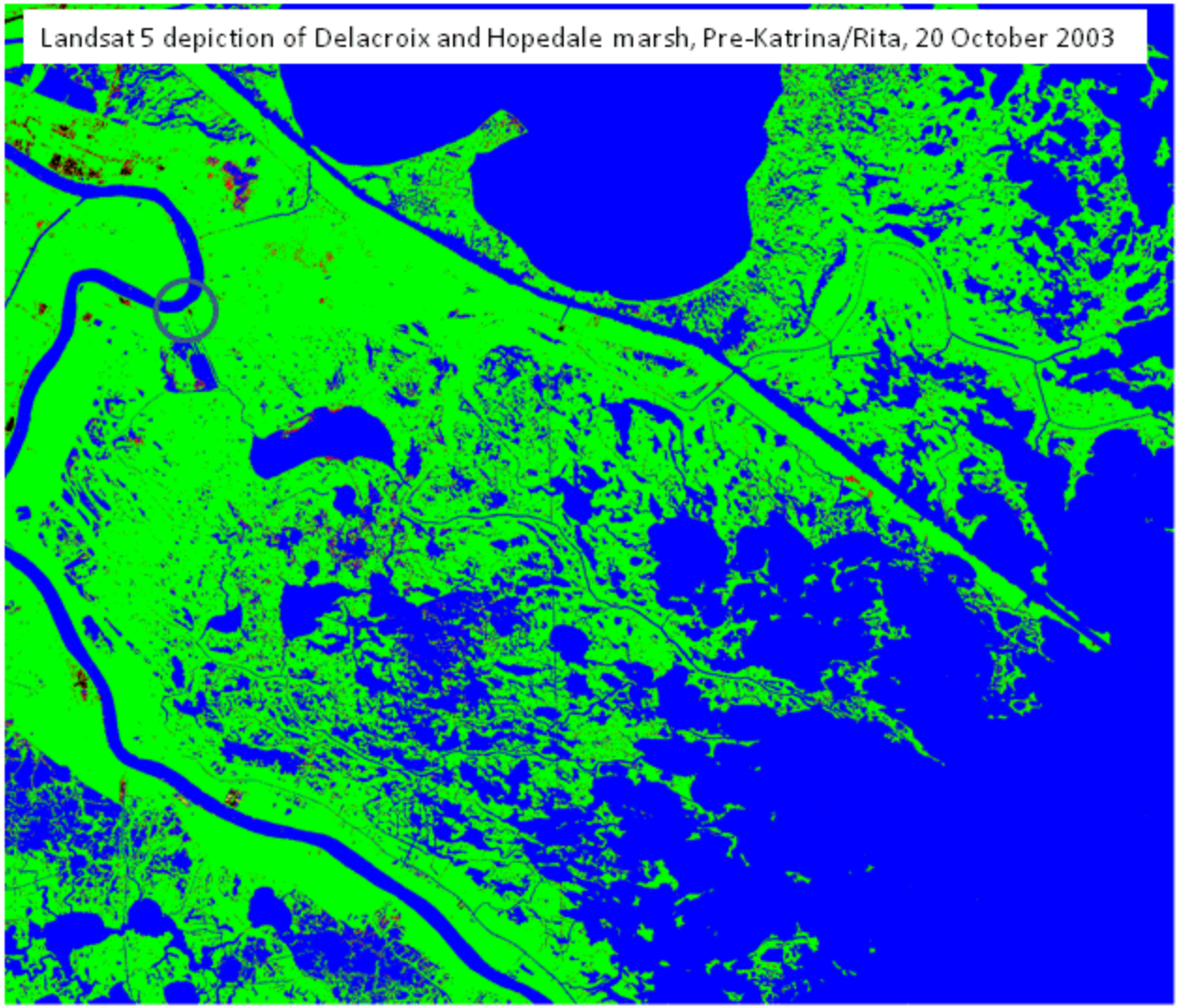
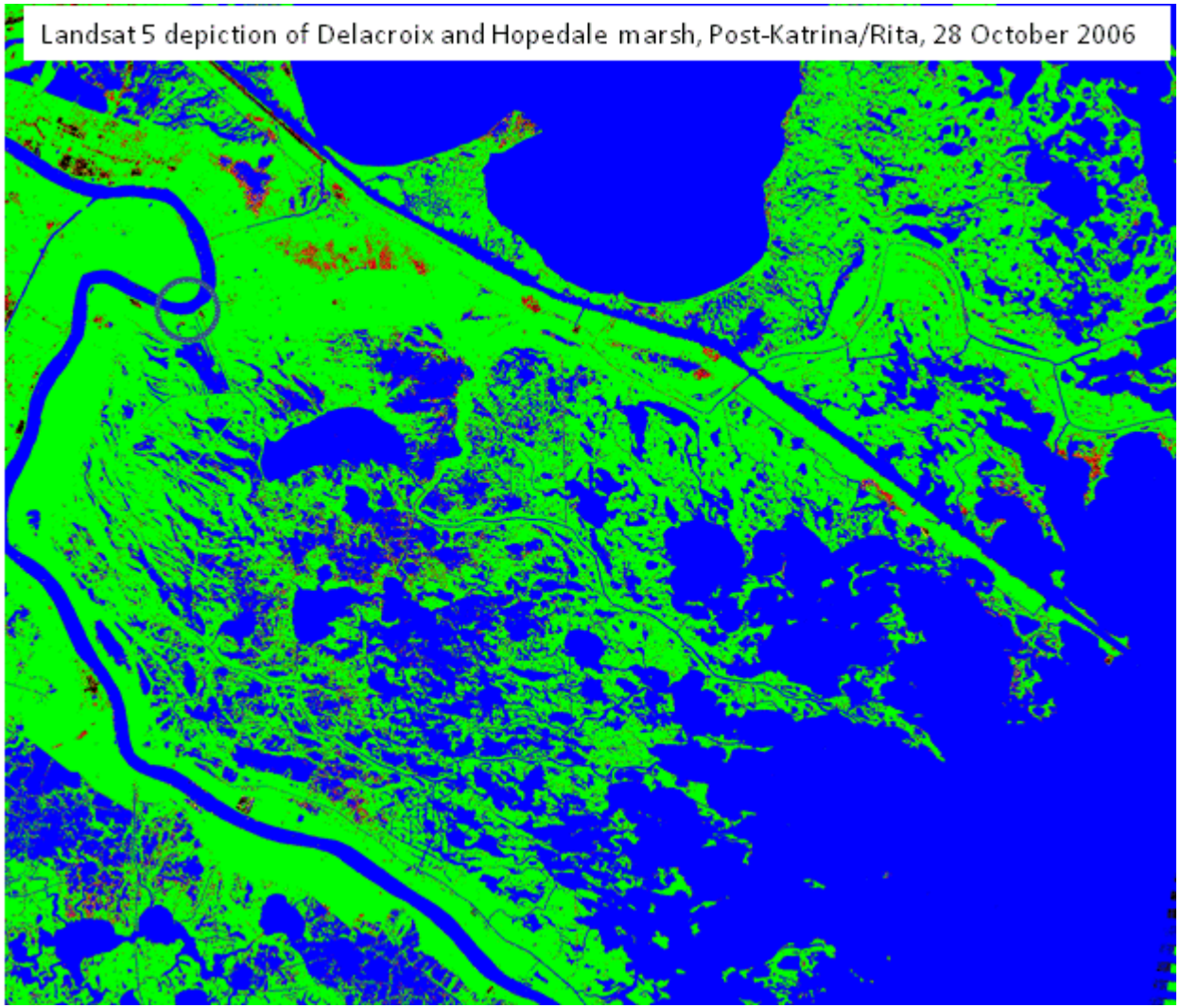
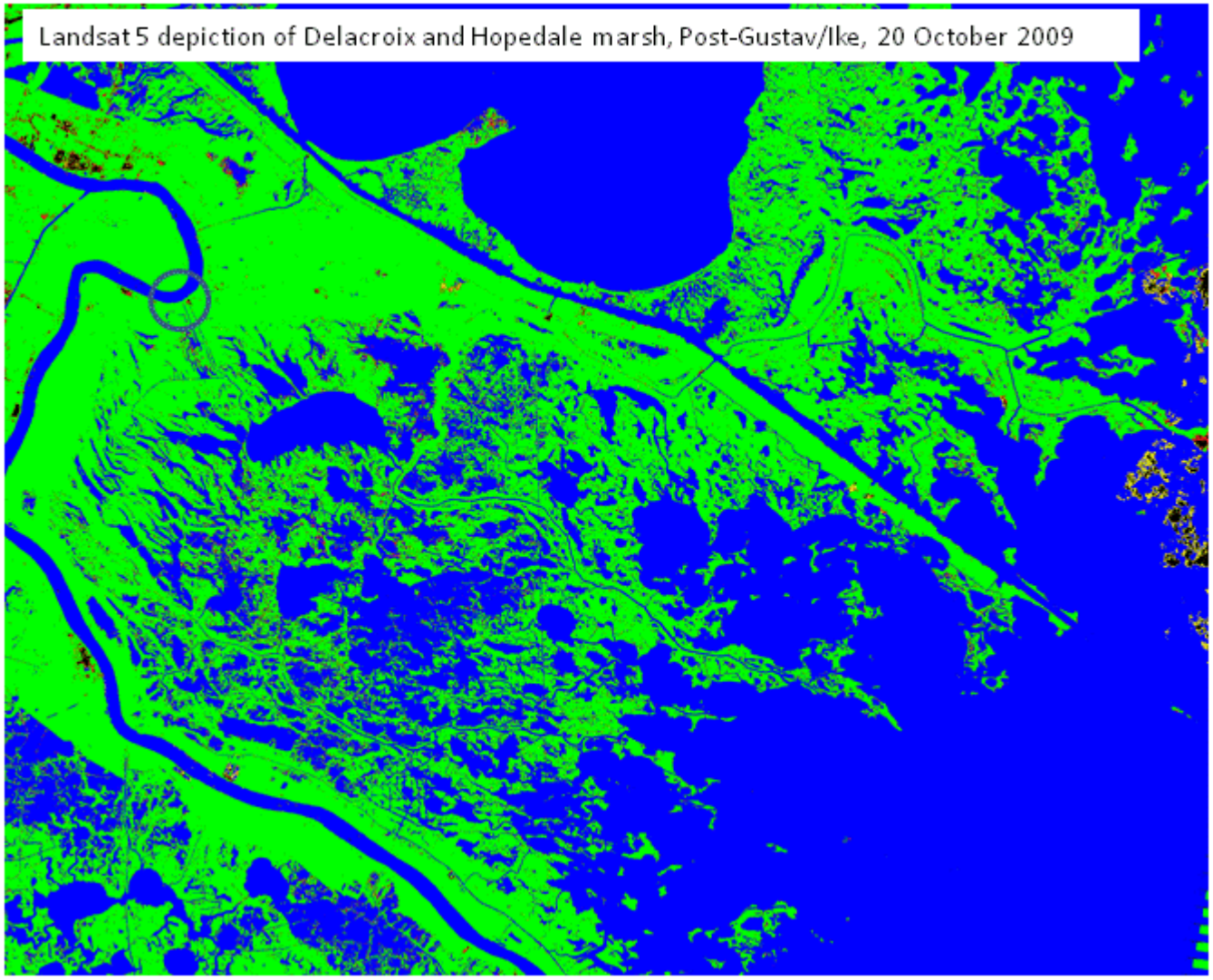
Wetland erosion issues near the Caernarvon freshwater diversion

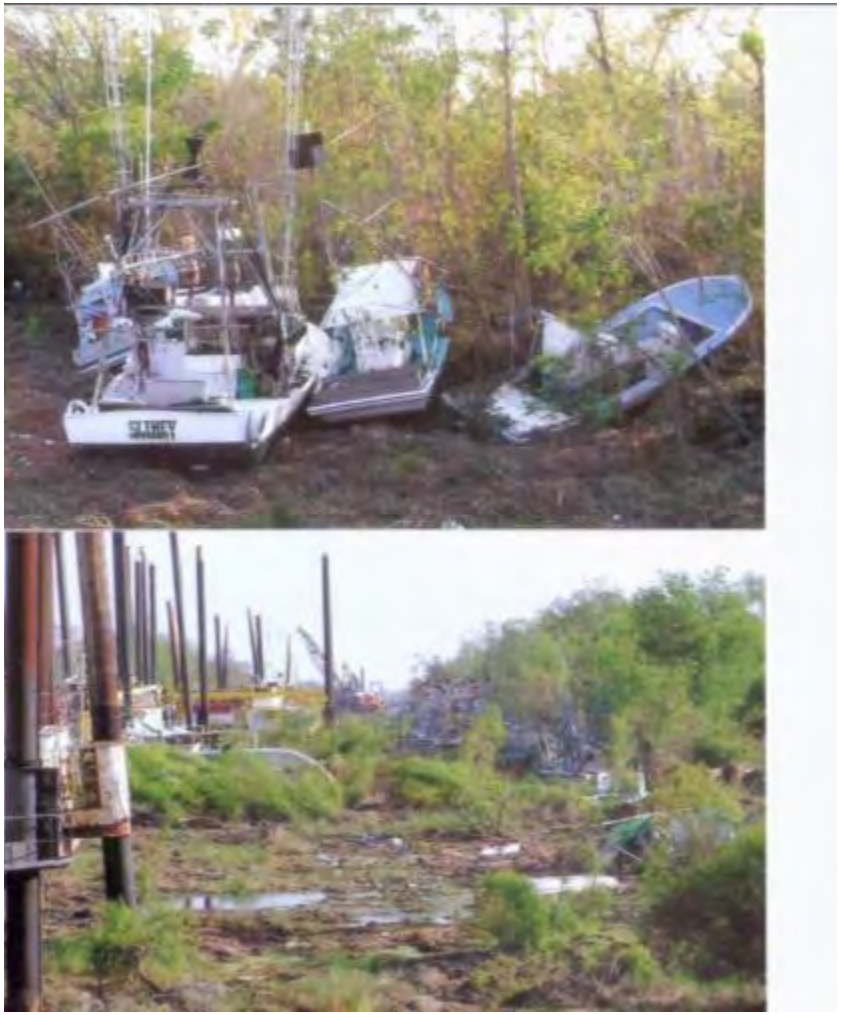
Pat Fitzpatrick, Yee Lau, Jim Chen, Kelin Hu, Valentine Anantharaj, and Suzanne Shean


Landsat 5 depiction of Delacroix and Hopedale marsh, Pre-Katrina/Rita, 20 October 2003


Landsat 5 depiction of Delacroix and Hopedale marsh, Post-Katrina/Rita, 28 October 2006


Landsat 5 depiction of Delacroix and Hopedale marsh, Post-Gustav/Ike, 20 October 2009

Where did land go? West towards MS River



From Chris Swarzenski (USGS)

Scoured and denuded aquatics after Gustav near diversion

Salt marsh relatively intact after all hurricane impacts

USGS
science for a changing world

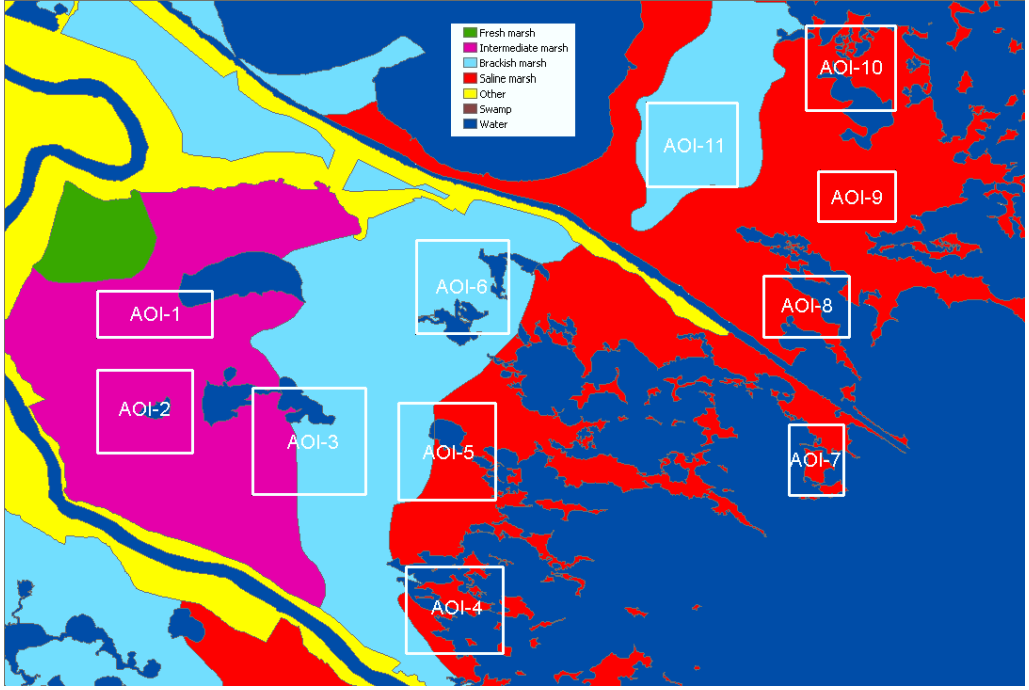
Video documentary from interviews

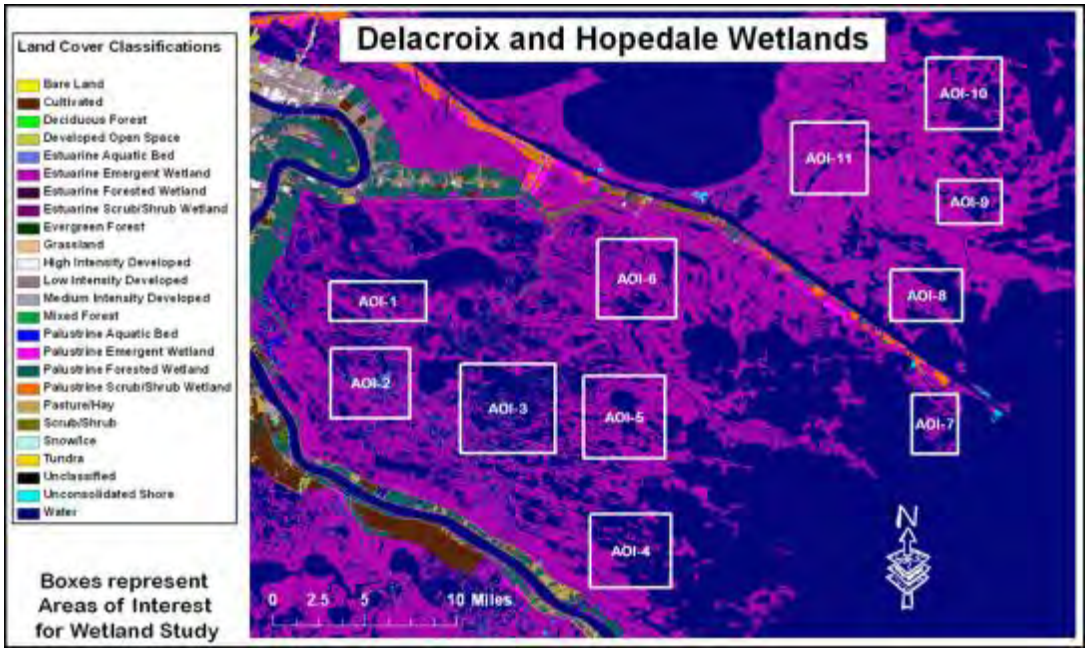
Research goal

- Quantify the land loss in the Hopedale and Delacroix regions after the 2005 and 2008 hurricanes
  - north of the MRGO
  - saline outer marsh of Delacroix
  - interior freshwater marsh
- Discussion of possible factors

Methodology

- Process C-CAP land cover data pre- and post 2005 hurricanes
- Develop pre-2005, post-2005, and post-2008 datasets;
  - MSU dataset based on Landsat 5 TM
  - Relatively cloud free
  - Land and water delineated using NDVI and NDVI scheme
- Computed mean water coverage in eleven Areas Of Interest (AOI) for both datasets
- Perform significance tests using Wilcoxon rank-sum test
  - $0.15 > p \geq 0.05$, suggestive but inconclusive
  - $0.05 > p \geq 0.01$, moderately convincing
  - $0.01 > p \geq 0.001$, convincing
  - $p < 0.001$, very convincing


Fresh marsh
Intermediate marsh
Brackish marsh
Saline marsh
Other
Swamp
Water
AOI-1
AOI-2
AOI-3
AOI-4
AOI-5
AOI-6
AOI-7
AOI-8
AOI-9
AOI-10
AOI-11

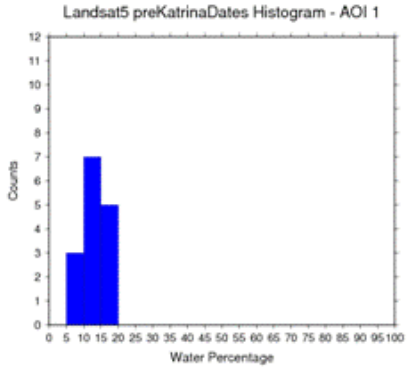

Land Cover Classifications
Bare Land
Cultivated
Deciduous Forest
Developed Open Space
Estuarine Aquatic Bed
Estuarine Emergent Wetland
Estuarine Forested Wetland
Estuarine Scrub/Shrub Wetland
Evergreen Forest
Grassland
High Intensity Developed
Low Intensity Developed
Medium Intensity Developed
Mixed Forest
Palustrine Aquatic Bed
Palustrine Emergent Wetland
Palustrine Forested Wetland
Palustrine Scrub/Shrub Wetland
Pasture/Hay
Scrub/Shrub
Snow/Ice
Tundra
Unclassified
Unconsolidated Shore
Water
Boxes represent Areas of Interest for Wetland Study
Delacroix and Hopedale Wetlands
AOI-1
AOI-2
AOI-3
AOI-4
AOI-5
AOI-6
AOI-7
AOI-8
AOI-9
AOI-10
AOI-11
0 2.5 5 10 Miles
N

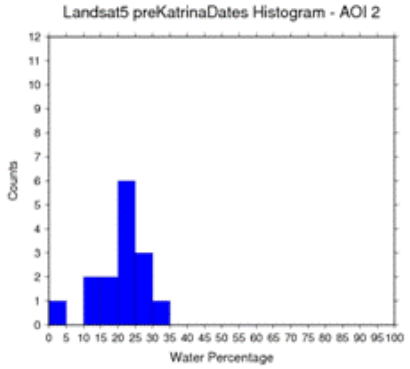
					C-CAP Percentage water		
Area Of Interest (AOI)	Distance from Caernarvon diversion (km)	Salinity	North or south of BTAB	North or south of MRGO	1996	Pre-Katrina/Rita (August 2005)	Post-Katrina/Rita
1	9.5	Low	S	S	11.7	13.5	52.5
2	16.1	Low	S	S	11.6	14.0	37.7
3	22.1	Low	S	S	54.1	56.1	68.4
4	38.5	High	S	S	66.5	67.1	69.1
5	28.4	High	S	S	37.1	38.1	41.8
6	21.5	High	N	S	29.7	30.9	34.1
7	48.2	High	N	S	72.6	72.9	75.3
8	44.9	High	N	N	49.6	49.6	51.1
9	46.2	High	N	N	38.4	38.5	40.1
10	46.9	High	N	N	48.8	49.0	50.9
11	34.5	High	N	N	12.0	13.0	14.5

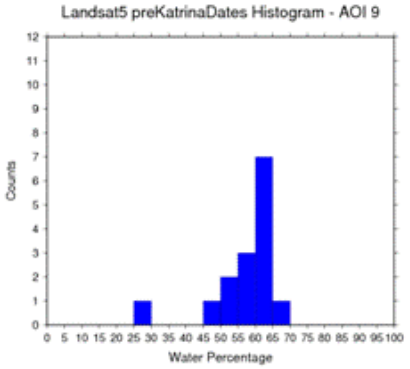
Landsat 5 Mean Percentage Water		
Pre-Katrina/Rita (n=15)	Post-Katrina/Rita (n=19)	Post-Gustav/Ike (n=11)
12.8	36.8	51.5
20.8	40.8	54.3
57.5	73.5	80.0
68.0	69.6	69.6
38.0	43.2	43.1
29.4	35.2	37.2
79.8	81.3	80.5
53.5	56.5	56.4
43.3	45.5	46.3
51.1	52.7	53.3
14.0	15.6	15.7

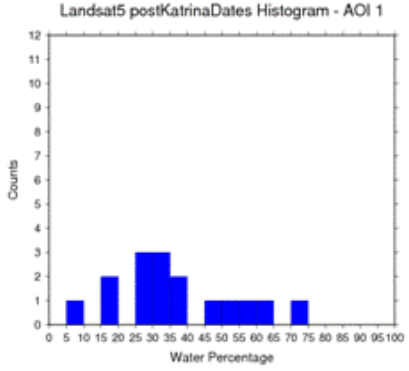
Table 3. Statistical significance results using Wilcoxon Rank-Sum test between Landsat 5 AOIs water coverage before and after Katrina/Rita and Gustav/Ike. ^ denotes $0.15 > p \geq 0.05$, * denotes $0.05 > p \geq 0.01$, ** denotes $0.01 > p \geq 0.001$, and *** denotes $p < 0.001$.

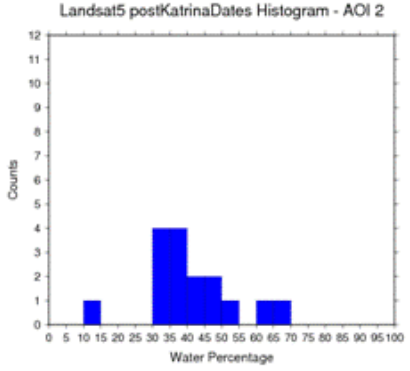
	Wilcoxon Rank-Sum Significance Test Difference in Water Coverage	
Area Of Interest (AOI)	Pre-Katrina/Rita vs. Post-Katrina/Rita	Post-Katrina/Rita vs. Post-Gustav/Ike
1	***	*
2	***	**
3	***	
4	**	
5	***	
6	***	^
7	*	
8	***	
9	**	
10	***	^
11	*	

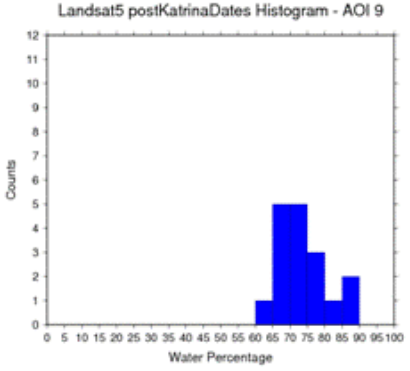

Landsat5 preKatrinaDates Histogram - AOI 1
Counts
Water Percentage

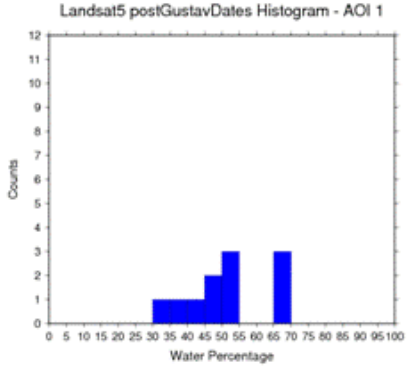

Landsat5 preKatrinaDates Histogram - AOI 2
Counts
Water Percentage

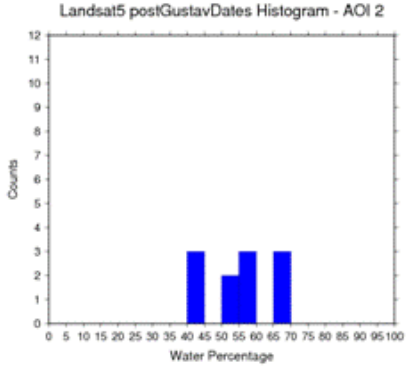

Landsat5 preKatrinaDates Histogram - AOI 9
Counts
Water Percentage

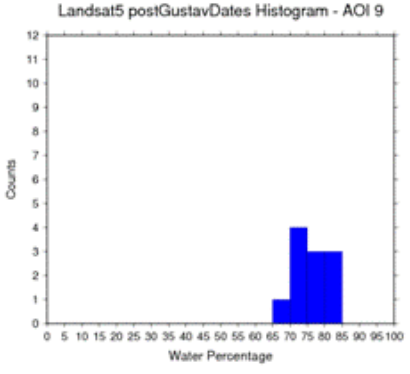

Landsat5 postKatrinaDates Histogram - AOI 1
Counts
Water Percentage

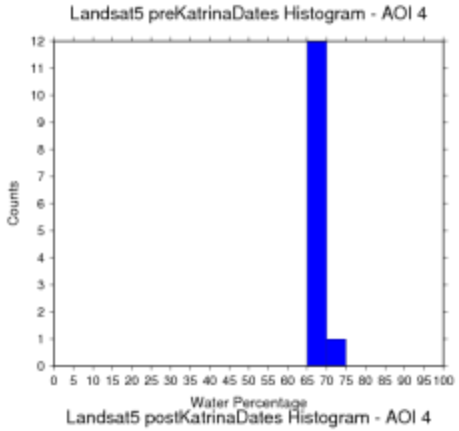

Landsat5 postKatrinaDates Histogram - AOI 2
Counts
Water Percentage

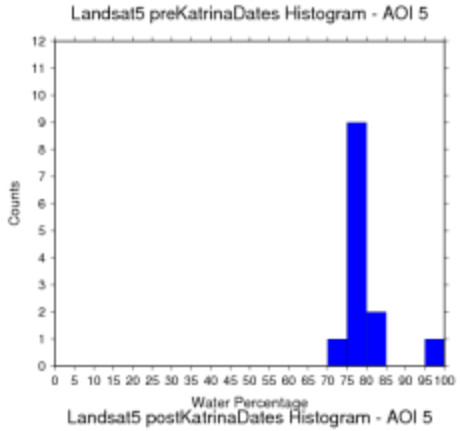

Landsat5 postKatrinaDates Histogram - AOI 9
Counts
Water Percentage

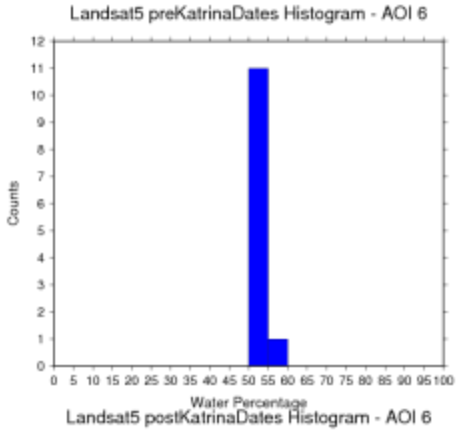

Landsat5 postGustavDates Histogram - AOI 1
Counts
Water Percentage

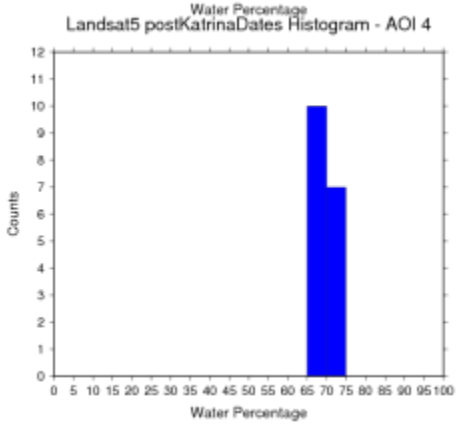

Landsat5 postGustavDates Histogram - AOI 2
Counts
Water Percentage

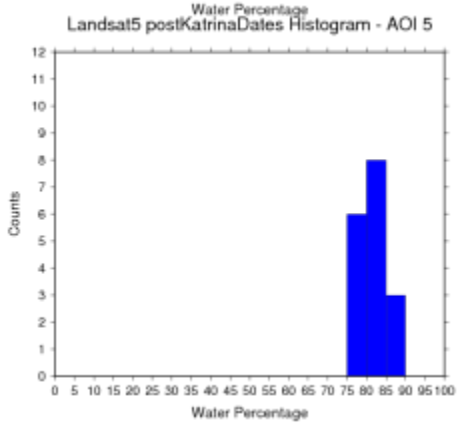

Landsat5 postGustavDates Histogram - AOI 9
Counts
Water Percentage

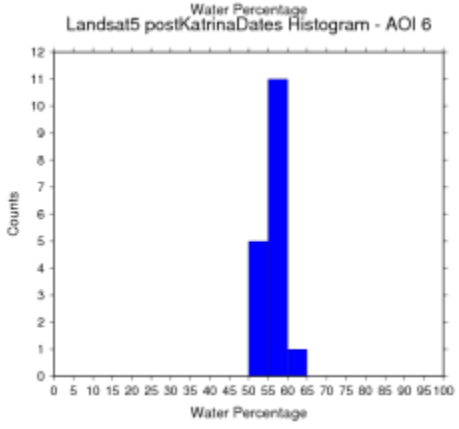

Landsat5 preKatrinaDates Histogram - AOI 4
Counts
Water Percentage

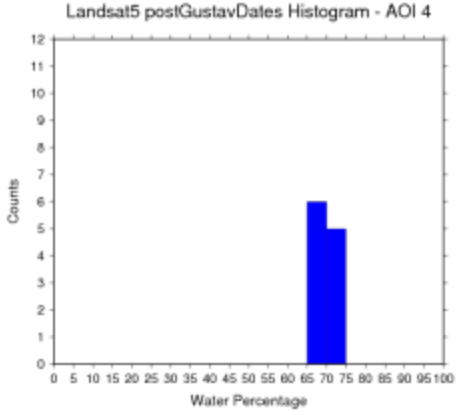

Landsat5 preKatrinaDates Histogram - AOI 5
Counts
Water Percentage

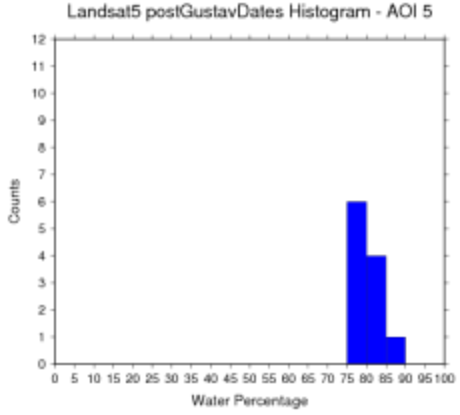

Landsat5 preKatrinaDates Histogram - AOI 6
Counts
Water Percentage

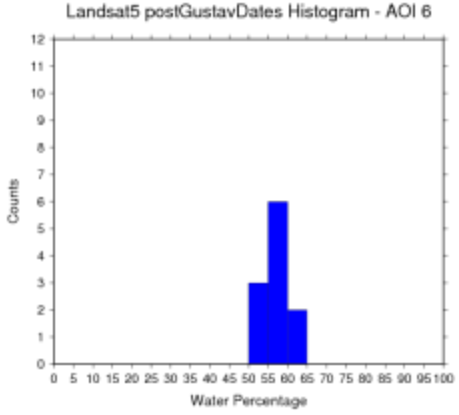

Landsat5 postKatrinaDates Histogram - AOI 4
Counts
Water Percentage


Landsat5 postKatrinaDates Histogram - AOI 5
Counts
Water Percentage


Landsat5 postKatrinaDates Histogram - AOI 6
Counts
Water Percentage


Landsat5 postGustavDates Histogram - AOI 4
Counts
Water Percentage


Landsat5 postGustavDates Histogram - AOI 5
Counts
Water Percentage


Landsat5 postGustavDates Histogram - AOI 6
Counts
Water Percentage

What has happened near diversion?

Howes et al. 2010 (*Proc. Nat. Academy of Sci.*)

- "Vegetation in low salinity marshes is subject to shallower rooting"
- "Hurricane Katrina (waves) produced shear stresses …..sufficient to cause widespread erosion of low salinity wetlands"

Eugene Turner, LSU (from *Responses of LA Marsh Soil and Vegetation to Freshwater Diversions Workshop*, 23 February 2011)

- "Nutrient enrichment (from the diversion) leads to lower root and Rhizome biomass, below ground production, organic accumulation, and soil strength"
- "Sustaining and restoring coastal marshes is more likely if they receive a lower, not a higher, nutrient load."
- "Large river diversions into organic soils, an unproven restoration approach, may be causing wetland loss, not restoring them."

Andrew Nyman, LSU (from *Responses of LA Marsh Soil and Vegetation to Freshwater Diversions Workshop*, 23 February 2011)

- "Bulk density is positively related to plant biomass; thus mineral sedimentation ….is indirectly important to accretion via vegetation growth.
- "….Bulk density of fresh marsh (0.07 g cm^{-3}) is much less than …..saline marsh (0.24 g cm^{-3})

Is current erosion near diversion reversible?

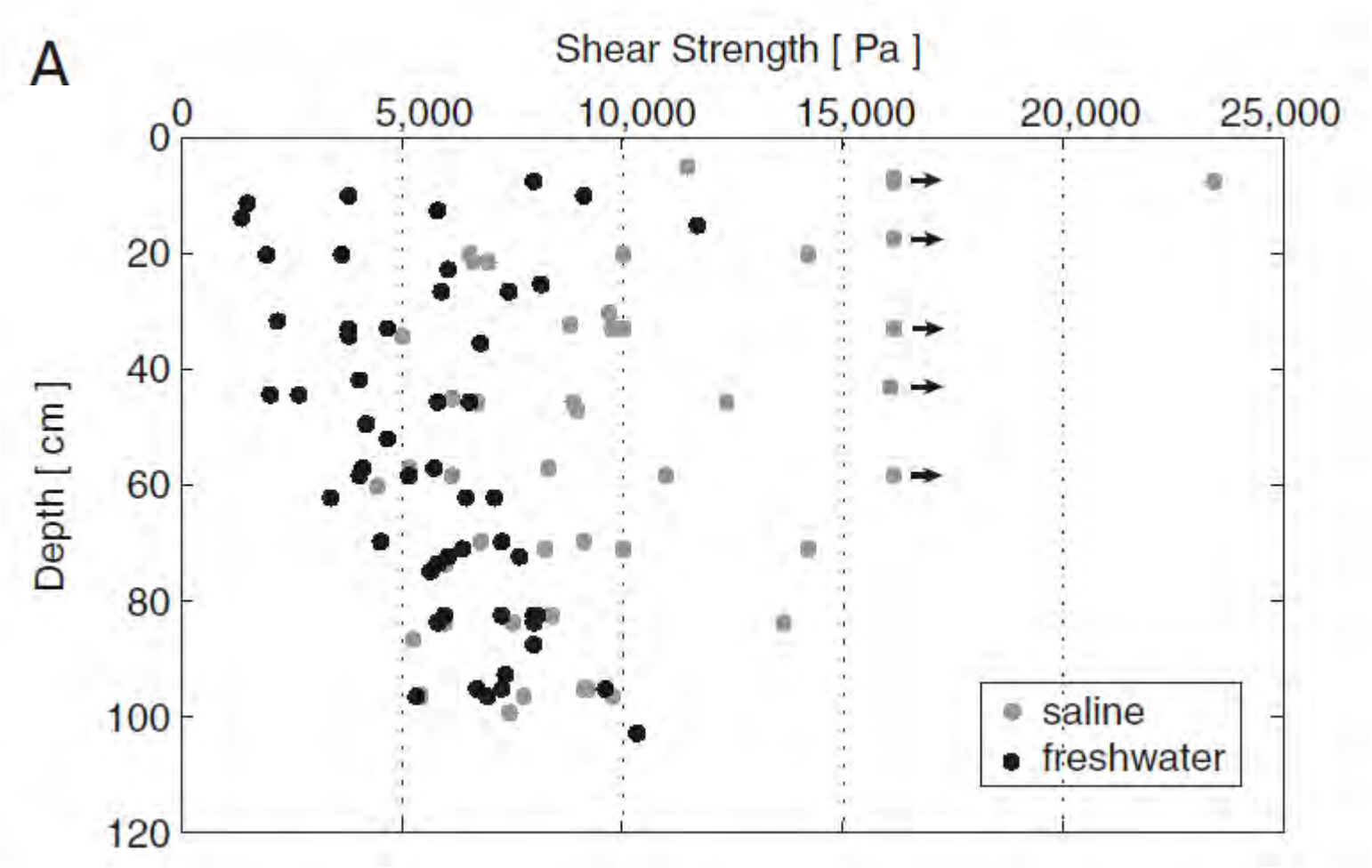
Richard Raynie, OCPR LA Applied Coastal Engineering & Science Division (from *Responses of LA Marsh Soil and Vegetation to Freshwater Diversions Workshop*, 23 February 2011)

- Maintains wave stress was higher in Breton Sound
- Betsy caused similar erosion; system recovered

R. D. DeLaune, A. Jugsujinda, and G. W. Peterson, LSU (from *Responses of LA Marsh Soil and Vegetation to Freshwater Diversions Workshop*, 23 February 2011)

- "Using ^{137}Cs dating and artificial marker horizons, increases in the rate of….accretion were measured….along….diversion"
- "Diversion….will enhance marsh accretion and stability…..slowing or reversing the wetland loss."

From Howes et al. 2010



Reference: Howes et al., 2010, Hurricane-induced failure of low salinity wetlands, *Proceedings of the National Academy of the United States of America*, **107(32)**, pp. 14014–14019.

From Howes et al. 2010

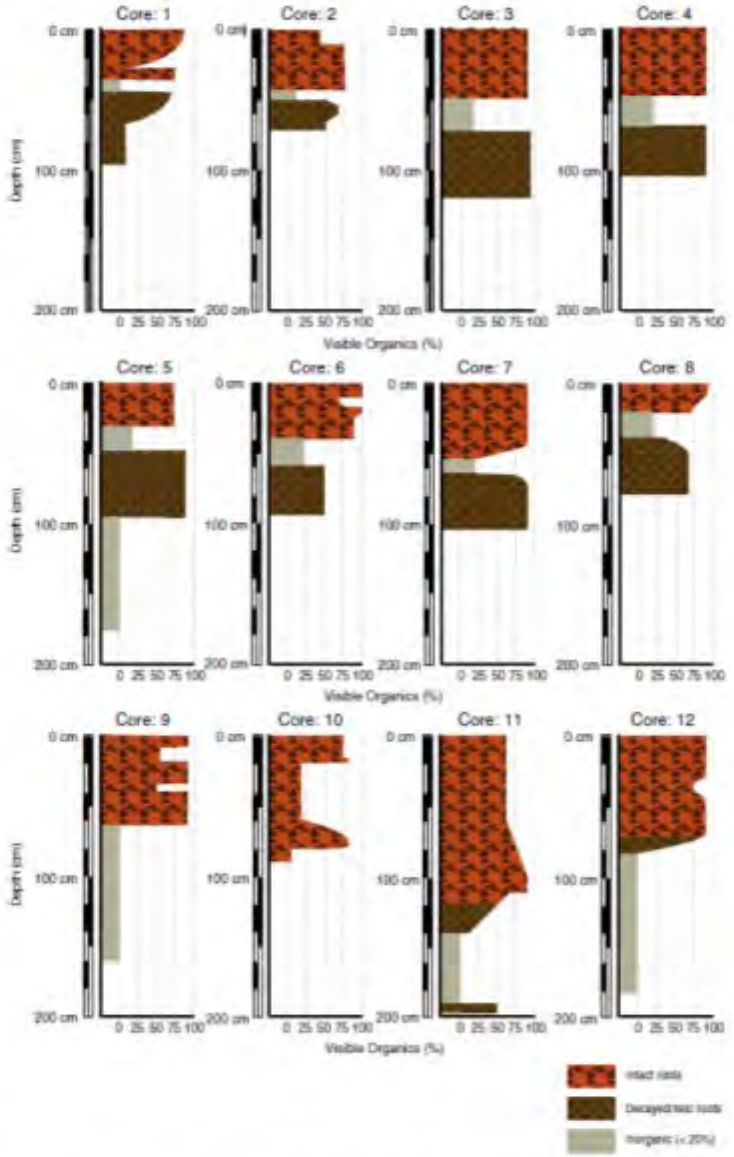


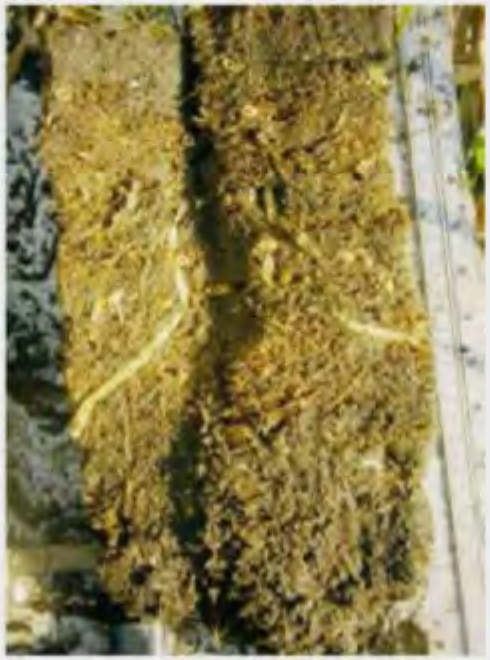
Fig. S2. Stratigraphy of the short cores. Cores 1–9 were taken in the low salinity wetland, while cores 10–12 were taken in high salinity wetlands. Intact rooting in the low salinity cores extends to average depth of 42 cm (range 31–67), below which an inorganic layer separates the live rooting from an older decomposing root horizon. In the high salinity region, roots extend to an average depth of 92 cm (range 74–112) and intact rooting is seen within relatively inorganic layers.

From Chris Swarzenski (USGS)

Soil Quality: with long-term (30+ years) river water influx decomposition appears enhanced (same plant community, *Panicum hemitomon*)

River water

Rain water



- No difference in year-end standing biomass

- No difference in accretion rates

BUT:
- Soil is much more decomposed

- links to river water include **sulfate, nitrate,** alkalinity

USGS

From Chris Swarzenski (USGS)

The importance of a fibric upper root layer

Control *S. patens* marsh west

In control marshes, the upper 15 cm has a fairly fibric tightly intertwined root mat, built from adventitious roots extending from stems.

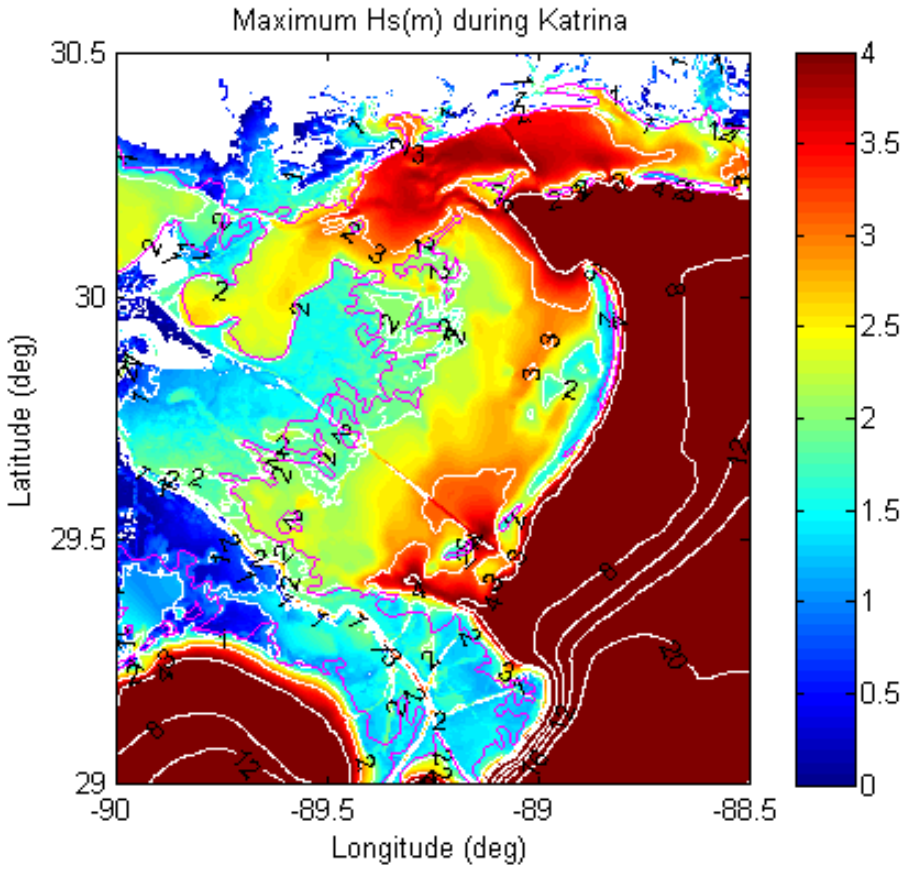
River water (quality and flooding) may affect the development of this layer, reducing resilience.

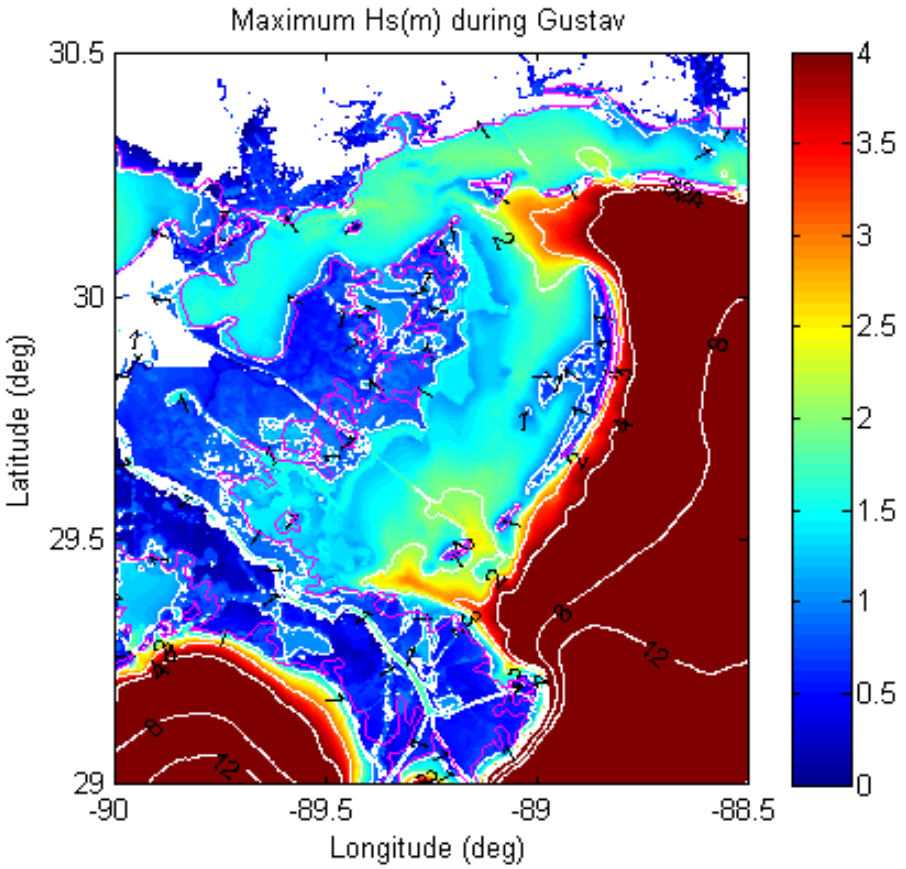
This is consistent with observed lignin phenol pattern

USGS

Read for example Nyman, J.A. et al. 2006. Marsh vertical accretion via vegetative growth. Estuarine Coastal and Shelf Science 69:370-380

Are wave heights different near diversion than in other marsh areas during hurricane surge events? (courtesy of Hu and Chen from LSU)





General discussion

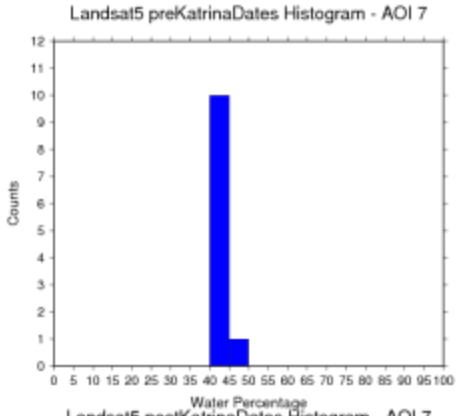
• These results suggest that freshwater diversions, while promoting biodiversity through salinity control, may also be enhancing Louisiana's wetland loss since it currently does not consider the shear stress from hurricane impacts on shallow low salinity root systems.

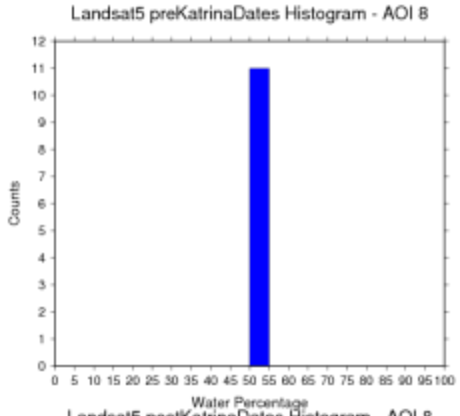
• This work also suggests that the negative perception of saltwater intrusion in wetland restoration be re-examined. Certainly saltwater intrusion is harmful, but an assessment of wetland resiliency is just as important before freshwater is reintroduced into an area. The Biloxi Marsh north of Hopedale is an example of a stable saltwater marsh environment that adjusted to habitat change from the saltwater intrusion of the MRGO channel, and survived the hurricanes of 2005 and 2008 relatively intact.

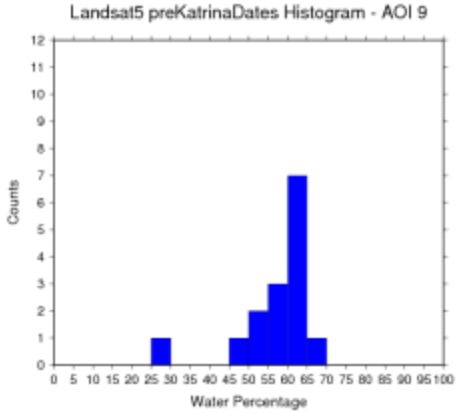
Some re-engineering concepts for diversions worthy of study

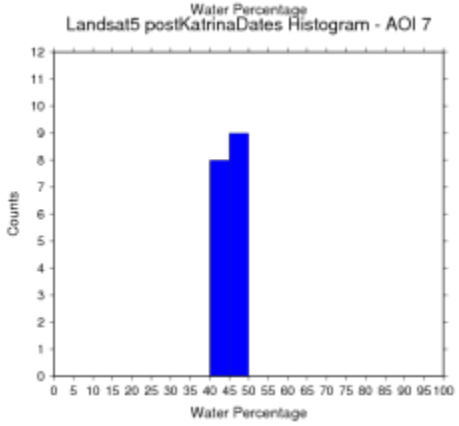
- Shorter, freshwater pulses during the rising and peak Mississippi River stages
- Targeted diversion releases during periods with southerly and easterly winds
- Target the placement of sediment by redistributing flow to eroding regions
- Distribute sediment with pipes and dredge material
- Planting of hardier low saline vegetation
- The use of sediment traps either with mechanical device or terrace construction
- Marsh management structures which control water levels and salinity
- Filtering diversionary waters of nutrient load

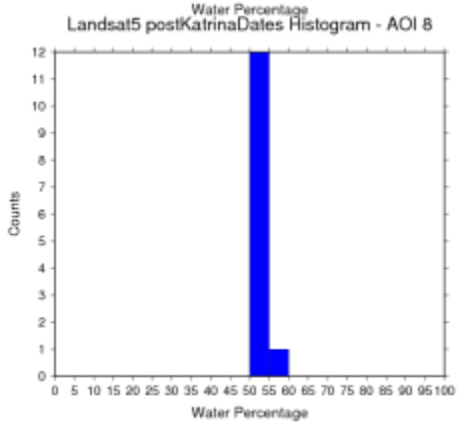
Extra material, not part of talk

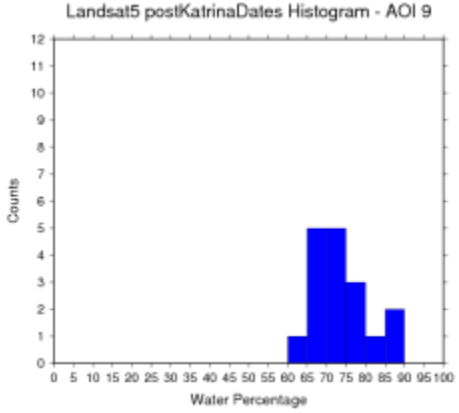

Landsat5 preKatrinaDates Histogram - AOI 7
Counts
Water Percentage

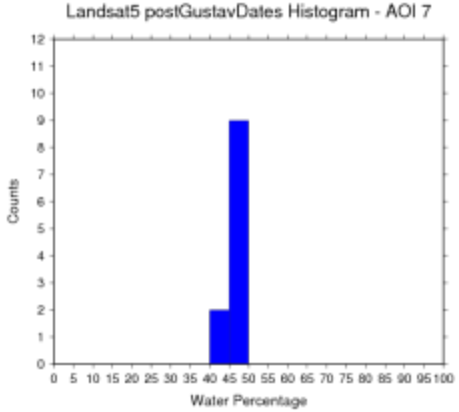

Landsat5 preKatrinaDates Histogram - AOI 8
Counts
Water Percentage

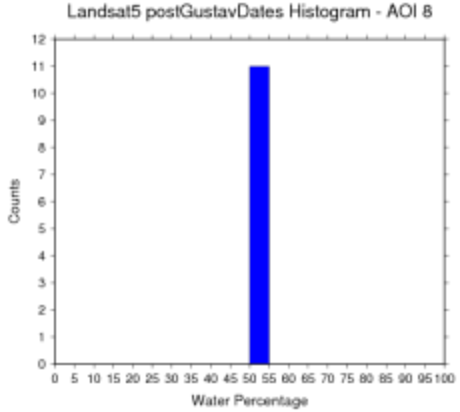

Landsat5 preKatrinaDates Histogram - AOI 9
Counts
Water Percentage

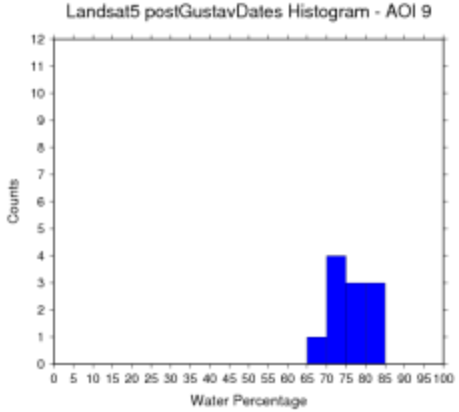

Landsat5 postKatrinaDates Histogram - AOI 7
Counts
Water Percentage

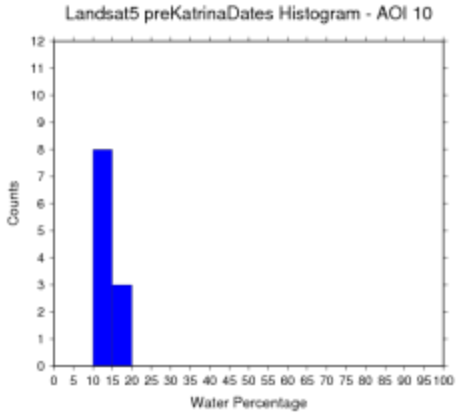

Landsat5 postKatrinaDates Histogram - AOI 8
Counts
Water Percentage

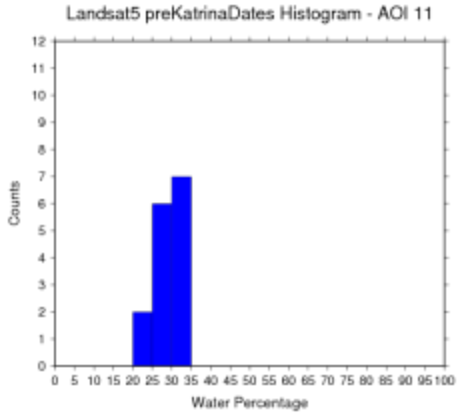

Landsat5 postKatrinaDates Histogram - AOI 9
Counts
Water Percentage

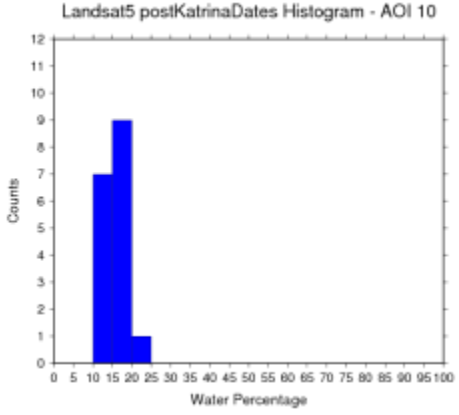

Landsat5 postGustavDates Histogram - AOI 7
Counts
Water Percentage

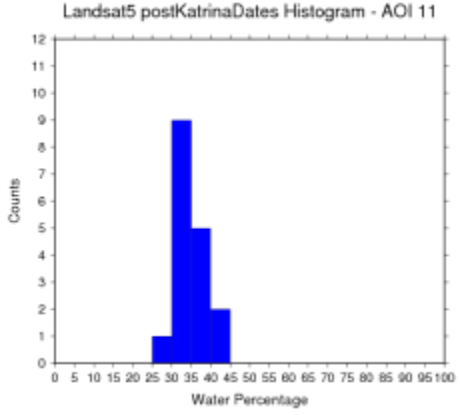

Landsat5 postGustavDates Histogram - AOI 8
Counts
Water Percentage

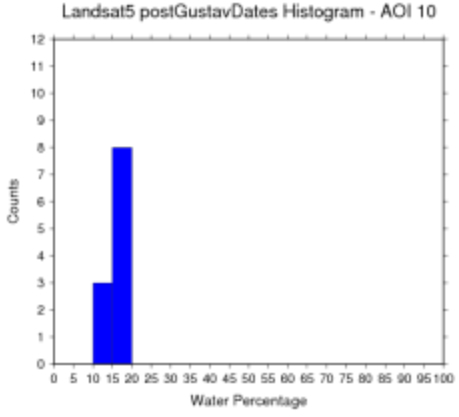

Landsat5 postGustavDates Histogram - AOI 9
Counts
Water Percentage

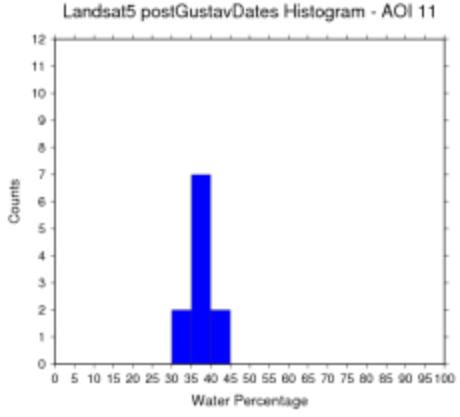

Landsat5 preKatrinaDates Histogram - AOI 10
Counts
Water Percentage


Landsat5 preKatrinaDates Histogram - AOI 11
Counts
Water Percentage


Landsat5 postKatrinaDates Histogram - AOI 10
Counts
Water Percentage


Landsat5 postKatrinaDates Histogram - AOI 11
Counts
Water Percentage


Landsat5 postGustavDates Histogram - AOI 10
Counts
Water Percentage


Landsat5 postGustavDates Histogram - AOI 11
Counts
Water Percentage