

Dangerous Waves



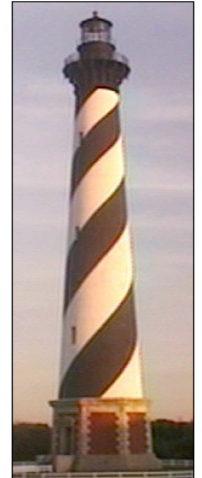
- Shallow water & shoreline
 - “Routine” coastal erosion
 - Under “normal” conditions
 - Under sea level rise
 - Under coastal subsidence
 - Storm erosion
 - Wind-driven waves
 - Storm surge (not a wave)
- Deep water
 - “Normal” large waves
 - “Rogue” waves

1

Shoreline Case Studies



- Cape Hatteras (NC) lighthouse
- Katrina & other hurricanes
- Southwest Washington



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Cape Hatteras (Outer Banks)



- Historic structure
 - Built 1803 1 mile inland
 - “Graveyard of the Atlantic”



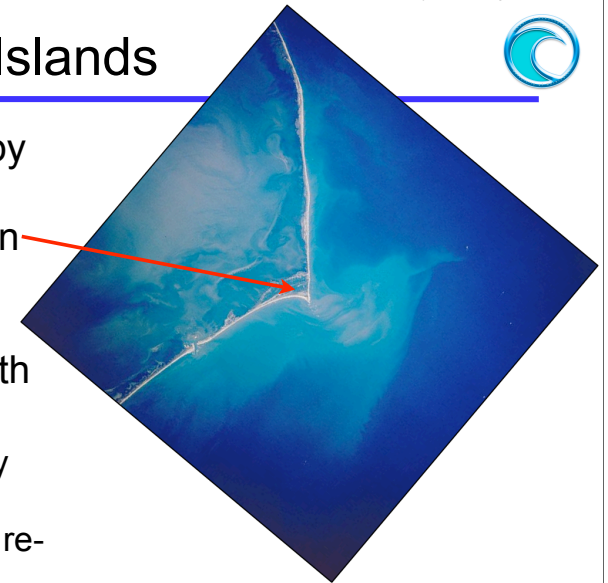
www.lib.unc.edu/ncc/ref/nchistory/dec2003/dec2003.html

3

Barrier Islands



- Formed by the interaction of wind-driven waves with the coast
 - Naturally move, erode & re-form

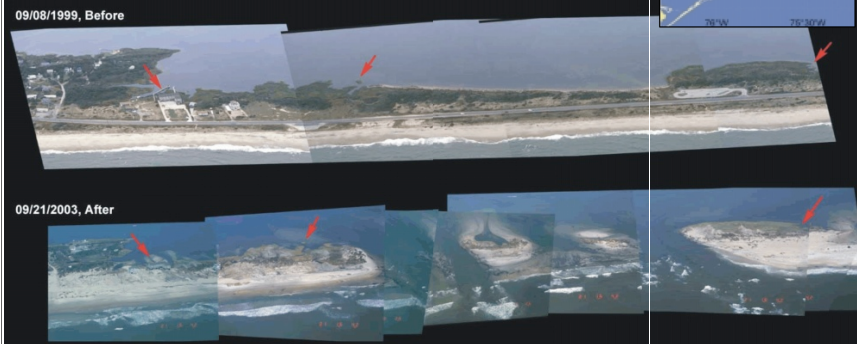


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<http://eol.jsc.nasa.gov/sseop/EFS/photoinfo.pl?PHOTO=STS034-83-69>

Barrier Islands & Storms

- Hurricane Isabel 2003
 - Multiple breaches in islands



5

<http://pubs.usgs.gov/of/2004/1064/html/gvariables.htm>

Cape Hatteras



- Taller structure built 1870
 - Tallest in the nation 208'
 - 1500 feet inland
- By 1936 seas were at its base
 - Closed as unsafe



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www.labs.net/anaiselise/lhse/lhse.htm

Cape Hatteras



- Shoreline reinforced
 - Sand pumped
 - Concrete bunkers & seawall
 - Groins
- Reopened 1950
 - By 1999 threatened again



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http://en.wikipedia.org/wiki/Cape_Hatteras

Cape Hatteras



- Save the lighthouse?
 - Or abandon it?
 - Vigorous debate
- Owned by National Park Service



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www.uscg.mil/hq/g-cp/history/WEBLIGHTHOUSES/LHNC.html

Cape Hatteras



- Moved summer 1999
 - 2900' inland on rails
 - 1600' from beach
 - \$10 million cost



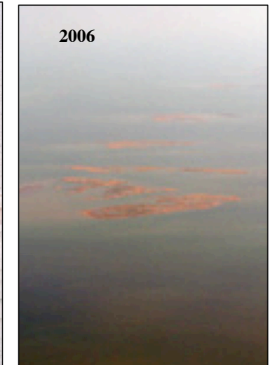
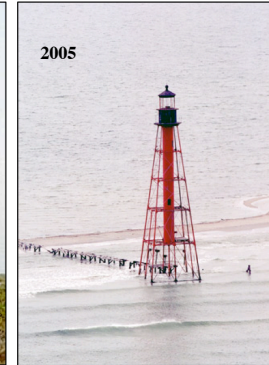
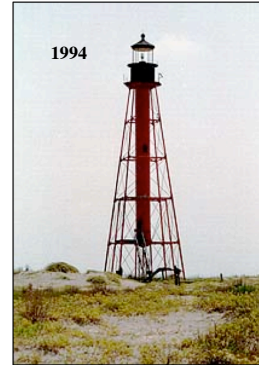
www.nps.gov/archive/caha/lrp.htm
www.labs.net/anaiselise/lhse/lhse.htm



Hurricane Erosion



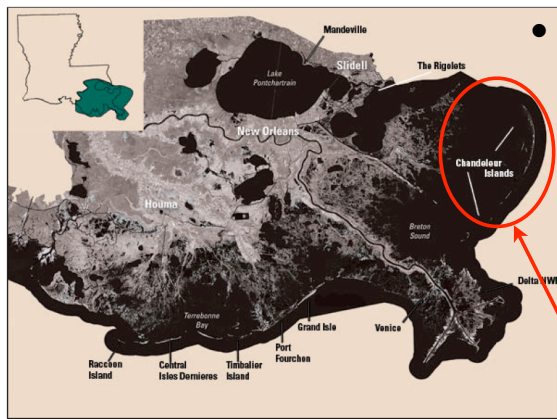
- Example: Chandeaur Island lighthouse



www.thelighthousepeople.com/Louisiana/chandeaur_la1.html
www.lighthousefriends.com/light.asp?ID=810

www.nwrc.usgs.gov/hurricane/post-hurricane-katrina-photos.htm

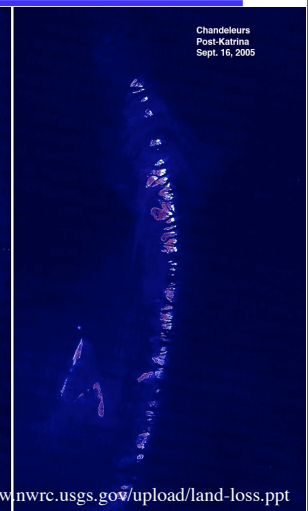
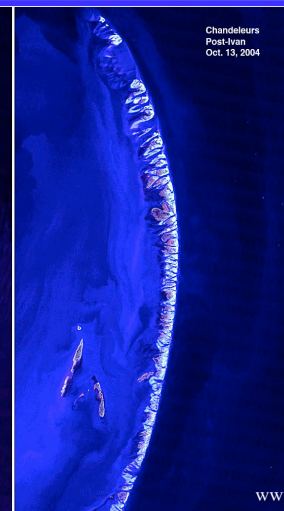
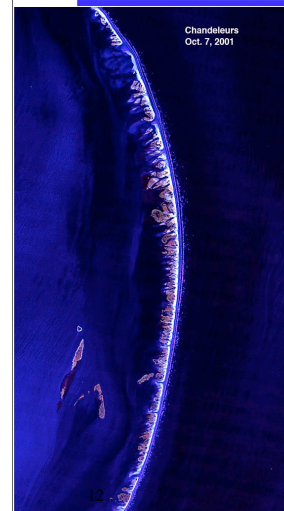
Louisiana



- Hurricane alley
 - Georges 1998
 - Isadore & Lili 2002
 - Ivan 2004
 - Katrina 2005
 - 50% loss

www.nwrc.usgs.gov/hurricane/post-hurricane-katrina-photos.htm

Chandeleur Islands



www.nwrc.usgs.gov/upload/land-loss.ppt

Causes of Hurricane Damage



- Wind!
- Rain & flooding
- Wind-driven waves
 - On more exposed coastlines, e.g. barrier island such as Cape Hatteras
- Storm Surge
 - Not a wave
 - Elevated sea level
 - Low atmospheric pressure
 - Wind-driven water
 - Garrison p. 245

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Causes of Hurricane Damage



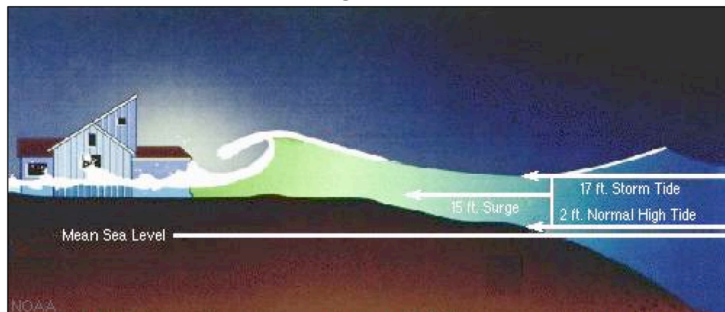
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Storm Surge



- Elevated sea level
 - Wind waves on top
 - More severe at high tide



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www.nhc.noaa.gov/HAW2/english/storm_surge.shtml

Storm Surge



- Drives water inland
 - Like a tsunami, but no 2nd & 3rd waves
 - Raises sea level for hours
 - Overwashes wetlands & barrier islands
 - More severe at high tide
- Funneled by shore
 - Katrina up to 30'



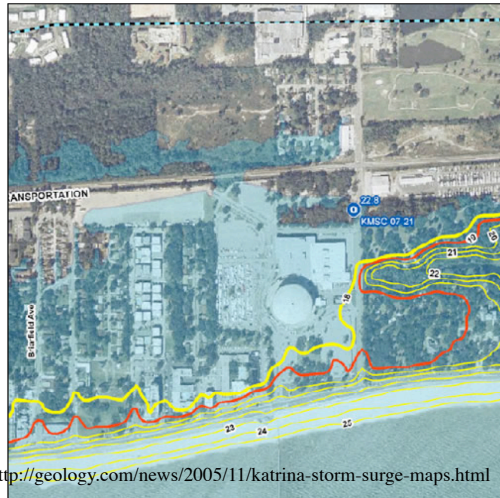
16

www.mthurricane.com/Hurricane_Katrina.htm

Storm Surge



- FEMA map
 - Mississippi
 - Surge flooding
 - Blue = extent of water intrusion
 - Red/ yellow isobaths of depth



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Are These for Real?



- Outside New Orleans



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hwww.wwtv.com/cleanup/160.htm

Are These for Real?



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hwww.wwtv.com/cleanup/160.htm

Are These for Real?



20

www.wwtv.com/cleanup/160.htm

Yes!



- Wave is steep as it tops a levee
 - Note sea level + waves behind it



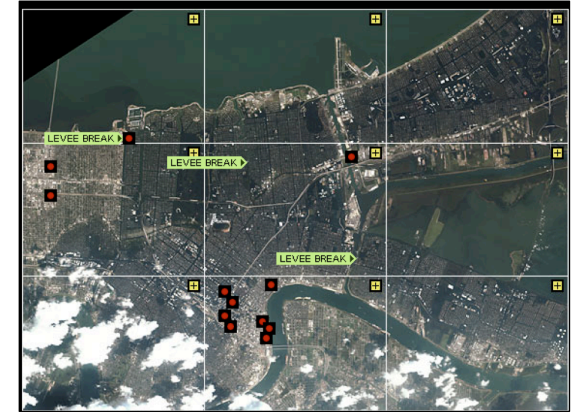
21

www.mgcollins.com/Katrina/, www.snopes.com/katrina/photos/surge.asp

New Orleans a Special Case



- City is below sea level
 - Protected by levees
 - Strong enough?
 - Kept water from escaping



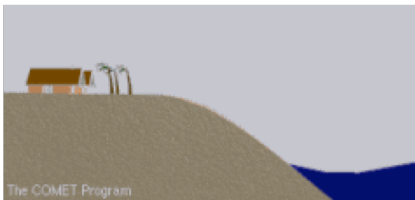
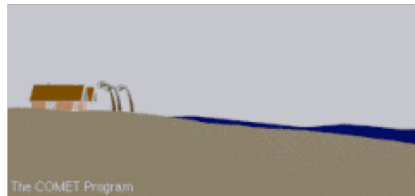
www.cnn.com/2005/WEATHER/09/01/orleans.levees/index.html

22

New Orleans a Special Case



- Broad, shallow passive shelf
 - Builds surge up to higher level
 - Penetrates inland on gradual shore
- Steeper coast is less vulnerable
 - Surge does not travel as far inland



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www.nhc.noaa.gov/HAW2/english/storm_surge.shtml

New Orleans a Special Case



- Louisiana & Mississippi coast is sinking
 - 0.3–1.5 inches/year = 1 foot/decade
 - Recent losses 24–39 mi²/year
 - Estimated loss of 15,000 mi² by 2070



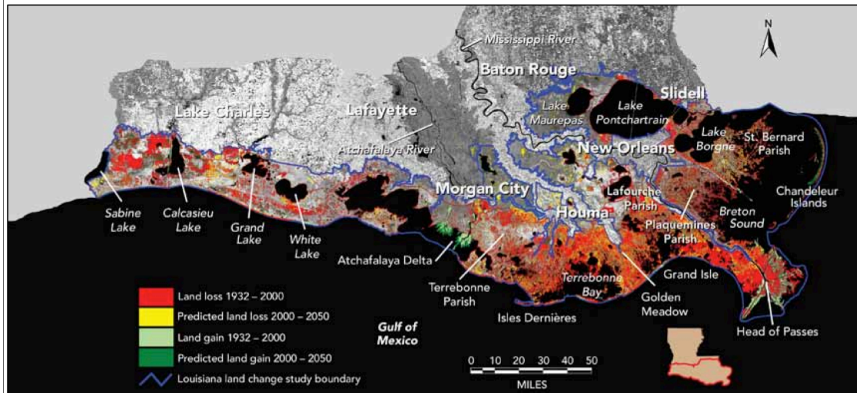
www.noaanews.noaa.gov/stories/s1128.htm
www.magazine.noaa.gov/stories/mag101.htm

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Gulf Coast Subsidence



- Past & predicted subsidence



25 www.naturalhistorymag.com/master.html?http://www.naturalhistorymag.com/0205/0205_feature2.html

Causes of Subsidence



- Sediment loss
 - Channelling of Mississippi River by levees
 - Reduces land flooding
 - But carries sediments into offshore waters
 - Rather than depositing in shallows
- Sediment compaction
 - Weight of sediments compressing them
 - Bedrock is extremely deep
- Isostasy
 - Sediment weight depressing lithosphere

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www.magazine.noaa.gov/stories/mag101.htm

Causes of Subsidence



- Dredging of shipping canals
 - Allows greater landward penetration of storm waves
 - Removes sediment to deeper water
- Drilling oil & water wells near shore
 - Reservoirs shrink



27 www.magazine.noaa.gov/stories/mag101.htm <http://web.naplesnews.com/03/10/naples/e1666a.htm>

Causes of Subsidence



- Loss of protective vegetation
 - Invasive animals eating native vegetation
 - Salt water intrusion from storms kills vegetation
- Storm erosion
- Rising sea level



www.flickr.com/photos/terrymct/sets/72057594098234962/

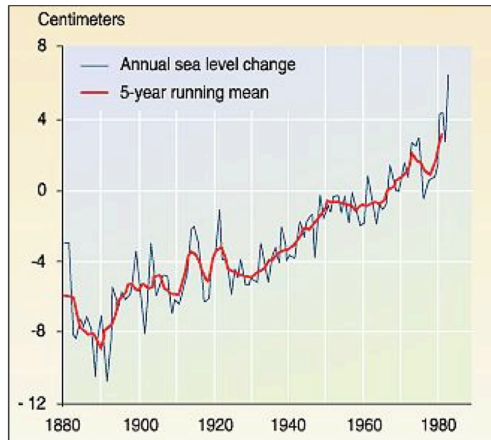
28

www.magazine.noaa.gov/stories/mag101.htm

Sea Level Rise



- Sea level has risen globally last 100 years
 - Estimated global average 10–20 cm (4–8 in.)
 - Variations depend on subsidence, uplift



<http://www.grida.no/climate/vital/19.htm>

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Causes of Sea Level Rise



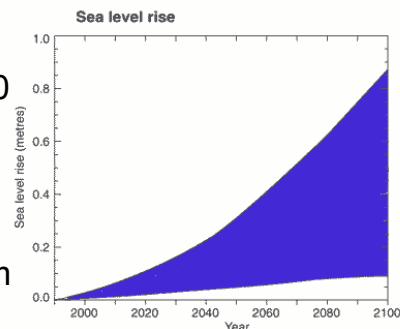
- Atmospheric warming in last century
 - 0.5–1°C global average
- Two main agents of sea level rise
 - Melting of terrestrial ice ~50%
 - Reduction of Greenland & alpine glaciers
 - Warming of the oceans ~50%
 - Thermal expansion of oceans
- Little controversy about observed rise
 - http://news.nationalgeographic.com/news/2004/04/0420_040420_earthday.html

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Sea Level Predictions



- Continued warming
 - IPCC (Intergovernmental Panel on Climate Change) 2001 report
 - +1.4–5.8°C (2.5–10.4°F) by 2100
 - Global average
- Continued sea level rise
 - 55 cm (2 ft.) – 110 cm (3.5 ft.) by 2100



<http://yosemite.epa.gov/oar/globalwarming.nsf/content/ClimateFutureClimateSeaLevel.html>

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Sea Level Predictions



- Controversy about predicted rise
 - Up to 7 meters (23 feet) if all Greenland melts
 - Up to 60 meters if W. Antarctic ice sheet melts
 - Would take centuries?
- Not just a gradual rise
 - Most would occur during catastrophic events
 - Katrina-like flooding
 - Hatteras-like erosion
 - Most difficult to prevent



Garrison Fig. 12.1

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