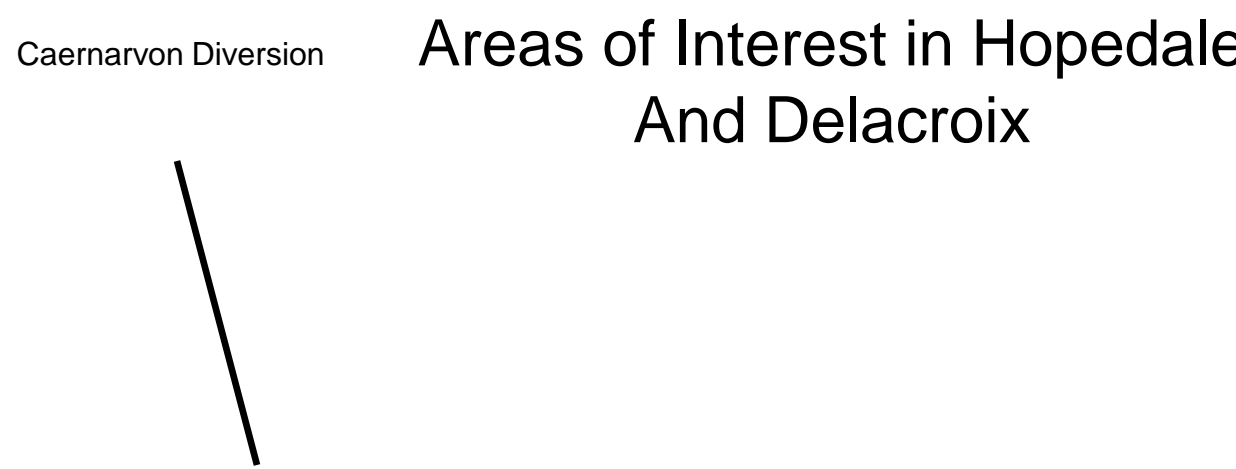


Wetland erosion in Delacroix and Hopedale from hurricanes this decade and the impact of the Caernarvon Freshwater Diversion

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Landsat 5 depiction of Hopedale and Delacroix marsh pre-Katrina, October 20, 2003

Background

The wetlands in coastal Louisiana have experienced substantial erosion since the 1930s. Mississippi River levees in the deltaic of lands sustaining sediments, and is the primary contributor to wetland loss. Man-made canals, faults activated by energy drilling, tropical cyclones, and sea level rise have also accelerated this land loss. As water bodies enlarge, wave action has also contributed to the erosion. An additional feedback from this erosion is saltwater intrusion, which changes the local ecology and is hypothesized to devastate wetlands.

The Caernarvon Fresh Water Diversion Project is a multi-state project designed to alter salinity conditions. The goal of the project is to restore the 5 ppt and 15 ppt salinity lines back to historical averages (Louisiana Department of Natural Resources, 2006). Caernarvon dramatically changed the near-shore area by increasing freshwater marsh plant coverage near the diversion, and growing intermediate marsh plants in the formerly brackish areas.

However, the altered landscape may not be resilient to hurricane storm surge. Hurricanes Gustav (2008), Ike (2008), and Katrina (2005) caused erosion of the Louisiana marshes (Barras 2006, 2007). The 2008 and 2005 hurricanes occurred within weeks of each other, and each was assessed as combined events. One area that experienced serious damage was the Delacroix region, particularly in the fresh and intermediate marsh regions near the MRGO. The damage consisted of expanded ponds; compressed, rolled, or inverted marsh; scoured and denuded marsh; and shoreline erosion.

The goal of this research is to quantify the marsh degradation areas: 1) north of the Mississippi River Gulf Outlet (MRGO) known as the Biloxi marsh (consisting of intermediate and saltwater marsh); 2) the saline outer marsh of Delacroix near Black Bay; and 3) the interior Caernarvon freshwater marsh in Delacroix. This analysis is performed for pre-Katrina/Rita, pre-Katrina/Rita, and post Katrina/Rita, and from the Landsat 5 Thematic Mapper (TM) satellite sensor. Interviews and a boat-based survey of the Delacroix marsh were also conducted with Mr. [Name] [Address] [City] [State] [Zip].

Methodology

The GCAP program provides a nationally standardized database on land cover and habitat change, typically over a 25-year period starting in 1996 (Dobson et al. 1995). A special dataset was also developed for post-Katrina. GCAP utilizes Landsat 5 and Landsat 7 TM scenes on days lacking clouds on extreme humidity, consisting of 23 satellite scenes. Landsat resolution is 30 m, sufficient for capturing marsh features and classification was determined from a Classification and Regression Tree (CART) scheme, then further refined by field mapping. This resulted in 25 land attributes as shown in the top left figure.

Because no GCAP data was available post-Katrina, we derived the Normalized Difference Water Index (NDWI) and Normalized Difference Vegetation Index (NDVI) where NDWI = (SWIR - Red) / (SWIR + Red) and NDVI = (NIR - Red) / (NIR + Red). The shortwave infrared (SWIR) channel (Band 5) exhibits a strong contrast between land and water features due to the high degree of absorption of infrared energy by water, even turbid water (Alesheikh et. al 2007). The increased (NIR) channel is Band 4, and visible red channel is Band 3. The computed values of NDWI and NDVI, ranging between -1 and +1, were converted to digital numbers (DN) in the range 0-255. The classification technique used was in the following sequential order: water, open water, emergent marsh, intermediate marsh, saltwater marsh, intermediate marsh, freshwater marsh, and land/not marsh.

Landsat 5 depiction of Hopedale and Delacroix marsh post-Gustav, September 2, 2009

However, producing a single composite dataset from multiple Landsat images is difficult. Pixel brightness values for classification schemes are affected by seasonal and annual phenological vegetation cycles; cloud coverage and cloud shadows; tide stage; water levels; sun angle; canopy roughness; atmospheric conditions, and sun/target/sensor geometry (phase angle). Therefore, our approach consisted of qualitative quality control to remove the most extensive cloud coverage. The data is then subsetted into 11 Areas of Interest (top left figure), and statistical significance tests are calculated for water coverage before and after Katrina and Gustav. Because the data is not normally distributed, the nonparametric Wilcoxon-rank test is used. Wilcoxon arranges two samples in ascending order of value orders, a rank is assigned to each value, and the ranks are added for each sample. The significance is then assessed by comparing the size difference between the cumulative rankings. A small p value is generally interpreted as evidence against the null hypothesis, which is to reject the premise of no difference between samples. Generally, the following interpretations are used by statisticians as evidence against the null hypothesis: p < 0.15 > 0.05, 0.05 > 0.01, and 0.01 > 0.001, respectively. These four situations are tabulated as ^, *, **, and ***, respectively.

Results

Table 1 shows wetland erosion results based on GCAP data. The largest erosion rates [calculated as 100*(Pre-Post value)/Pre value] from 1996-2005 occurred near the diversion in AOI1 and AOI2 of 14.5% and 20.9%, respectively. Additional notable erosion rates include: AOI0, 8.1%; AOI9, 3.9%; AOI11, 3.9%; and AOI6, 2.7%. Other regional changes were negligible. Katrina caused erosion throughout the region, but the biggest proportional change was in AOI1. AOI1 changed from 13.5% to 52.5% water coverage, a 289.4% increase; and AOI9 from 14.0% to 37.7% water coverage, a 168% increase. The intermediate marsh degradation as well but not as large with AOI9 from 56.1% to 68.4% water coverage (a 22.0% increase). Other regions ranged from a 1% to 5% increase in water coverage.

The MSU methodology shows similar results. The mean water coverage is shown in Table 2, but because the data contains regional values are different than Table 1. Histograms of these plots are attached to this poster. It is more appropriate to use the statistical significance tests to assess the coverage change (Table 3). Table 3 shows statistically significant changes to all diversion regions at a very convincing level. Also note that Hurricane Gustav caused a largest water percentage increase in AOI1, AOI2, and AOI9. Because of scatter, the significance levels are not as high, but the areas closest to the diversion have the most significant example of Landsat water classification is shown in the top right figures for pre-Katrina and Post-Gustav. Note the increased open water and marsh patterns near the diversion region from both hurricanes.

These results suggest that the current Caernarvon implementation for land restoration may be flawed since it does not consider impacts. It is clear that regions near the diversion experienced large amounts of land loss relative to areas near Black Bay and north of MRGO after the 2005 hurricanes. We hypothesize that the freshwater diversion does protect sediment, which then gets transported to the levee system as shown in the figure. The result is a loss, the opposite of its intended purpose. The primary cause is possibly the manipulation of nature through a narrow canal system instead of allowing a riverine system to overflow. Given enough time, a healthy, rooted freshwater vegetation may become established in western Delacroix with the Caernarvon diversion. However, the erosion in this region is 25 years for tropical storms, 610 years for Category 1 hurricanes, and 24 years for Category 3 hurricanes (National Hurricane Center 2010, Emanuel and Jagger 2010). Therefore, establishment of a hurricane-hardy wetlands in the freshwater marsh regions may not occur, and suggests that freshwater diversion corridors are engineered possibly into a multiple of hardy wetlands. This work also suggests that the negative perception of saltwater intrusion in wetland restoration can be reduced. Certainly saltwater intrusion can have negative consequences, but we propose that an assessment of wetland resiliency is just as important before freshwater diversion 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 MRGO.

Where did the land go during Katrina? Toward western Delacroix. This is the diversion canal where commercial and jackup boats sought safe-harbor. Its filled with vegetation and sediment !

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Diversion canal today after dredging

78-1H DU RO G 3% XGG \ ' -long Channel fish Brackish water in Delacroix, gave detailed background information on the diversion impact during the interview process.

% XGG \ ' JUDQGV RQ 3KLOLS 0RQH V SURY LGHG D ERDW WRXU Philip was a great with him. Red tide land that now he crabs on. This is about 5 miles from the diversion, near AOI-1.

