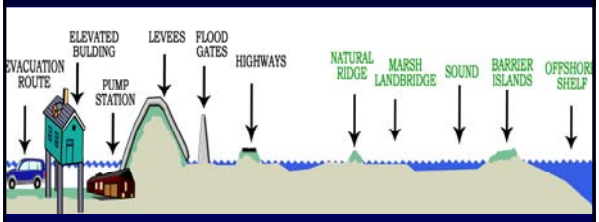
## Post-Storm Choices for Louisiana

**CIAP** – The Coastal Impact Assistance Program (CIAP), Title 371 of the Energy Policy Act of 2005, returns a portion of federal oil and gas royalties to coastal states and counties based on their respective levels of energy production, population and coastline.

Under the current version of this title, Louisiana could receive $540 million over the next four years for coastal impact assistance.

Louisiana's congressional delegation is working to get a more permanent piece of the OCS (outer continental shelf) royalties to pay for ongoing restoration and protection in the coastal zone.

## LPBF Multiple Lines of Defense




The Lake Pontchartrain Basin Foundation (LPBF) has put forward the suggestion that 5 natural barriers (green) and 6 human measures should be considered in protecting against a storm in the future. The suggestion is that natural barriers should be built up before artificial levees receive large financial investments. Evacuation is also line fo Defense that people should remember is part of their arsenal. This model was developed for New Orleans, but most of the ideas can be applied to other parts of Louisiana.

www.saveourlake.org

## Post-Storm Choices for Louisiana

***There are no conclusions to this story yet…***

What should be done about coastal Louisiana, New Orleans, levees, etc.?

**Choices are:**

**Multi-dimensional**: not just science, also economic, and cultural

**Complex**: not just the coast, but the human-modified, subsiding delta that was already experiencing land loss faster than anywhere on earth, AND the chenier plain.

**Expensive**: How much do levees cost? What are the alternatives? What do all of these alternatives do to our valuable coastal and estuarine habitat? What about the communities that are closer to the Gulf of Mexico? How can we decide what to do about ALL of these problems?

***…Science provides information to use in making decisions, but ultimately, people are responsible for making decisions wisely for themselves, their community and their environment.***

## Resources

**Pre-K general interest BOOKS**

***The Control of Nature***, 1990
John McPhee

***Rising Tide***, 1997
John Barry

***Holding Back the Sea***, 1999
Christopher Hallowell

***Bayou Farewell***, 2003
Mike Tidwell

**Comments**

☺ Thanks for all the donations, benefits, volunteer hours, prayers, karma, good thoughts, letters, etc.

☺ We in south Louisiana can never repay the kindnesses we have received in the past year, nor those we continue to receive. But we appreciate you sending them anyway.

**WEBSITES** (besides those cited)

www.lca.gov
www.btnep.org
www.wetmaap.org
www.coast2050.gov
www.crcl.org
www.lumcon.edu
www.lacoast.gov
www.katrina.lsu.edu
www.americaswetland.org
www.savelawetlands.org
www.saveourlake.org