State of Louisiana
Coastal Protection and Restoration Authority of Louisiana (CPRA)

2018 Operations, Maintenance, and Monitoring Report

for

Holly Beach Sand Management

State Project Number CS-31
Priority Project List 11

June 2018
Cameron Parish

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For
Holly Beach Sand Management Project (CS-31)

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Preface

This report includes monitoring data collected through December 2017, and annual Maintenance Inspections through May 2018.

The 2018 report is the 6th report in a series of reports. For additional information on lessons learned, recommendations and project effectiveness please refer to the 2004, 2005, 2007, 2010 and 2013 Operations, Maintenance, and Monitoring Reports on the LDNR web site (http://sonris-www.dnr.state.la.us/sundown/cart_prod/cart_bms_avail_documents_f).

I. Introduction

The Holly Beach Sand Management (CS-31) project was proposed on the 11th priority list of the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA) and is co-sponsored by the Natural Resources Conservation Service (NRCS) and the Coastal Protection and Restoration Authority (CPRA). The project area is located between the communities of Holly Beach and Constance Beach on the Gulf of Mexico shoreline of southwestern Louisiana, west of Calcasieu Pass in Cameron Parish (Figure 1) and is comprised of approximately 10,849 acres (4,426 ha), of which 8,900 acres (3,603 ha) are classified as wetlands (U.S. Geological Service, National Wetland Research Center [USGS-NWRC] 2001). The project area is divided into two areas separated by the Louisiana Highway 82 embankment, which is built on a chenier ridge. Area A includes approximately 8,600 acres (3,481 ha) of brackish and intermediate marsh located along the north side of the highway. Area B includes approximately 300 acres (121 ha) of beach dune and coastal chenier habitat located south of the highway along 8.0 miles (12.9 km) of beach between Holly Beach and Ocean View Beach.

Chronic erosion in this area is caused by a deficit of sand and sediment in the littoral transport system due to stabilization of the Mississippi River and regulation of the Atchafalaya River to the east (U.S. Department of Agriculture, Natural Resources Conservation Service and Louisiana Department of Natural Resources [USDA-NRCS and LDNR] 2001). In addition, the Calcasieu and Mermentau rivers are not supplying coarse grained sediment (sand) to the area, and the Cameron jetties associated with the Calcasieu Ship Channel deflect what little material that exists away from the project area (Byrnes et al. 1995, Byrnes and McBride 1995).

Today, this ridge is the only remaining hydrologic barrier separating thousands of acres of low energy, intermediate and brackish marsh along the southern boundary of Sabine National Wildlife Refuge (SNWR) from the high energy, saline waters of the Gulf of Mexico. The highway revetment has already been undermined and repaired in some sections, and the underlying chenier is in danger of being breached. A breach of this ridge would lead to direct wave erosion and saltwater intrusion into fragile, low energy wetlands in Area A to the north.

In Area B, the intent of the project was to modify the design of 18 existing breakwaters on the west end of the breakwater field and remove 6 experimental breakwaters located landward of existing breakwaters 35 through 40, to enhance their sediment trapping capability. In addition, utilizing the beneficial placement of sand dredged from offshore, the beach was widened and a sub-aerial beach profile was re-established to reduce the occurrence of wave over-wash of the chenier-beach ridge.

Figure 1. Holly Beach Sand Management (CS-31) project area boundaries.

The breakwater modifications, which were funded by the state of Louisiana, were completed on June 19, 2002. The removal of the experimental breakwaters was completed on September 5, 2002. Approximately 1,750,000 cubic yards (1,600,200 cu meters) of coarse grained sand were pumped from a distance of 5 miles offshore between Holly Beach and OceanView Beach. Construction of the sand-pumping portion of the project was initiated in July 2002 and was expected to be completed in November 2002. Inclement weather and equipment problems delayed completion until March 2003. Construction of 18,797 linear feet of sand fencing on the eastern end of the project parallel to LA Hwy 82 was completed in March, 2003, and installation of 18,400 gallons of *Panicum amarum* (Bitter Panicum) was completed in August 2003. Shortly thereafter, another 11,000 linear feet of sand fencing was installed on the western portion of the project.

Hurricane Rita struck the coast of Louisiana on September 24, 2005 with a maximum storm surge of 14-15 ft (4.3 – 4.6m) in the CS-31 project area. USGS calculated the amount of land that changed to water resulting from the storm to be 98 square miles in southwestern Louisiana, 22 square miles of land lost in the Cal/Sab basin (Barras, 2006). This land loss can be attributed to several patterns. Shearing, which is ripping and removal of marsh vegetation in historically healthy marshes was observed north of Johnson's Bayou and south of the Sabine National Wildlife Refuge. The removal of remnant marsh from areas with historical land loss from the surge was observed in the marsh just north of Johnson's Bayou and north of Mud Lake.

Hurricane Ike struck near Galveston, Texas on September 13, 2008. A maximum storm surge of 15 – 16 ft (4.6 – 4.9m) was reported for the CS-31 project area (East et al. 2008). The surge caused additional scour and expansion of open water areas south of Sabine Refuge formed by Hurricane Rita.

II. Maintenance Activity

a. Project Feature Inspection Procedures

The purpose of the annual inspection (inspection has moved to every three (3) years, due to the state of the project) of the Holly Beach Sand Management Project (CS-31) is to evaluate the constructed project features to identify any deficiencies and prepare a report detailing the condition of project features and recommended corrective actions needed. Should it be determined that corrective actions are needed, CPRA shall provide, in the report, a detailed cost estimate for engineering, design, supervision, inspection, and construction contingencies, and an assessment of the urgency of such repairs (O&M Plan, 2003). The annual inspection report also contains a summary of maintenance projects, if any, which were completed since completion of constructed project features and an estimated projected budget for the upcoming three (3) years for operation, maintenance and rehabilitation. The three (3) year projected operation and maintenance budget is shown in Appendix B.

An inspection of the Holly Beach Sand Management Project (CS-31) was held on November 01, 2016 under cloudy skies and cold temperatures. In attendance were Dion Broussard of CPRA, Brandon Samson of NRCS, and Darryl Clark of USFWS for other inspections. The annual inspection began at approximately 12:00 p.m. on the western boundary of the project area.

The field inspection included a complete visual inspection of all features. Staff gauge readings where available were used to determine approximate elevations of water, sand dunes, and sand fencing. Photographs were taken at each project feature (see Appendix A) and Field Inspection notes were completed in the field to record measurements and deficiencies (see Appendix C).

b. Inspection Results

Beach Nourishment

There has been substantial loss of beachhead. There is a need for more beach nourishment, however the borrow area utilized for the previous nourishment project (2003), has been consumed and there is no known economical borrow source in the project area. (Photos: Appendix A, Photos 1 – 4).

Sand Fence

The sand fence has suffered extensive damage due to wave and tidal action, and loss of beachhead. There is very little fence remaining. It is estimated that 10 percent of fence is intact and functioning as intended, in areas where there is significant beachhead to prevent wave and tidal encroachment. (Photos: Appendix A, Photos 1 - 4).

II. Maintenance Activity (continued)

c. Maintenance Recommendations

i. Immediate/ Emergency Repairs

There are no immediate repairs required at this time.

ii. Programmatic/ Routine Repairs

The project team will make a site visit to inspect the remaining sand fence and determine whether a maintenance event is required to remove remaining fence posts where the sand fence has been damaged.

d. Maintenance History

General Maintenance: Below is a summary of completed maintenance projects and operation tasks performed since April 2003, the construction completion date of the Holly Beach Sand Management Project (CS-31).

April 2005 - The LA Dept. of Agriculture along with the Cameron Parish Police Jury installed approximately an additional 10,000 linear feet of sand fencing along with approximately 4,000 plants in April 2005.

July 2006 – The LA Dept. of Agriculture installed approximately 5,550 plants along the entire length of the beach project.

October 2006 – Sand Fence Replacement (FEMA Project) – A maintenance event was performed to replace 46,000 linear feet of sand fence destroyed by Hurricane RITA. The contractor was Landscape Management Services from Lake Charles, LA. Work began on October 9, 2006 and the contract was completed on November 27, 2006. The cost associated with the engineering, design and construction of the Holly Beach Sand Fence Maintenance Project is as follows:

Construction:	$ 218,473.50
Engineering & Design:	$ 10,000.00
Construction Admin./Oversight:	$ 10,000.00
As builts:	$ 8,797.50
TOTAL CONSTRUCTION COST:	**$ 247,271.00**

(Note: FEMA reimbursed $222,843)

September 2011 – Sand Fence Replacement – A maintenance event was performed to replace 46,000 linear feet of sand fence destroyed by storm surge from Hurricane Ike. The primary contractor was Petron L.L.C. Subcontractors were Lohmann Fencing and Landscape Management Services. Work began on September 9, 2011 and the contract was completed on December 22, 2011. There were 45,434 feet of sand fence constructed and approximately 30,000 bitter panicum plants planted. The cost associated with the engineering, design and construction of the Holly Beach Sand Management Sand Fence Project (Post Hurricane Ike – 2010) is as follows:

Construction:	$290,989.60
Engineering and Design:	$10,000.00
Construction Admin./Oversight:	$16,312.00
As builts:	$11,309.00
TOTAL CONSTRUCTION COST:	**$328,610.60**

III. Operation Activity

a. Operation Plan

There are no water control structures associated with this project, therefore no Structural Operation Plan is required.

b. Actual Operations

There are no water control structures associated with this project, therefore no required structural operations.

IV. Monitoring Activity

a. Monitoring Goals

The objective of the Holly Beach Sand Management Project is to protect approximately 8,600 acres (3,481 ha) of existing low energy, intermediate and brackish wetlands north of the chenier/beach ridge between Holly Beach and Constance Beach and to protect approximately 300 acres (121 ha) of beach dune and coastal chenier habitat along the shoreline from erosion and degradation caused by high energy wave action from the Gulf of Mexico.

The following goals will contribute to the evaluation of the above objectives:

1. Evaluate the beach response to sand nourishment and modification of 18 existing breakwaters after 2 years to facilitate re-evaluation of the existing breakwater design and the ability of the constructed beach profile to reduce predicted over-wash events (Note: Downdrift of the 18 existing breakwaters to be modified, it will not be possible to determine if changes in beach response are the result of the beach nourishment or the breakwater modifications, or both.).

2. Determine shoreline position to assess project-effectiveness at maintaining the shoreline (high water/rack line along beach ridge) seaward of its pre-nourishment position for the first 5 years (for breakwaters 10 thru 72).

3. Determine shoreline position to assess project-effectiveness at maintaining shoreline (high water/rack line along beach ridge) seaward of its pre-nourishment position for an additional 5 years should the beach need re-nourishment.

4. Evaluate water salinity in the project area north of the beach/ridge, Area A, for effects of over-wash occurrences.

5. Evaluate maintenance of existing intermediate and brackish marsh vegetation in Area A, the project area north of chenier/beach ridge.

6. Evaluate condition of the *Panicum amarum* plantings along the project area shoreline.

b. Monitoring Elements

Aerial Photography:

To measure marsh and open water areas (in Areas A and B), near-vertical color-infrared aerial photography (1:12,000) was acquired pre-construction in December 2001, December 2002 (since project completion was delayed), October 2005 and December 2009. The original photography was checked for flight accuracy, color correctness, and clarity and was subsequently archived. Aerial photography was scanned, mosaicked, and georectified by USGS personnel according to standard procedures (Steyer et al.1995, revised 2000). Additional photography may be obtained in response to storm events.

Percent land trends were calculated using Landsat Thematic Mapper (TM) data for 1985 - 2016. Linear regressions were calculated for the period of record. The variability in percent land data points around the slope illustrates the influence of various sources of environmental variance or classification error. Positive slopes indicate increasing percent land or historical land gain and negative slopes indicate decreasing percent land or historical land loss (Couvillion et al., 2017).

Bathymetry/Topography:

To document both horizontal and vertical change along the project area shoreline, transect lines used to measure elevation were established parallel and perpendicular to the breakwaters, and tied in to a known elevation datum by professional surveyors. These transect lines were surveyed incrementally pre-construction in 2002-2003, and immediately post-construction in March 2003 and were surveyed in August 2005, post-hurricane Rita in January 2006 and post-hurricane Ike in January 2009.

Vegetation Plantings:

The general condition of the *Panicum amarum* (Bitter Panicum) plantings in Area B was documented using a generally accepted methodology similar to Mendelssohn and Hester (1988), Coastal Vegetation Project, Timbalier Island. Plots were chosen by randomly selecting numbers based on the coordinates within the project area to represent a 10 percent sample of the plantings. The GPS coordinates were used to mark one corner of a plot of 16 plants to determine % survival by counting live plants within each plot, dividing by the total number of plants, and multiplying by 100. Ocular estimates of percent canopy cover were recorded for each plot. The percent cover for each plot was broken down into the percent cover provided by the *P. amarum* plantings, by other wetland species and by upland species. These criteria were documented in the fall of 2003 and in the spring and fall of 2004. The possibility of herbivore damage is recognized and was recorded if observed.

Shoreline Change:

To document shoreline movement between Holly Beach and Constance Beach, differential global positioning system (DGPS) surveys of unobstructed sections of the shoreline were conducted using the high water/rack line as the vegetative edge. DGPS shoreline positions were mapped and used to measure shoreline erosion/growth rates. Shoreline change rates were used to calculate the average ft/yr gained/lost along the project area shoreline. Surveys were conducted immediately post-construction in 2003, the fall and spring of 2003, 2004, 2005, the fall of 2006, and the fall and spring of 2007, 2009, and 2011. No monitoring was scheduled for 2006, but a survey was conducted to evaluate the effects of Hurricane Rita.

To document shoreline movement after 2011, Louisiana Barrier Island Comprehensive Monitoring Program (BICM) data were analyzed. The BICM program used high-resolution orthorectified aerial imagery to interpret high-water shoreline position, which represents the upper limit of average wave run up at high tide (Byrnes and et. al. 2018). Interpreted shoreline positions from BICM were analyzed for 1998, 2004, 2008 and 2015 using the Digital Shoreline Analysis System (DSAS) to quantify changes between the epochs within the CS-31 project areas as well as a reference area immediately east of the project.

Water Salinity:

To assist in determining the frequency that high salinity water enters the interior marsh in Area A from wave over-wash, three continuous recorders were installed to collect hourly salinity data: one at the southern end of Cowboy Ditch, one adjacent to the low section of La. Hwy 82 with concrete block revetment between Peveto Beach and Holly Beach, and one in a marsh pond on the east side of the project area (Figure 1). Hourly salinity data were collected at these three stations preconstruction, from September 2002 to February 2003, and 3 years post-construction from March 2003 to March 2006. Data collected from these stations were compared to hourly salinity data collected from the East Mud Lake (CS-20) project reference recorder to aid in determining the origin of high salinity water entering the project area. This recorder reflects conditions in Calcasieu Lake. The CS-20-15R data were collected through 2014.

Salinity is currently monitored hourly utilizing one CRMS-*Wetlands* station (680) within the project area and a selected reference site (2219). Continuous data were used to characterize average annual salinities throughout the project and reference areas. CRMS0680 was also compared to the CS20-15R data. For the 2015-2017 period, CRMS0685, also located in Calcasieu Lake, was used for comparison.

Emergent Vegetation:

To document the condition of the emergent vegetation in the project area over the life of the project, vegetation was monitored at 30 sampling stations established along 3 transect lines within Area A. Using the Braun-Blanquet methodology outlined in Steyer et al. (1995), percent cover, species composition, and dominant plant height were documented in replicate 2 m by 2 m sampling plots established at each station. A pole installed in one corner of each plot allows for locating and reevaluating established plots over time. Descriptive observations of SAV was noted during monitoring of emergent vegetation. Vegetation was monitored once pre-construction in 2002 and postconstruction in the fall of 2003, 2004, 2005 and 2009. Subsets of the vegetation transects were also collected in the fall of 2006, 2007, 2008 to document the effects of Hurricane Rita.

Vegetation composition and cover were also estimated from 10 permanent 2m x 2m plots that are randomly distributed along a transect in the emergent marsh within each of the 1 km^2 CRMS-*Wetlands* sites. Data were collected in the late summer to early fall of 2006 - 2017 using the Braun Blanquet method.

Individual species' cover data were summarized according to the Floristic Quality Index (FQI) method (Cretini et al., 2012). The FQI assigns a low score to invasive species indicative of disturbance and a high score to native species indicative of stability. CRMS sites inside (608) and outside (2219) the project area were used for this report.

Porewater Salinity:

At each project-specific emergent vegetation station, we attempted to obtain soil porewater salinity data, utilizing the sipper method, down to 10 cm below the soil surface. Data were collected pre-construction in 2002 and post construction in the fall of 2003, 2004, 2005 and 2009. Subsets of the data were also collected in the fall of 2006, 2007, 2008 to document the effects of Hurricanes Rita and Ike.

At each servicing of the CRMS-*Wetlands* station recorders, a measurement of the interstitial water salinity at 10 and 30 cm is collected adjacent to the boardwalk. Interstitial water salinity is also determined at the vegetation plots, when vegetation is surveyed.

CRMS Supplemental

In addition to the project specific monitoring elements listed above, a variety of other data are collected at CRMS-*Wetlands* stations which can be used as supporting or contextual information. Data types collected at CRMS sites include hydrologic from continuous recorder (mentioned above), vegetative, physical soil characteristics, discrete porewater, surface elevation, and land:water analysis of 1 km^2 area encompassing the station (Folse et al., 2017). For this report, data from CRMS0680 within the project area was compared to data from CRMS2219 outside the project area in a traditional project versus reference manner. Data collected from the CRMS network are used to develop integrated data indices at different spatial scales (local, basin, coastal) from which we can assess project performance.

Soil cores were collected one time (within a year of site establishment) to describe soil properties (bulk density and percent organic matter). Three, 4" (10.16-cm) diameter cores were collected to a depth of 24 cm and divided into 6, 4-cm sections at the site. The soil was processed by the Department of Agronomy and Environmental Management at Louisiana State University.

Soil surface elevation change utilizing a combination of sediment elevation tables (RSET) and vertical accretion from feldspar horizon markers are being measured twice per year at each site.

These data are used to describe general components of elevation change and establish accretion/subsidence rates. The RSET was surveyed to a known elevation datum (ft, NAVD88) so it can be directly compared to other elevation variables such as water level. The submergence vulnerability index (SVI) determines a sites vulnerability to sea-level rise. Surface elevation change, vertical accretion, and water elevation measured at each site are used along with regional estimates of global eustatic sea-level rise to make direct comparisons of wetland surface elevation to local relative water-level trends.

IV. Monitoring Activity (continued)

c. Monitoring Results and Discussion

<u>Aerial Photography:</u>
Land to water analysis was completed for the pre-construction photography acquired in November 2001 and December 2002 and post-construction acquired in October 2005 and December 2009 (Figures 2 - 5). Results are presented in Table 1. The difference between the 2001 and 2002 analyses was due to the partial construction of the beach at the time of the 2002 photography. The 2005 analysis followed Hurricane Rita and showed approximately 40 acres of land lost, mostly along the shoreline. The 2009 analysis, which would have covered the period of Hurricane Ike, showed another 48 acres lost since the 2005 analysis.

The general land change trend within the project area prior to construction was slightly positive (0.22% per year) from 1984 – 2002 (Figure 6). Incorporating the 2002 to 2016 data, which includes the post-construction satellite imagery, causes the general trend to increase slightly (0.33% per year), demonstrating the overall land change trend of the project area has improved since the construction of the project, even though the project area saw land loss following the hurricanes.

Table 1. Land:Water acreages from 2001, 2002 (pre-construction), 2005 and 2009 (post-construction) in the project area.

		Project		
Year		Acres	Hectares	%
2001	Land	8812	3566	81.6
2001	Water	1989	805	18.4
2002	Land	8938	3617	82.8
2002	Water	1863	754	17.2
2005	Land	8907	3601	82.5
2005	Water	1894	767	17.5
2009	Land	8855	3581	82.0
2009	Water	1946	788	18.0

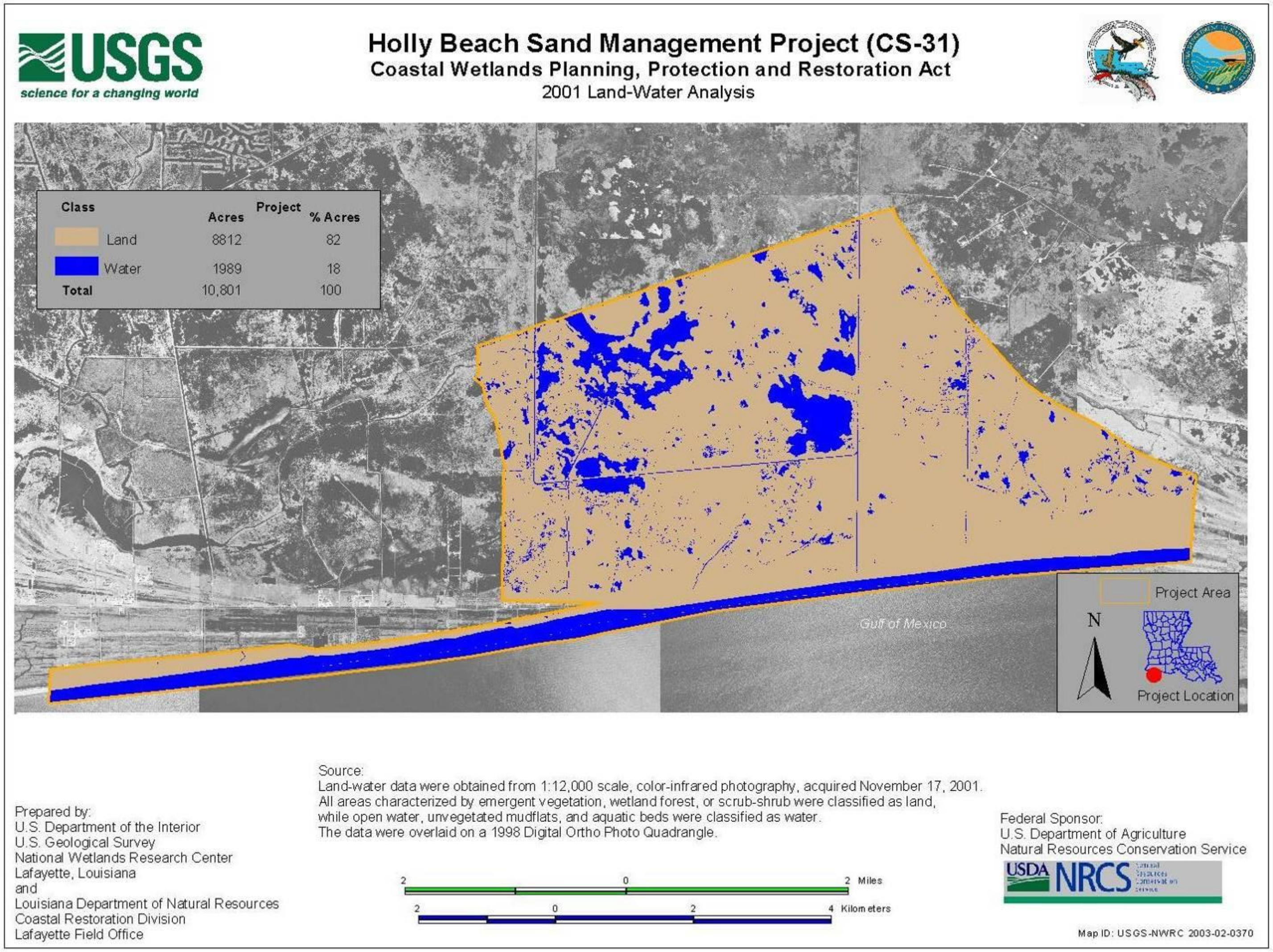


Figure 2. Land/Water analysis of the Holly Beach Sand Management (CS-31) project area from photography obtained November 17, 2001.

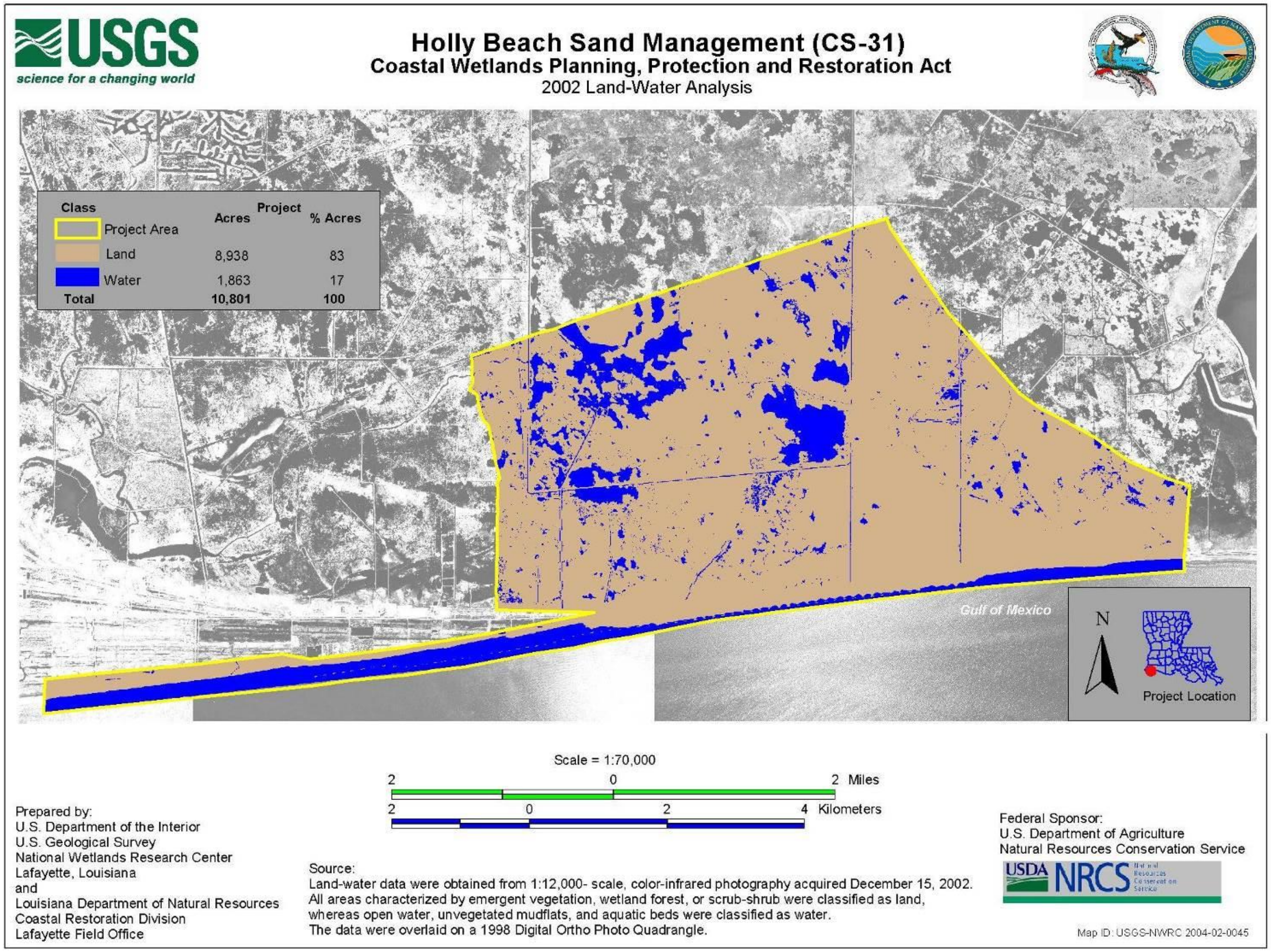


Figure 3. Land/Water analysis of the Holly Beach Sand Management (CS-31) project area from photography obtained December 15, 2002.

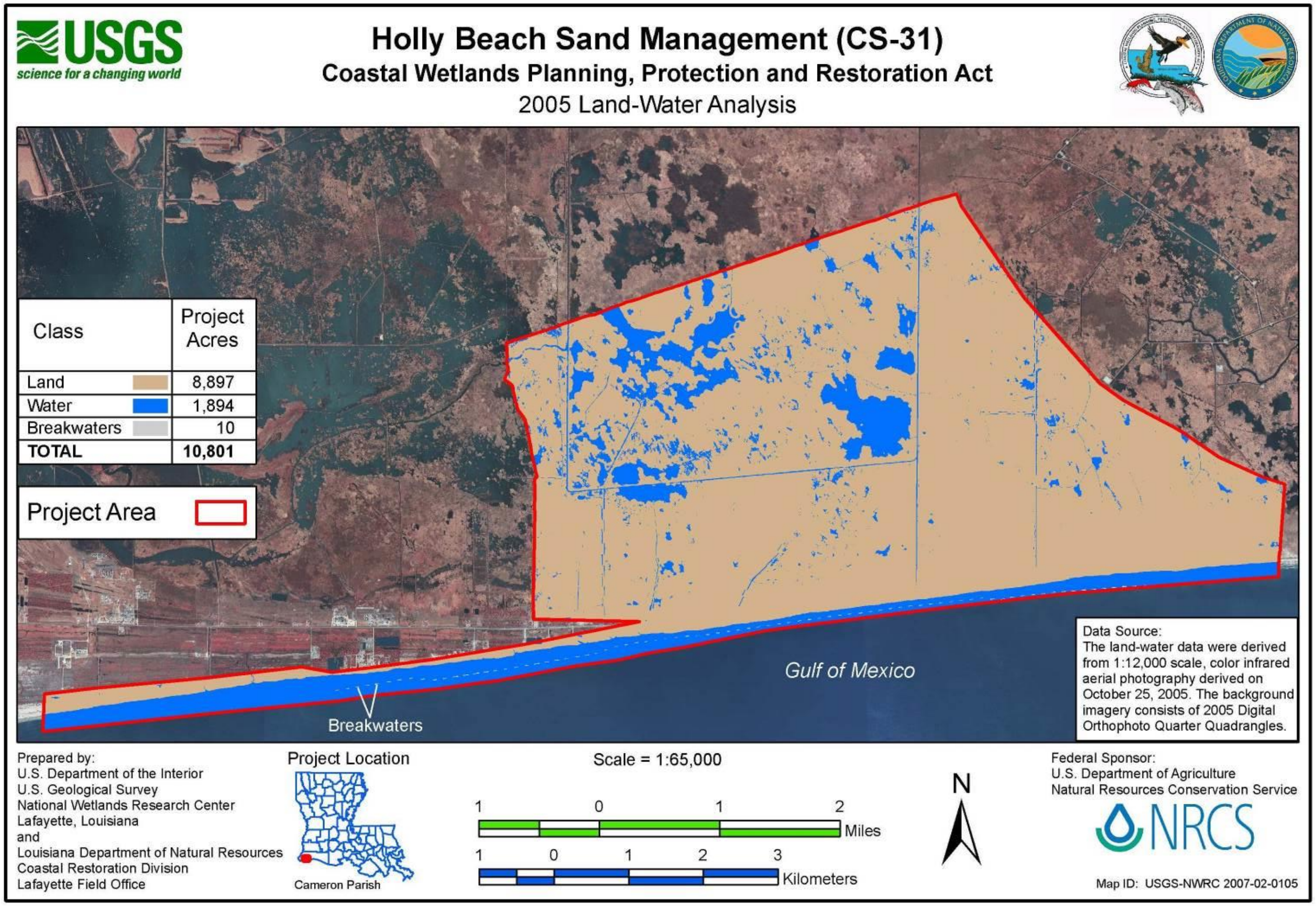


Figure 4. Land/Water analysis of the Holly Beach Sand Management (CS-31) project area from photography obtained October 25, 2005.

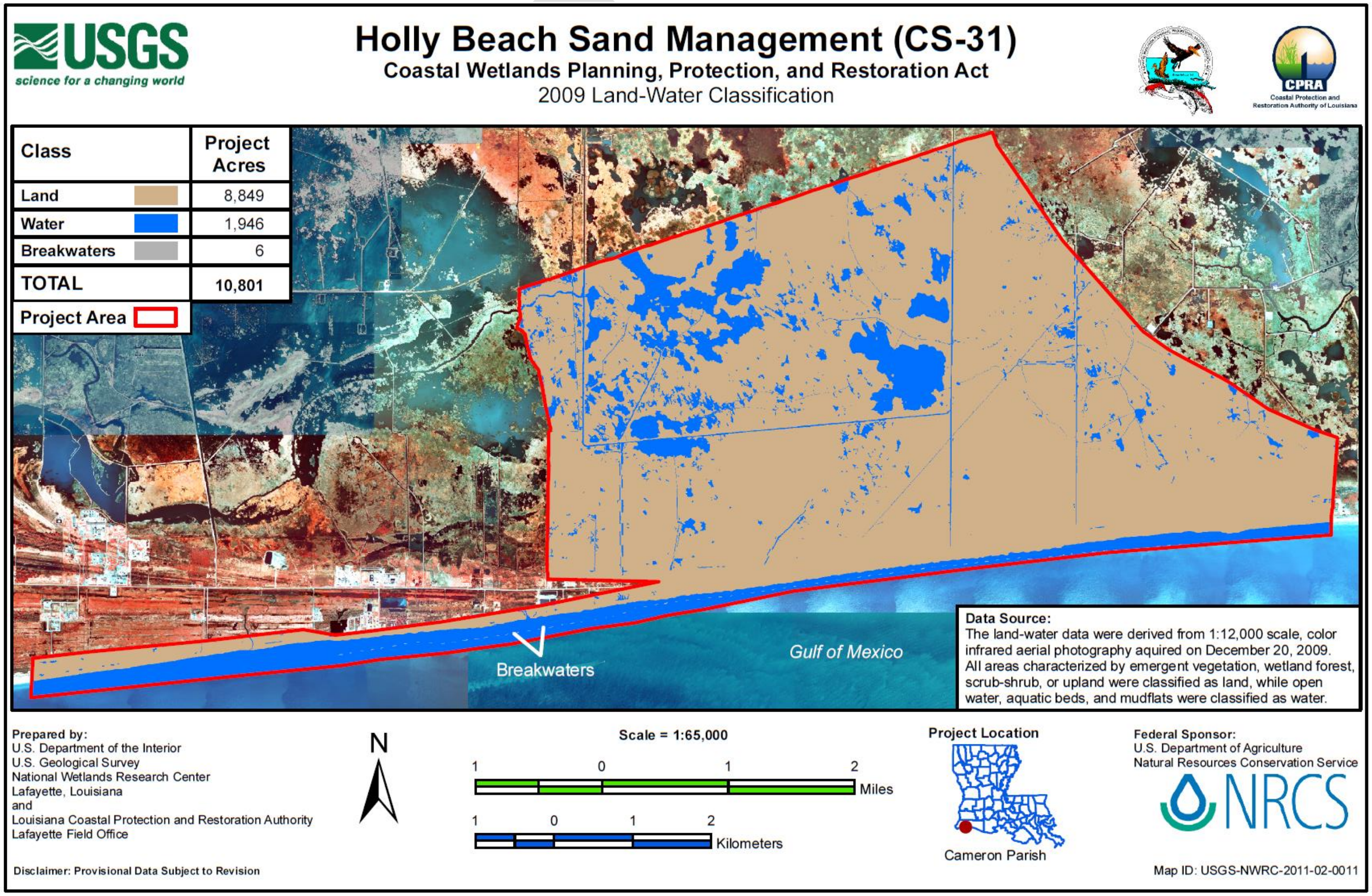


Figure 5. Land/Water analysis of the Holly Beach Sand Management (CS-31) project area from photography obtained December 20, 2009.

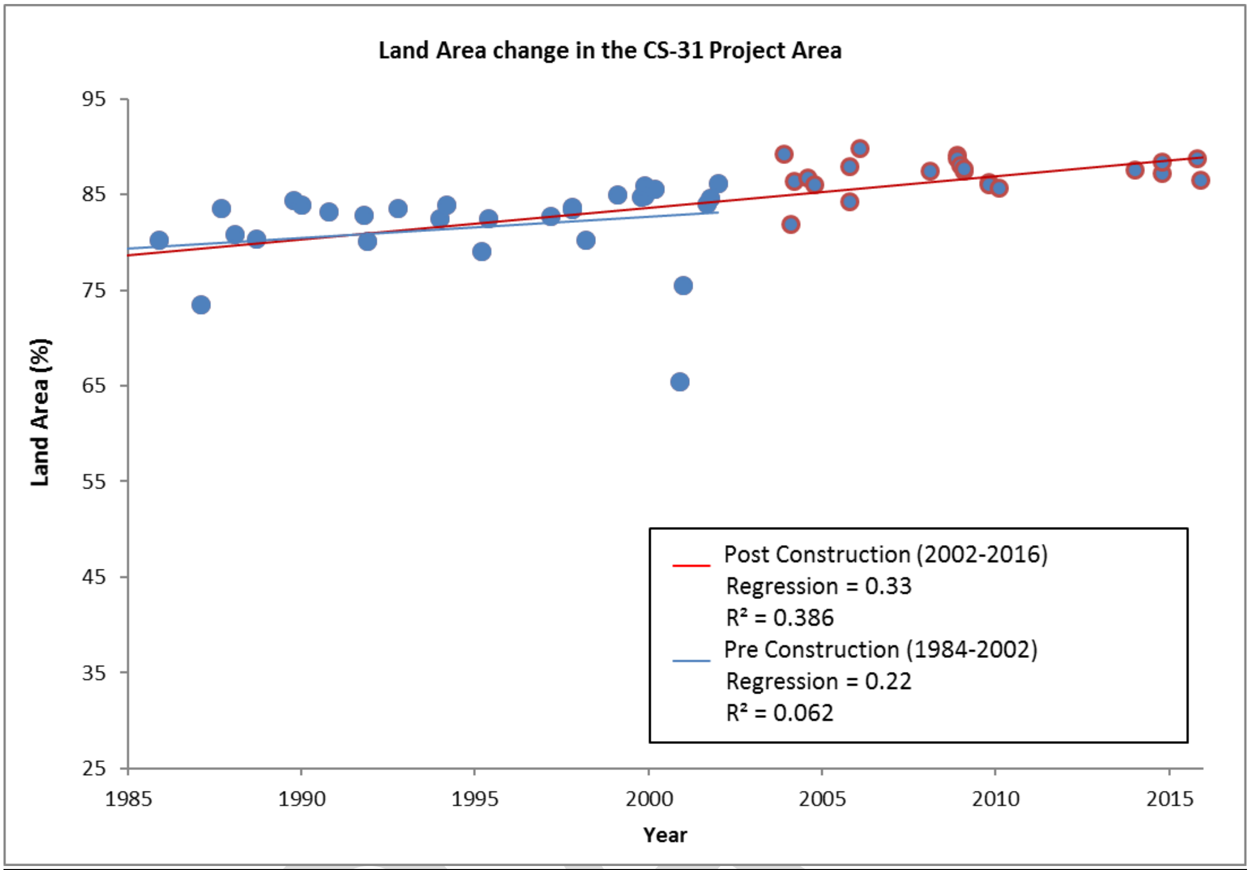


Figure 6. Project scale percent land change for CS-31. Percent land values are displayed for all cloud free TM images available for 1985-2016. The red line depicts the percent land trend for the entire period of record. The blue line depicts the percent land trend for the pre-construction time period only. Percent land calculated as percent land of total project area. See Couvillion et al. 2017.

<u>Bathymetry/Topography:</u>

A Geographic Information System (GIS) database was developed to facilitate the data processing and analysis phase of this investigation. Substantial data processing was required to prepare survey coordinate data for beach profile analysis. Survey data were imported to ArcGIS and reprojected to a Universal Transverse Mercator (UTM) coordinate system for surface interpolation. A triangulation-based (TIN) digital terrain model was then generated from each survey in order to produce two interpolated surfaces for comparison.

Shoreline position change rates were calculated using the Digital Shoreline Analysis System (DSAS Ver. 3.2). Shoreline position was defined as the location of the 2.55 foot contour along the beach. Inspection of the beach profiles indicated that the 2.55 foot contour tended to coincide with a distinct break in slope along the upper beach (Figures 7a and 7b). This position is an interpretation of the upper limit of wave activity at high tide; relative to geomorphology, this position is generally recognized as the berm crest or a scarp at the toe of the dune (see Byrnes and Hiland 1995). Transect start points were generated using a baseline created by drawing a straight line north of the beach, running parallel to the beach (for breakwaters 10 thru 72). Transects were placed perpendicular to the baseline, spaced 20 m apart, and measured from the

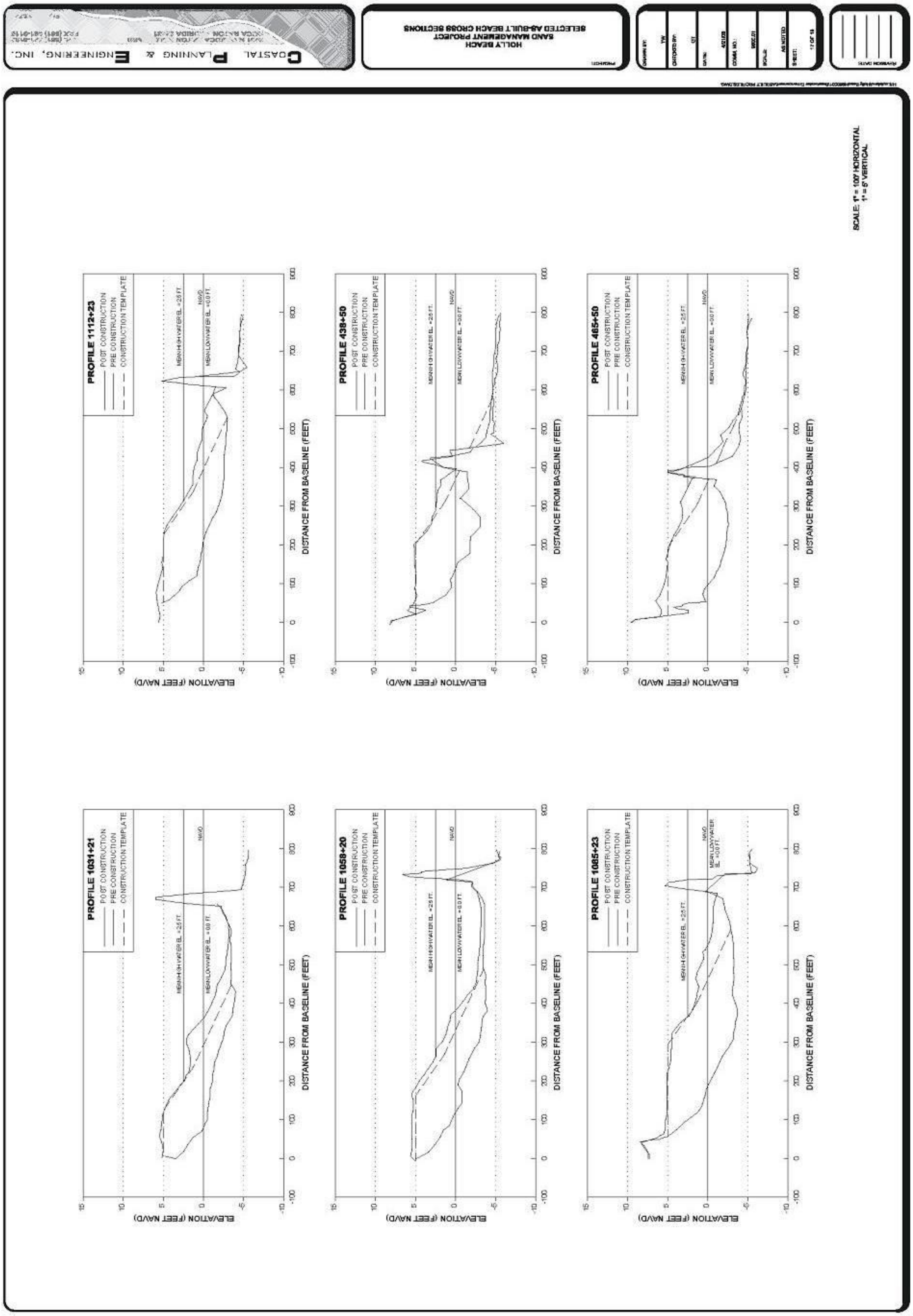


Figure 7a. Holly Beach Sand Management (CS-31) selected pre-construction and as-built cross-sections.

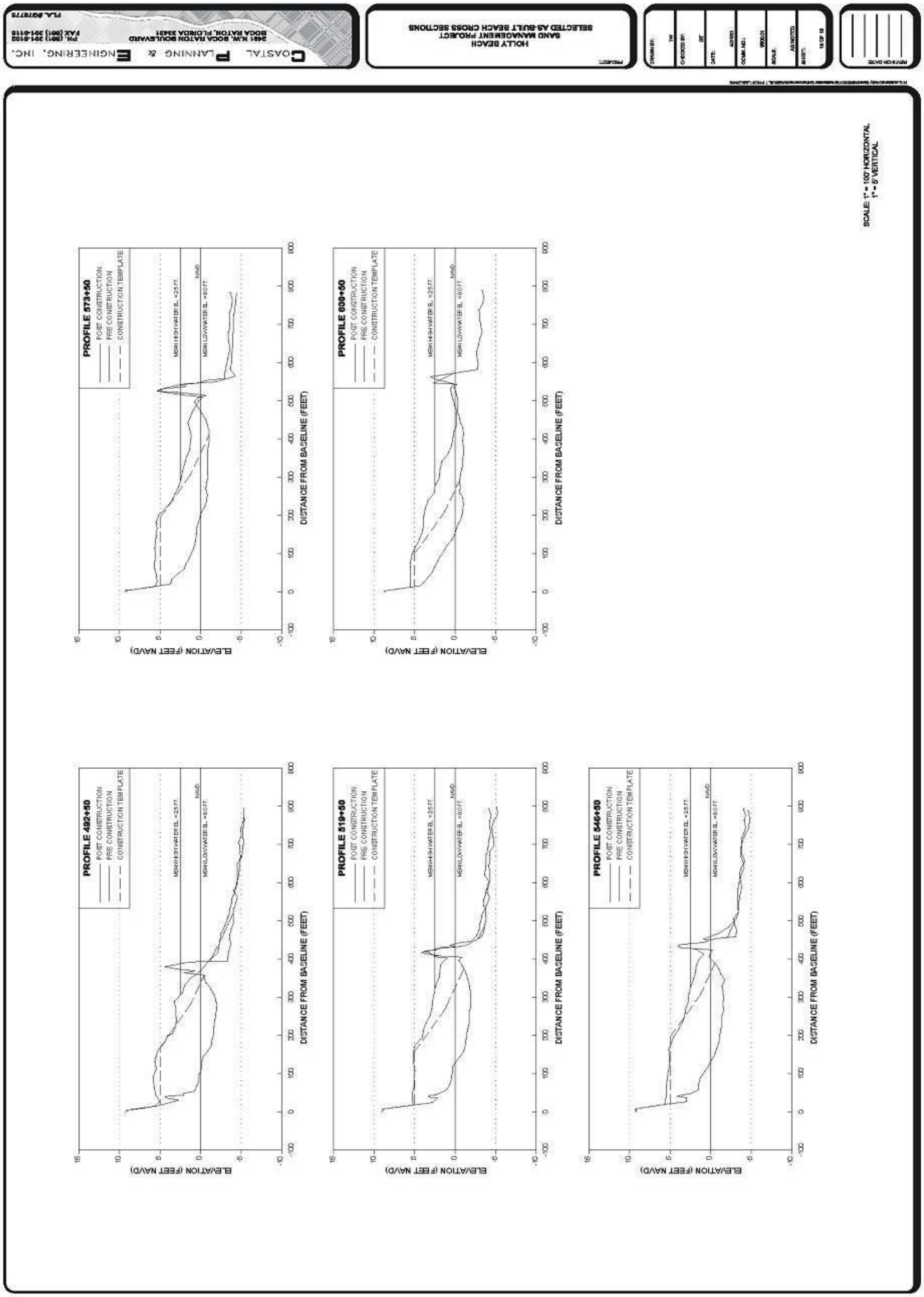


Figure 7b. Holly Beach Sand Management (CS-31) selected pre-construction and as-built cross-sections.

baseline to the shoreline position at the 2.55 ft contour within each survey. Shoreline change was calculated by subtracting the August 2005 shoreline position from the January 2006 shoreline position and then the January 2006 shoreline position from the January 2009 shoreline position. The 2006 data indicate that the shoreline retreated at an average of 21 ft/yr during the time period that included Hurricane Rita. By comparing the 2009 data to the 2006 data, the data indicated that 11 ft/yr was lost during the time period that included Hurricane Ike.

Vegetation Plantings:

Data were collected on October 6, 2003, April 20, 2004 and October 12, 2004 (Table 2, Figure 8). Mean percent survival and mean percent cover in the fall of 2003 were 82.5% and 13.07%, respectively. In the spring of 2004 mean percent survival was 81.1% and mean percent cover was 26.7%. Mean percent survival dropped to 76.7% in the fall of 2004, while mean percent cover increased to 46.4% (Figure 9). Many of the original plants were actually covered by the dune that formed behind the fences. The dunes were becoming colonized by both *Panicum amarum* and other species as well. The last scheduled monitoring of the vegetation plantings occurred in the fall of 2004. As documented in the inspection report, though, the plantings were severely impacted by Hurricane Rita and were replanted by the La Dept. of Agriculture and Forestry. These plantings were again severely impacted by Hurricane Ike and were replanted in the fall of 2011. During the 2016 O&M inspection, it was noted that very little of the plantings remained. The remaining vegetation was flourishing in areas along the beach front which were not impacted by beach retreat and direct wave action. There was minimal to no vegetation remaining where the beach was severely eroded and experiencing constant wave energy.

Figure 8a. View of the sand fencing and Vegetation Plantings at Station CS31-108 taken in April 2004. Note the dune formation almost covering the fences. The photograph is facing east.

Figure 8b. View of the Sand Fencing and Vegetation Plantings at Station CS31-150 taken in October 2004. The photograph is facing east.

Figure 8c. View of a section of the sand fencing and vegetation plantings taken October 2005, following Hurricane Rita. The photograph is facing west.

Holly Beach Sand Management (CS-31)
Vegetation Plantings

Table 2. Vegetative species observed during the 2002, 2003, and 2004 vegetation plantings survey.

Scientific Name	Common Name
Cakile geniculata	gulf searocket
Chrysopsis mariana	Maryland goldenaster
Pluchea odorata	sweetscent
Symphyotrichum subulatum	eastern annual saltmarsh aster
Spartina patens	marshhay cordgrass
Solidago sempervirens	seaside goldenrod
Amaranthus rudis	tall amaranth
Amaranthus australis	southern amaranth
Eclipta prostrata	false daisy
Alternanthera philoxeroides	alligatorweed
Ipomoea pes-caprae	bayhops
Vigna luteola	hairypod cowpea
Cyperus odoratus	fragrant flatsedge
Ipomoea imperati	beach morningglory

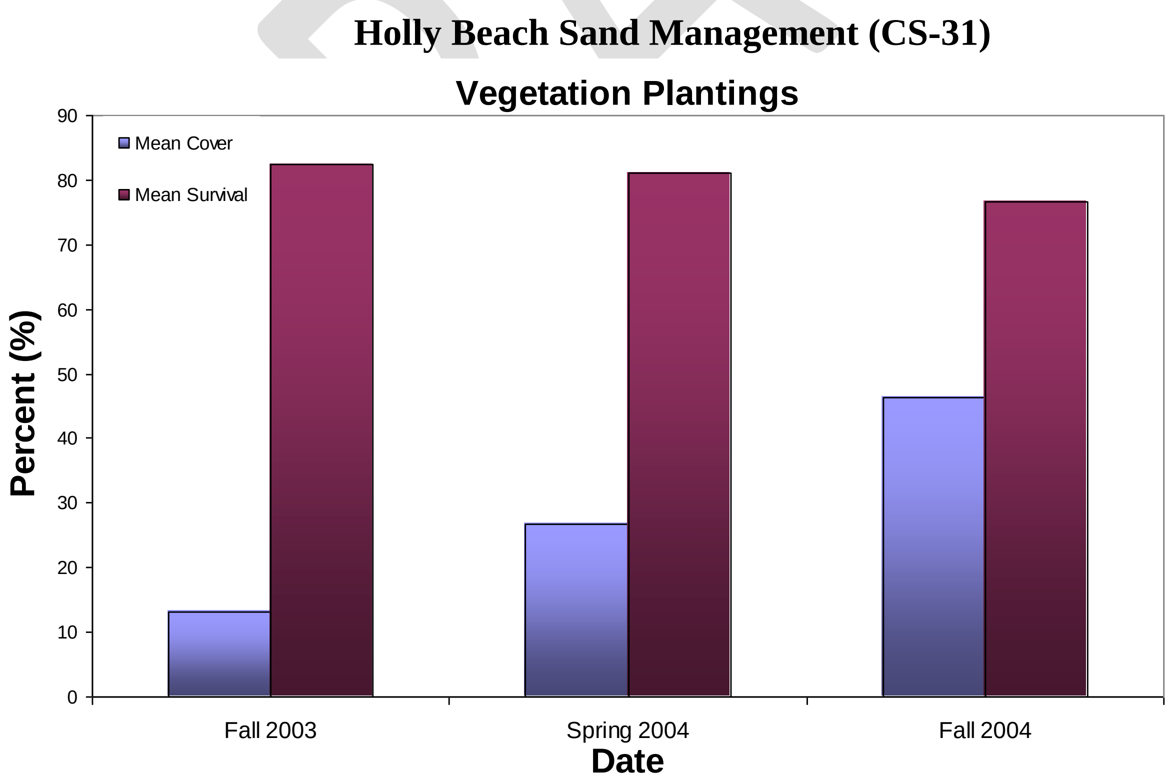


Figure 9. Mean percent cover and survival of the *Panicum amarum* plantings on the 2003 and 2004 surveys.

Shoreline Change:

The data indicated an average loss of -6.12 ft/yr between the spring 2003 and spring 2004 surveys (Table 3). This period would be considered the initial adjustment period after construction when the beach was taking shape. The beach was expected to quickly degrade during this time period due to an overfill of sand by the contractors. The pre-Hurricane Rita data (spring 2003 to spring 2005) indicate an average loss rate of -17.72 ft/yr. The post-Hurricane Rita survey (comparing spring 2005 to fall 2005) showed an average of -46.33 ft/yr was lost during the storm (Figure 10b). Comparing the fall 2005 to spring 2006, which would be considered the recovery period after the impact, indicated an average loss rate of -41.47 ft/yr. The post-Hurricane Ike survey (comparing spring 2007 – fall 2009) showed an average of -5.27 ft/yr was lost during the storm (Figure 10c). The post-Hurricane Ike recovery period (comparing fall 2009 to spring 2011) showed an average loss of -15.52 ft/yr. The final survey (comparing spring 2011 to fall 2011) showed a gain of +8.79 ft/yr. Average loss across all surveys (spring 2003 to fall 2011) was -8.76 ft/yr (Figure 10a). These should not be taken individually as an actual indication of loss rates along the beach, but rather an indication of the processes occurring along the beach. Unlike the bathymetric/topographic surveys, these shoreline surveys can be influenced by tide levels considering the gentle slope of the beach (1:40 during construction) and the fact that elevation is not taken into account during data collection. For instance, tide levels were 1.66 ft higher during the spring 2006 survey compared to the fall 2005 survey which may have exaggerated loss rates. Tide levels during the surveys are presented in Table 3. Loss rates appeared to be fairly uniform across the project area in most surveys prior to Hurricane Rita. However, the post-Hurricane Rita and post-Hurricane Ike data indicate greater loss rates along the eastern side of the beach and some gain along the western end (Figure 10b). The hurricanes appear to have shifted large amounts of sand to the western side.

Table 3. Shoreline survey results and tide levels during shoreline surveys. Tide data were collected at Sabine Pass in ft Mean Sea Level.

Date of Survey	Tide level (Ft MSL)	Survey Results (ft/yr)	Survey Description
Spring 2003	0.51	-6.12	Initial Adjustment
Fall 2003	0.47		
Spring 2004	0.18	-17.72	Pre-Rita
Fall 2004	-0.17		
Spring 2005	0.17		
Fall 2005	-0.89	-46.33	Rita Effects
Spring 2006	0.77	-41.47	Rita Recovery
Spring 2007	-0.7	-8.76	Average across all
Fall 2007	0.71	-5.27	Ike Effects
Spring 2009	-0.42		
Fall 2009	0.78		
Spring 2011	0.34	-15.52	Ike Recovery
Fall 2011	-0.32	+8.79	Final Survey

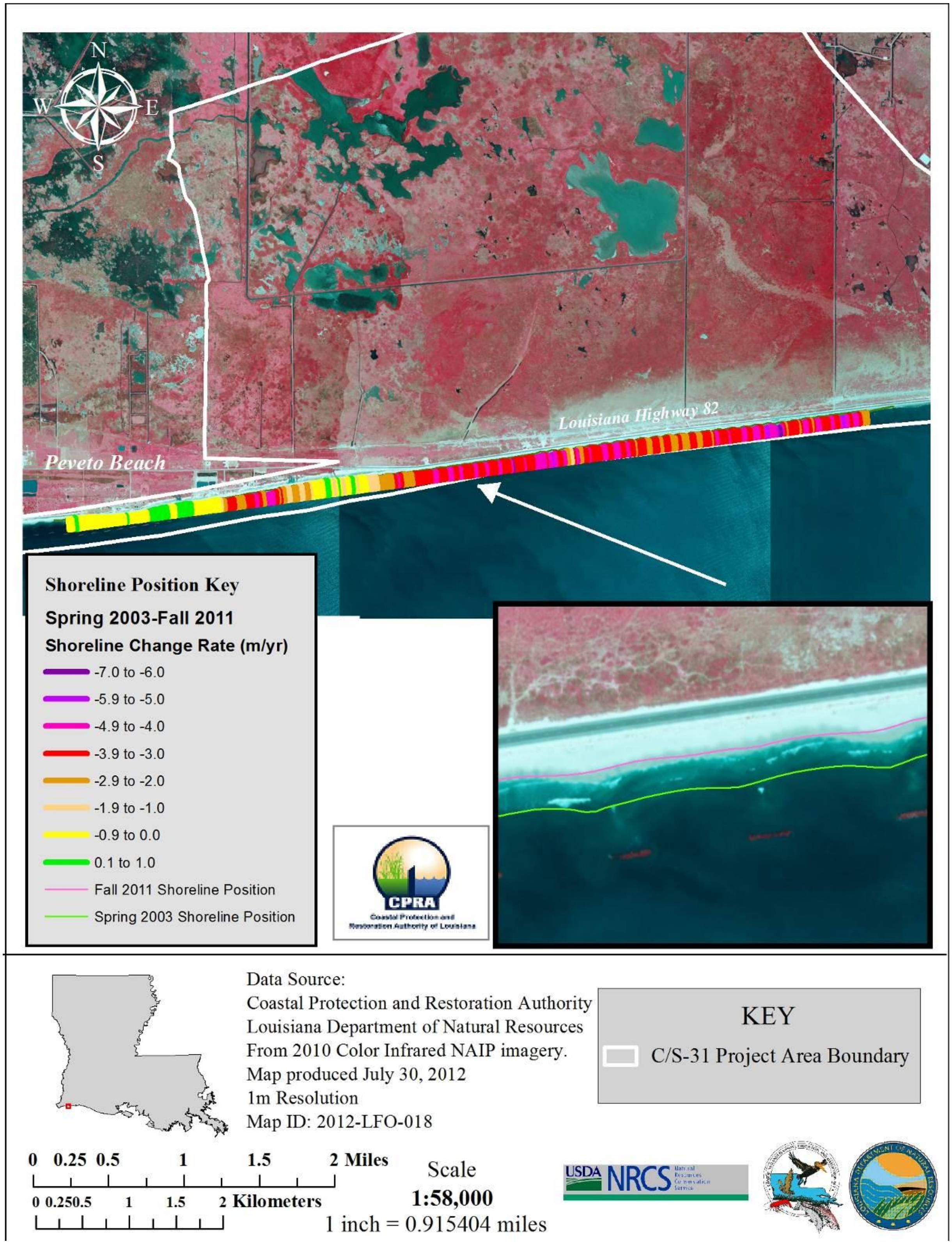


Figure 10a. Shoreline Change Rates across all surveys from Spring 2003 to Fall 2011.

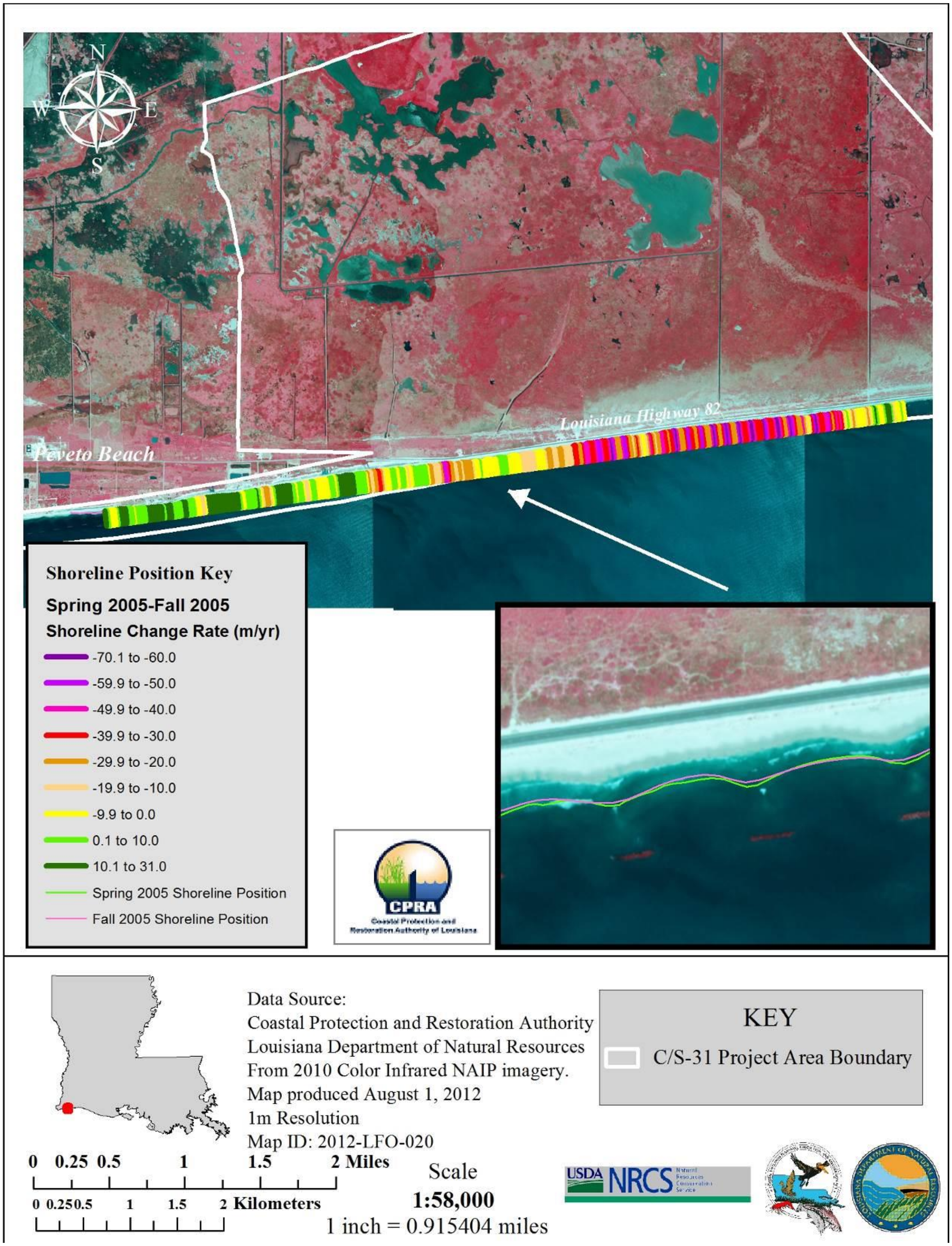


Figure 10b. Shoreline change rates comparing pre- and post- Hurricane Rita surveys.

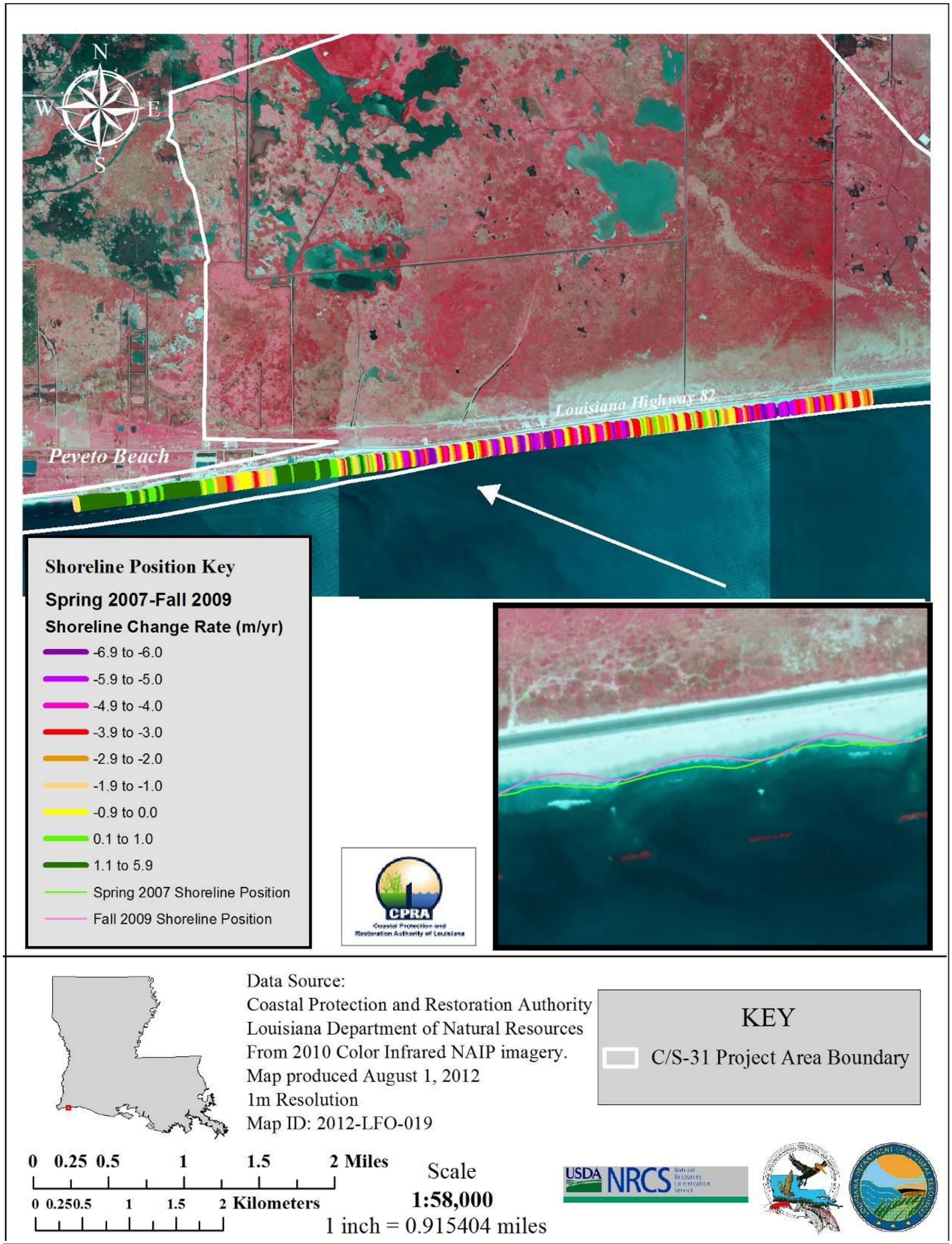


Figure 10c. Shoreline change rates comparing pre- and post- Hurricane Ike surveys

The analysis of BICM data for the 1998-2004 time period showed the effect of project construction, with the shoreline gain occurring at an average of 25.56 ft/yr (Table 4, Figure 11a). In comparison, the reference area had an average of -0.69 ft/yr of loss for this period. During the period of Hurricanes Rita and Ike (2004-2008), the project area lost an average of -10.53 ft/yr compared to -5.74 ft/yr in the reference area (Figure 11b). The loss rate was much lower in the project area during 2008-2015 at -0.07 ft/yr while the reference area showed a large gain of 12.30 ft/yr (Figure 11c). The gain in the reference area can likely be attributed to the construction of the Cameron Parish Shoreline Restoration (CS-33) project in 2014 to the east of the Holly Beach Community. It's probable that sediment from that beach nourishment project shifted west to the reference area and to a lesser extent, the project area. Average change across all time periods (1998-2015) showed a gain of 5.87 ft/yr in the project area and a lesser gain of 3.12 ft/yr within the reference area (Figure 11d).

Table 4. Barrier Island Comprehensive Monitoring data shoreline survey results.

Time Period	**Results**	
	Project (ft/yr)	**Reference (ft/yr)**
1998-2004	25.56	-0.69
2004-2008	-10.53	-5.74
2008-2015	-0.07	12.30
1998-2015	5.87	3.12

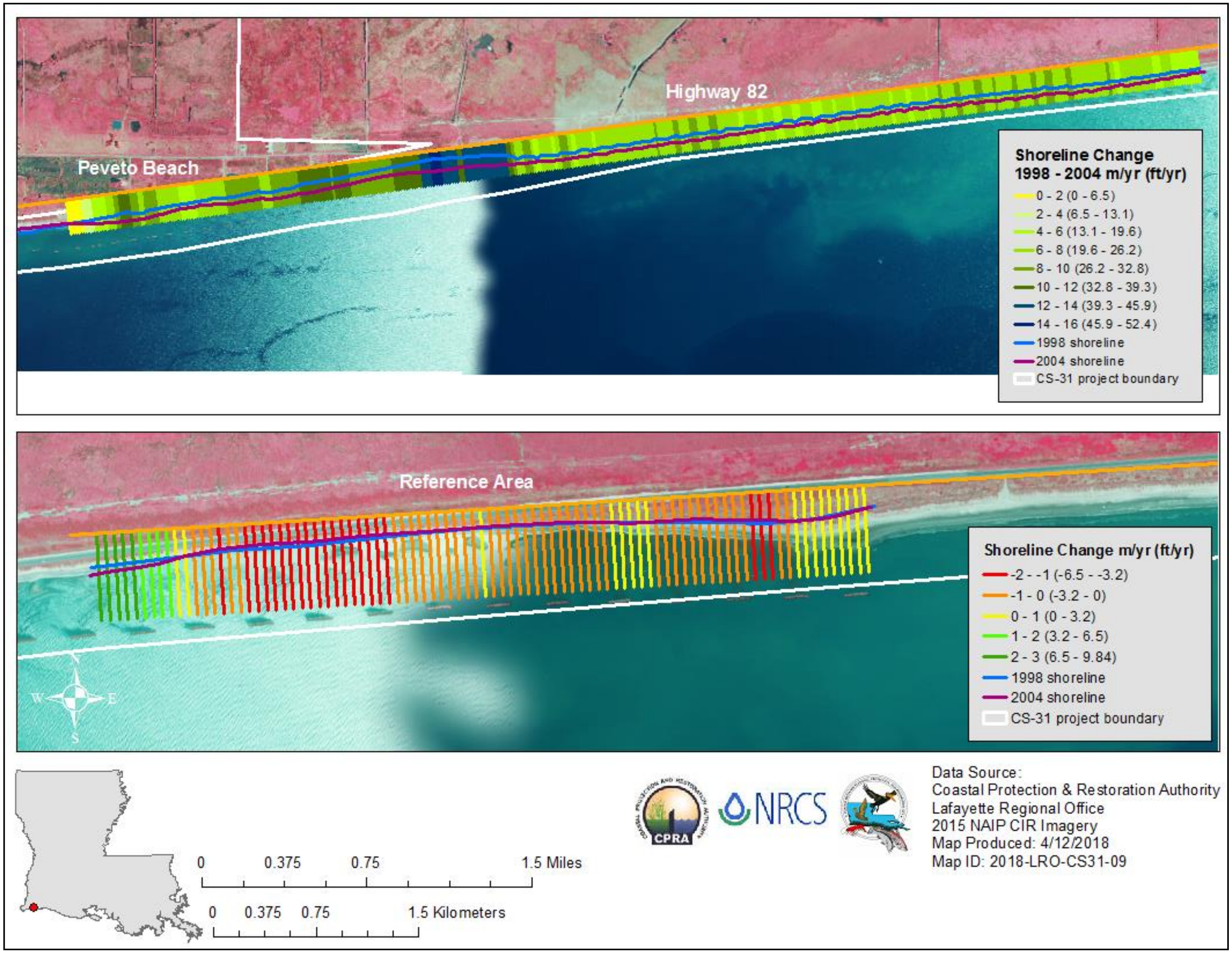


Figure 11a. Project and reference area shoreline change rates based on BICM data for 1998-2004.

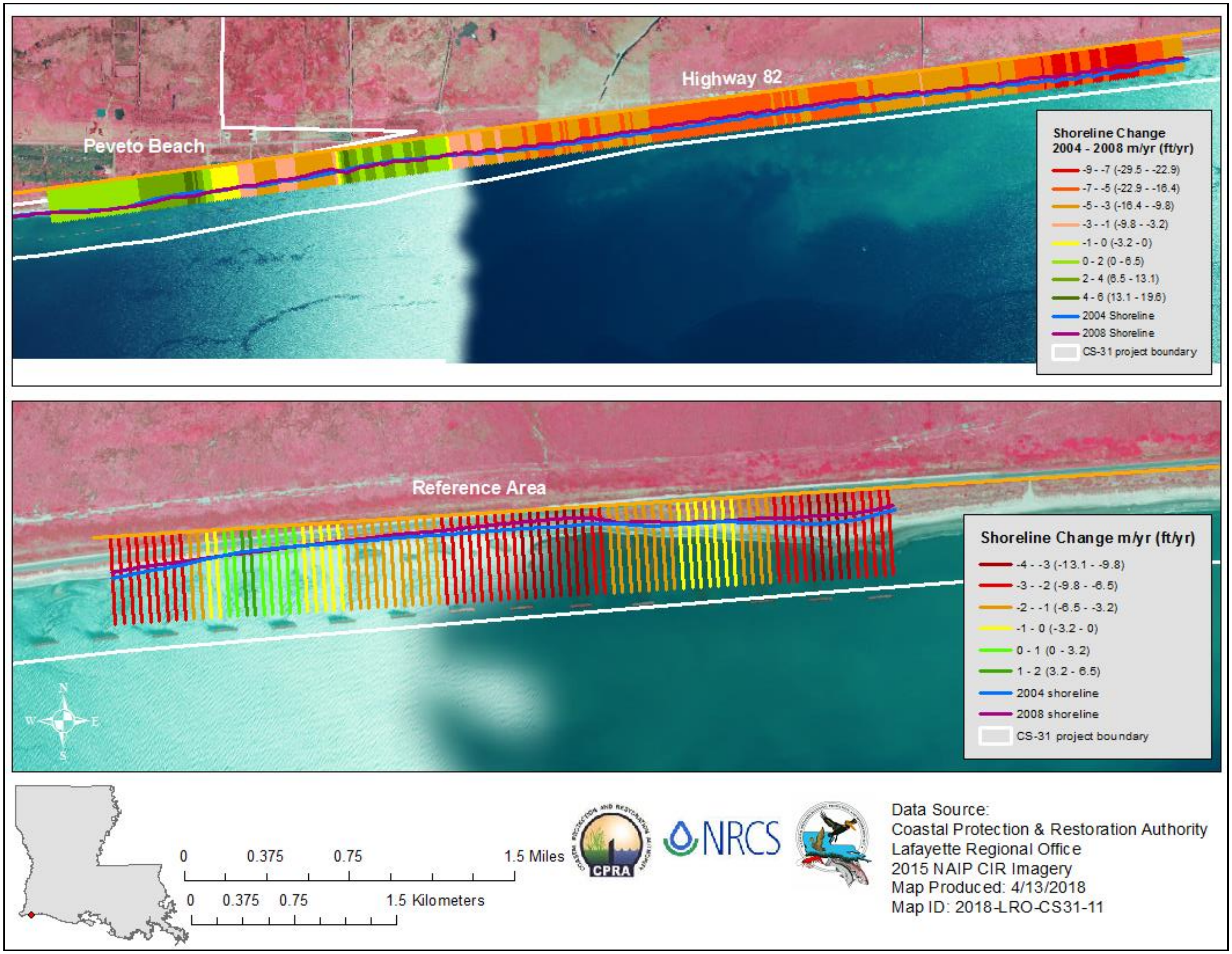


Figure 11b. Project and reference area shoreline change rates based on BICM data for 2004-2008.

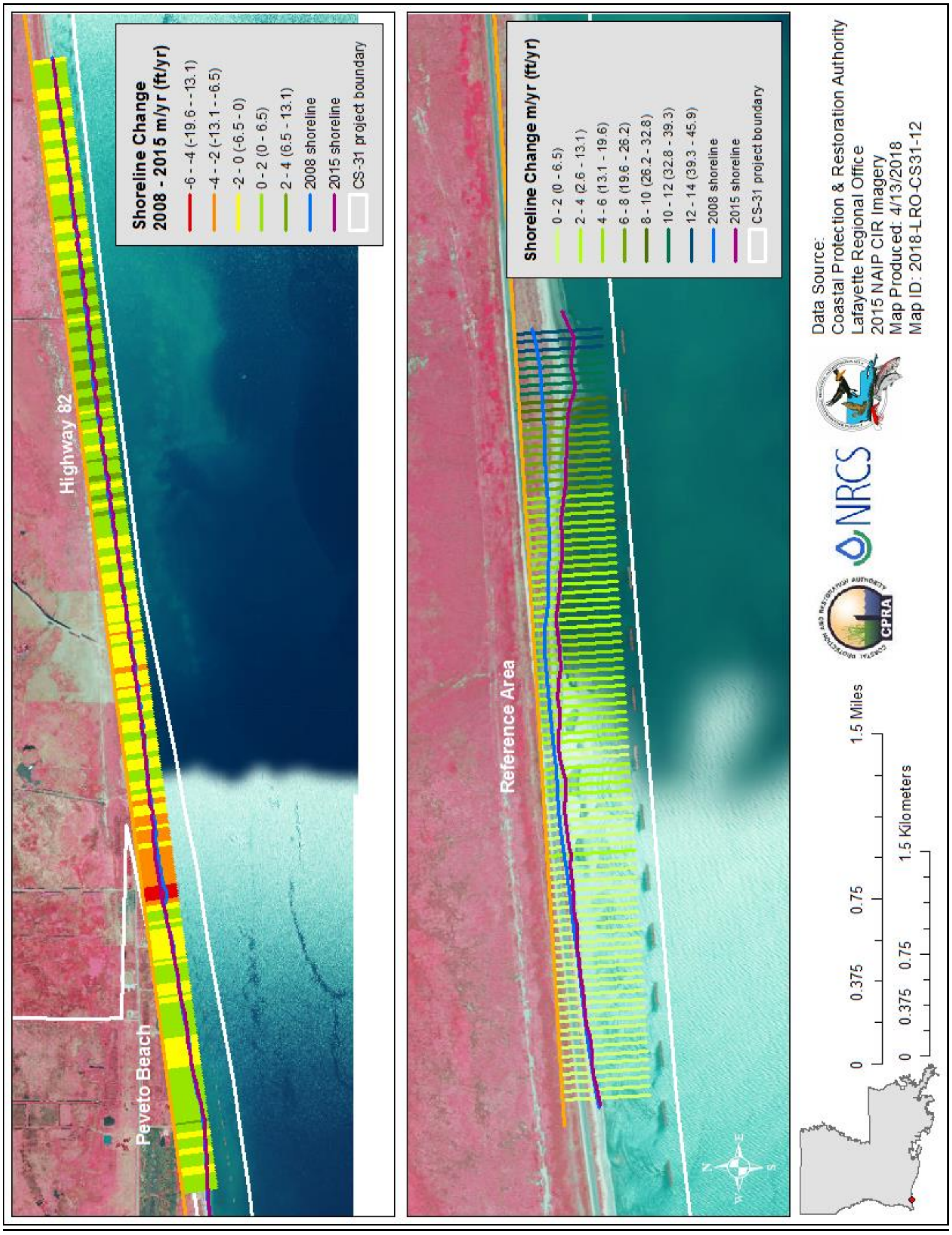


Figure 11c. Project and reference area shoreline change rates based on BICM data for 2008-2015.

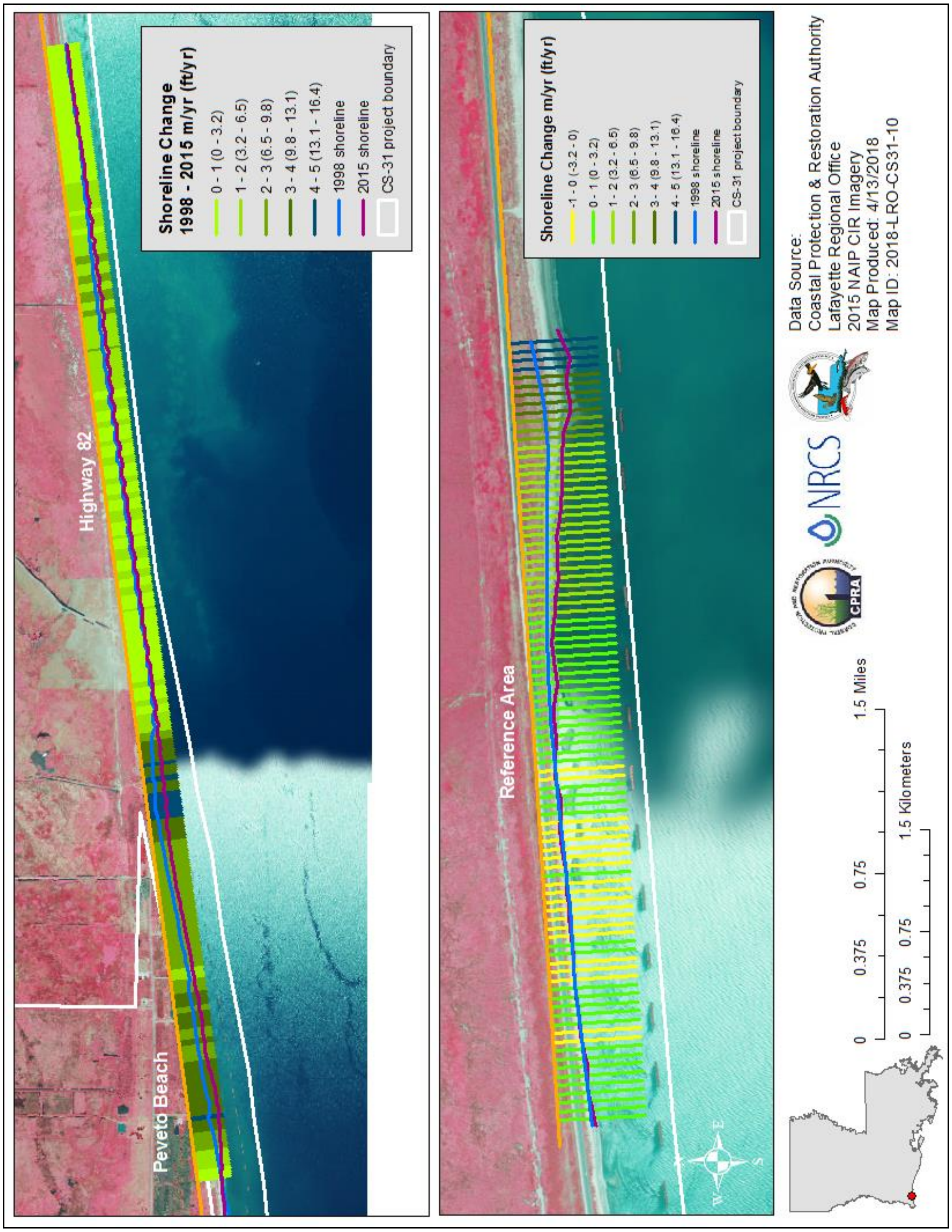


Figure 11d. Project and reference area shoreline change rates based on BICM data for 1998-2015.

Water Salinity:

Hourly salinity data were collected at the following continuous recorder stations (Figures 12 and 13a-c).

Station	**Data collection period**
CS31-01	9/10/02 – 6/11/07
CS31-02	2/18/03 – 6/11/07
CS31-03	2/18/03 – 5/1/07
CS20-15R	1/1/95 – 12/31/14
CRMS0680	7/30/07 – 12/31/17
CRMS2219	7/1/09 – 12/31/17
CRMS0685	3/10/06 – 12/31/17

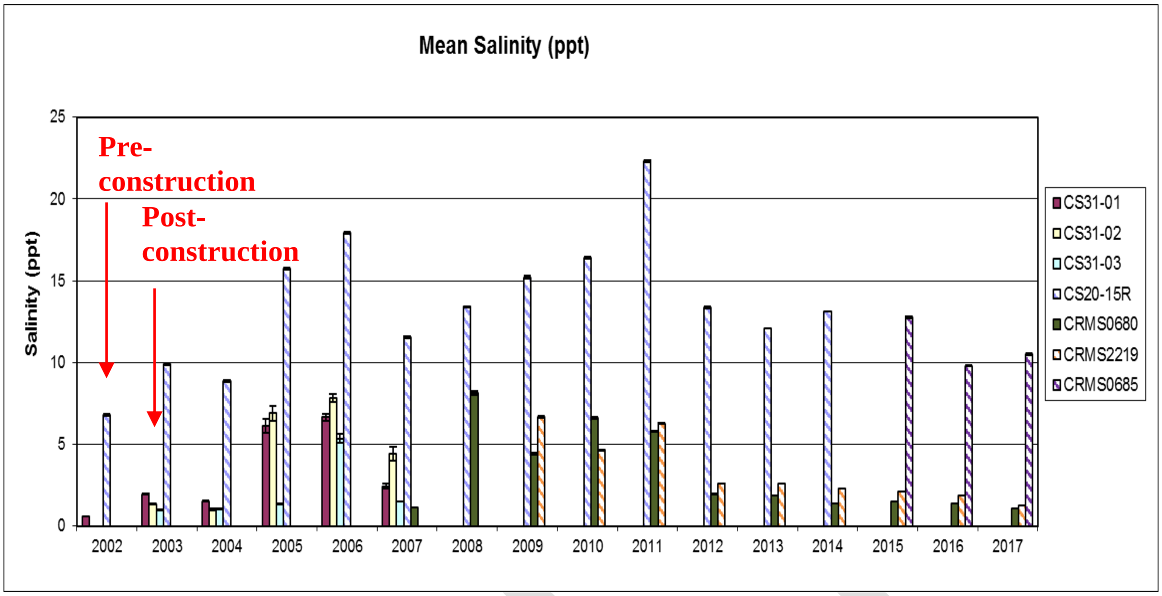
The project goals for salinity were to maintain levels within the intermediate to brackish range of 3-12 ppt. Yearly means of all project area recorders were less than 3 ppt through 2004 (Figure 13a). Monthly means at all project area stations stayed within the target range until Hurricane Rita struck in September. CS31-02 was the only recorder that continued to log through the hurricane where salinities reached 24 ppt. Monthly salinity means remained above 20 ppt at stations CS31-01 and CS31-02 until December 2005 (Figures 13b – 13c). CS31-03 was not redeployed until March 2006. In July 2006, monthly salinities returned to normal and remained below 7 ppt until April 2007. Data from station CS20-15R in the East Mud Lake Marsh Management (CS-20) reference area, which reflects conditions in Calcasieu Lake, are presented for comparison. Yearly mean salinities at this recorder were below 12 ppt for the years preceding Hurricane Rita. However, following Rita, monthly mean salinities remained around 15 ppt through the end of 2006 as salinities in the project area had returned to normal. In May and June of 2007, salinities spiked at CS20-15R to near 20 ppt. An increase was also detected at CS31-01 and CS31-02 indicating some influence from the Calcasieu Ship Channel may have occurred in the project area.

The recorder at CRMS0680 is located in the same canal as CS31-03. Salinities at this station were below 5 ppt until Hurricane Ike made landfall in September 2008. During this event, the salinity reached 26 ppt. Monthly salinities dropped below the target level of 12 ppt in December of 2008 and remained below that level until the end of 2010, where salinities exceeded 15 ppt due to a drought. Salinities at the site have remained below 5 ppt since 2012 with average to above average rainfall and a lack of tidal surges, even though salinities have often exceeded 15 ppt at CS20-15R and CRMS0685 through 2017. Reference station CRMS2219 had similar salinities as CRMS0680 throughout most of the sampling period. However, salinities at 2219 didn't reach the levels recorded at 680 in late 2010/early 2011.

Project area yearly salinities were within the target range of 3-12 ppt 94% of the time in years 2003 – 2012 and 100% since 2013 (Figure 13d). In contrast, yearly salinities at reference stations CS20-15R/CRMS0685 were within this range only 45% of the time.

Water level data did not indicate any over wash events other than the surges from Hurricanes Rita and Ike (Figure 13e). There was a maximum storm surge in the project area of 14-15 ft for Hurricane Rita (Barras, 2006) and 15-16 ft for Hurricane Ike (East et al. 2008). Excessive rainfall and upstream flooding during Tropical Storm Harvey in September 2017 prompted the opening of the flood gates on the Toledo Bend Reservoir. This resulted in increased water levels of over 4 ft within the project area. However, since this was due to upstream flooding and not storm surge, salinities were extremely low.

Figure 12. Location of continuous recorder stations at Holly Beach Sand Management (CS-31) project.



*Project area sites are displayed as solid bars

Figure 13a. Yearly salinity means at all CS-31 project area stations, CS20-15R, CRMS0680 and CRMS2219 for years 2002-2017.

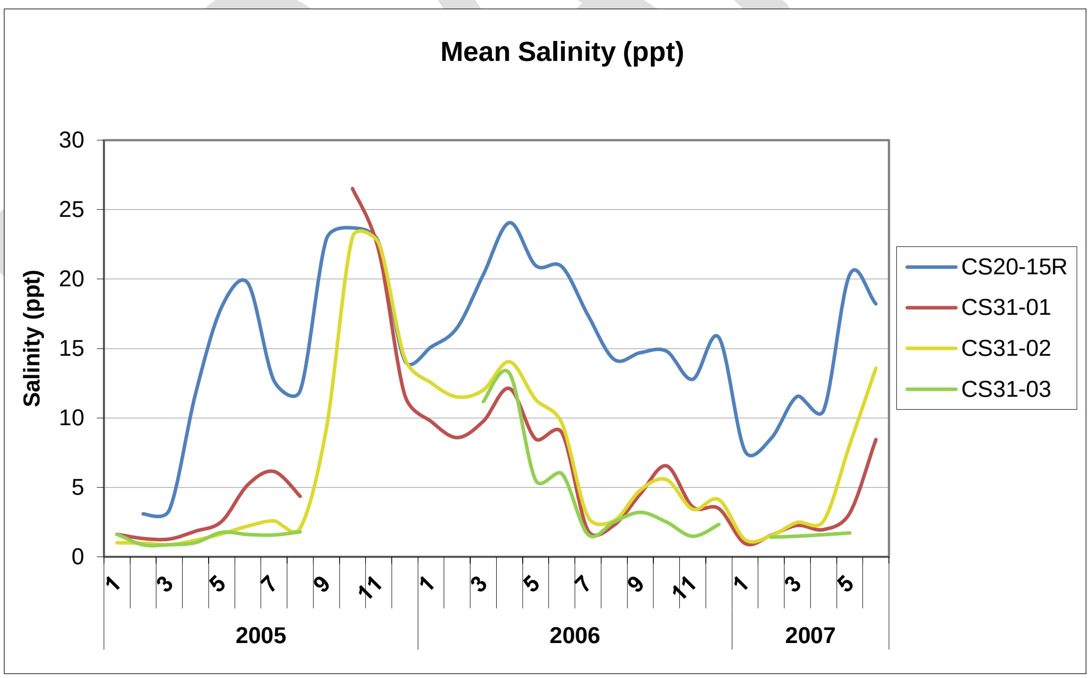


Figure 13b. Monthly means at CS-31 project area stations and CS20-15R for years 2005 - 2007.

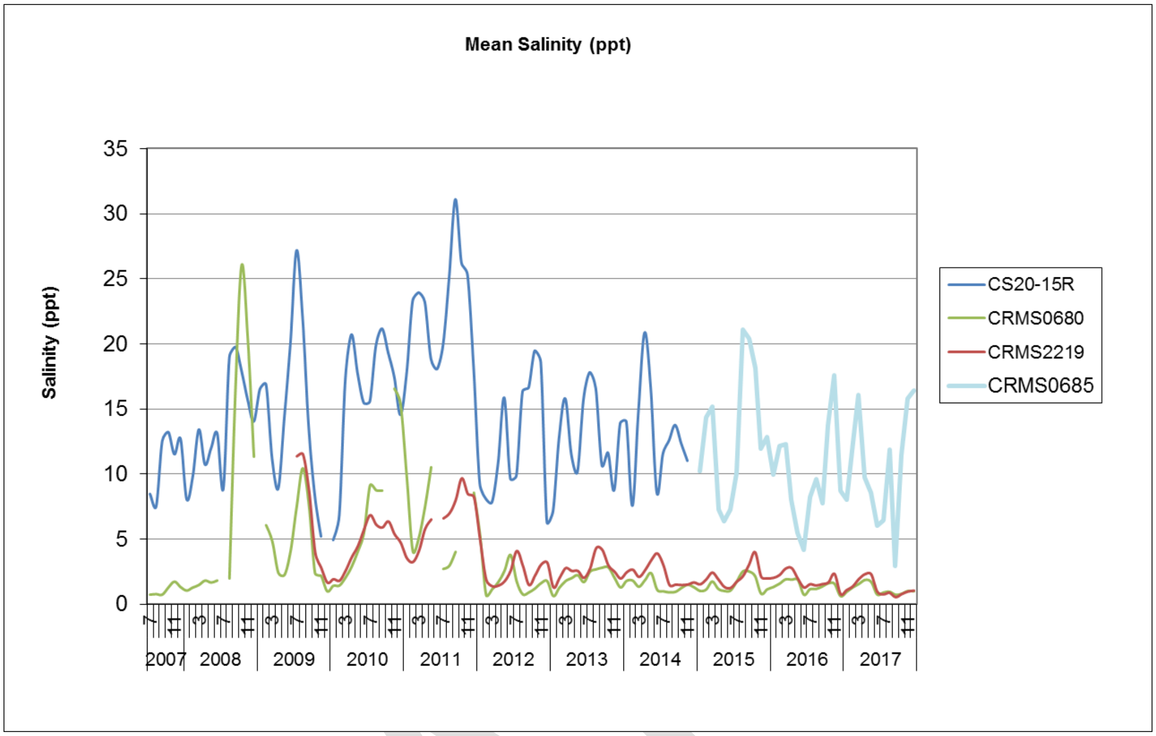
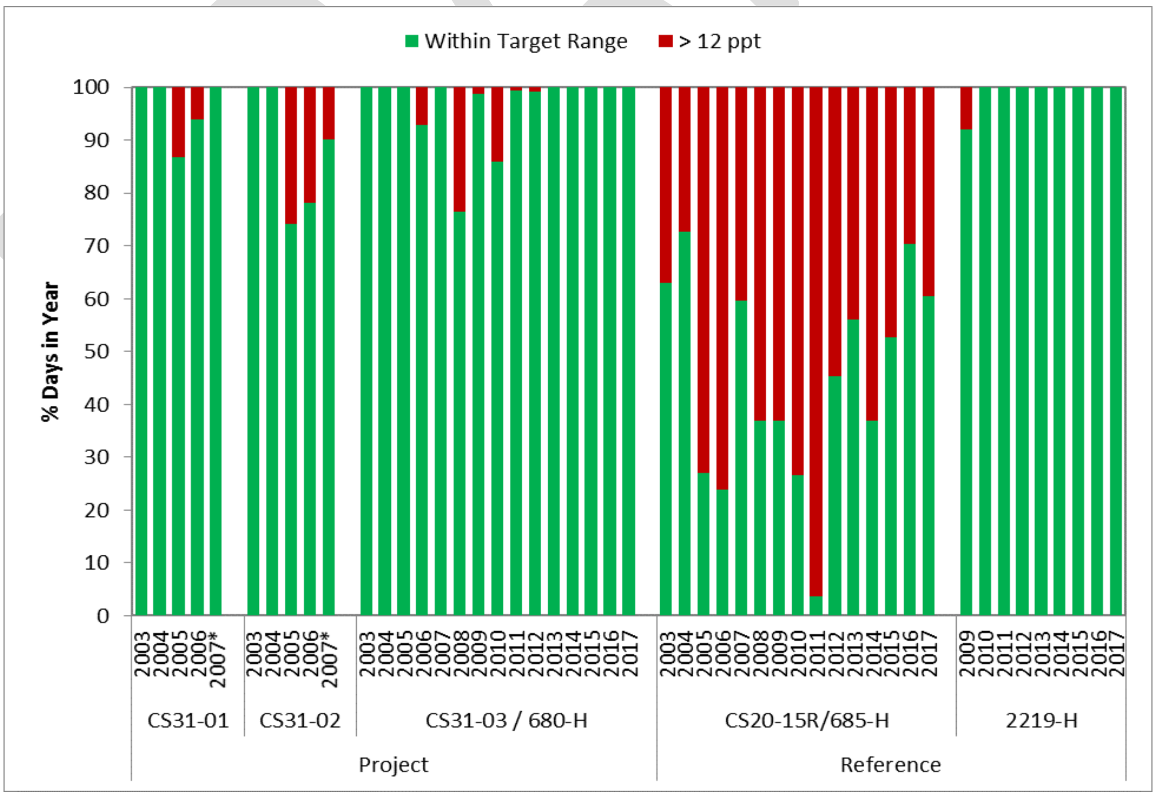


Figure 13c. Monthly means at project site CRMS0680, and reference sites CS20-15R, CRMS2219 and CRMS0685 for years 2007 – 2017.



*Represents the first 6 months of the year

Figure 13d. Percentage of year salinities were inside and outside of target range post-construction for project and reference stations.

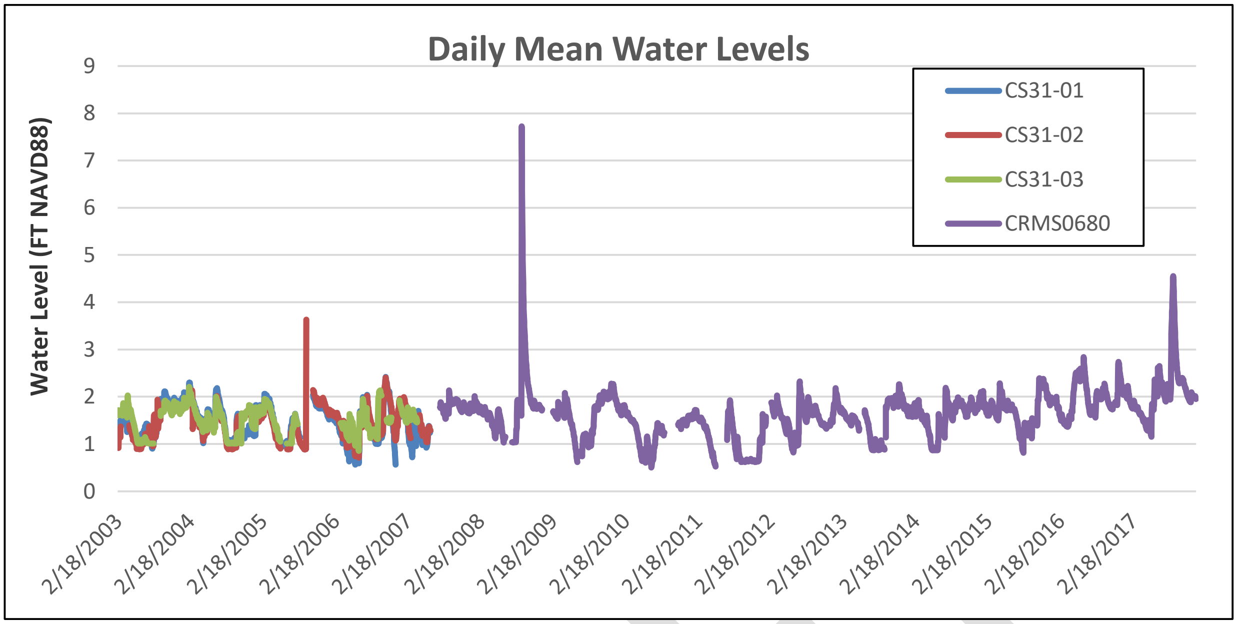


Figure 13e. Daily mean water levels (Ft NAVD88) for CS-31 and CRMS0680 continuous hydro stations for 2003-2017.

Emergent Vegetation:

The project goal was to maintain the existing intermediate and brackish marsh vegetation community in project Area A north of the chenier/beach ridge. The dominant species in all surveys were *Spartina patens*, *Schoenoplectus americanus* and *Distichlis spicata*. Other frequently occurring species were *Paspalum vaginatum*, *Bolboschoenus robustus*, and *Paspalum vaginatum*. These are all species that typically inhabit brackish marshes (Figures 14a-c).

Total percent cover for the pre-construction survey in 2002 was over 100% with an FQI score of 76. The FQI score dropped in 2003 and 2004 but remained above 60. Following Hurricane Rita, cover and FQI (6.4) dropped dramatically within the project area, but showed a good recovery in 2006. Percent cover, as well as the quality of vegetation rebounded in 2007 to the 2002 level but dropped in 2008 following Hurricane Ike. A slight decrease in FQI score occurred again in 2009 (43 versus 47 FQI score), but cover remained the same as in the 2008 survey (Figure 14a).

CMRS site 680 (project) showed the same trend as the project-specific sites; however, the 2008 CRMS survey showed an increase in FQI score and cover (Figure 14b). The 2009 values showed the same decline in quality and cover as the project-specific sites. Low rainfall and extensive cattle herbivory in 2011 cause another sharp decrease in cover and quality of vegetation at the CRMS station. The site did not show full recovery until 2012, where cover (~105%) and FQI (~76) rebounded sharply and have remained high through 2017 with consistent rainfall in the region. Reference site CRMS2219 showed a mild increase in cover and FQI from 2006 to2007 (Figure 14c). Cover dropped in 2008 following Hurricane Ike, but, unlike the sites in the CS-31 project area, cover and FQI score increased in 2009 and continued to increase through 2012. A drop in cover and quality occurred in 2013 within this area, but has been high since. The reference site was not subjected to herbivory.

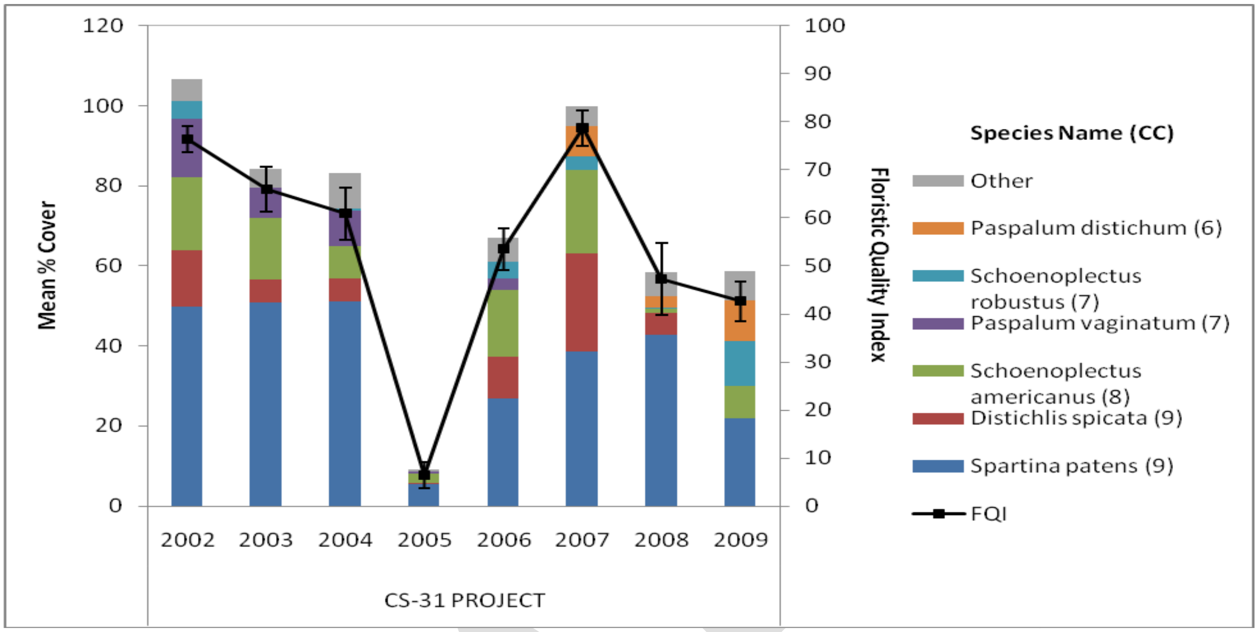


Figure 14a. Percent coverage and floristic quality index of species collected from the CS-31 project area in years 2002 – 2009. Values are means of 30 stations within the project area; therefore, the sum of % coverage of individual species can be greater than 100%.

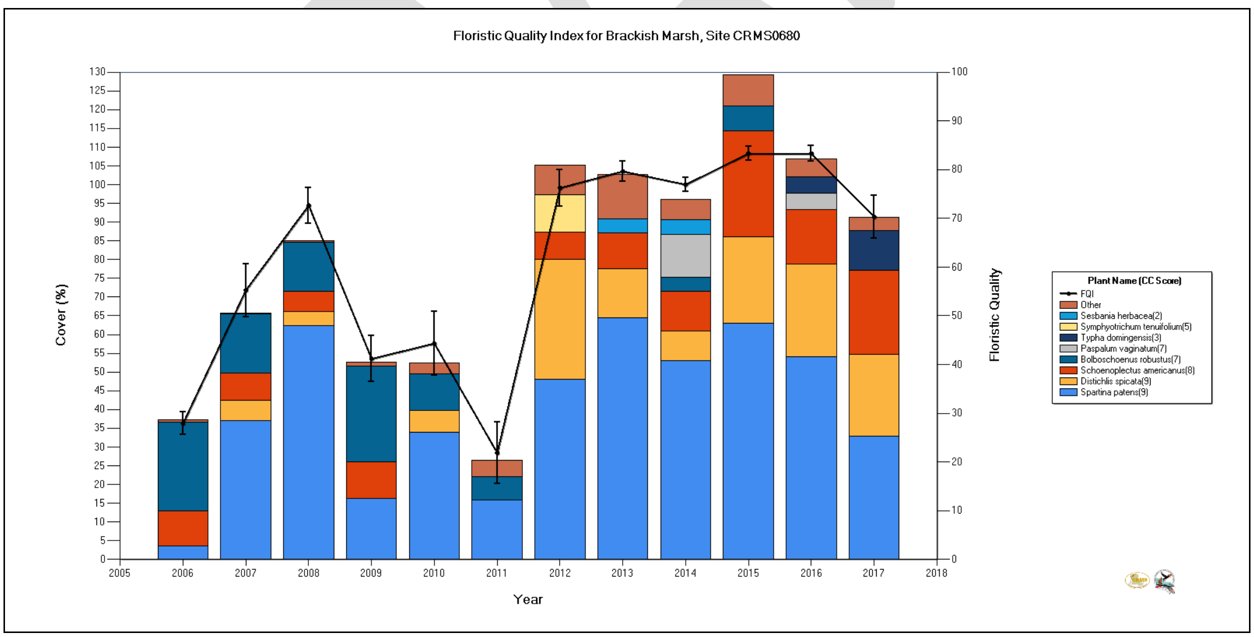


Figure 14b. Percent coverage and floristic quality index of species collected from CRMS site 680 within the project area in years 2006 – 2017. Values are means of 10 stations within the site; therefore, the sum of % coverage of individual species can be greater than 100%.

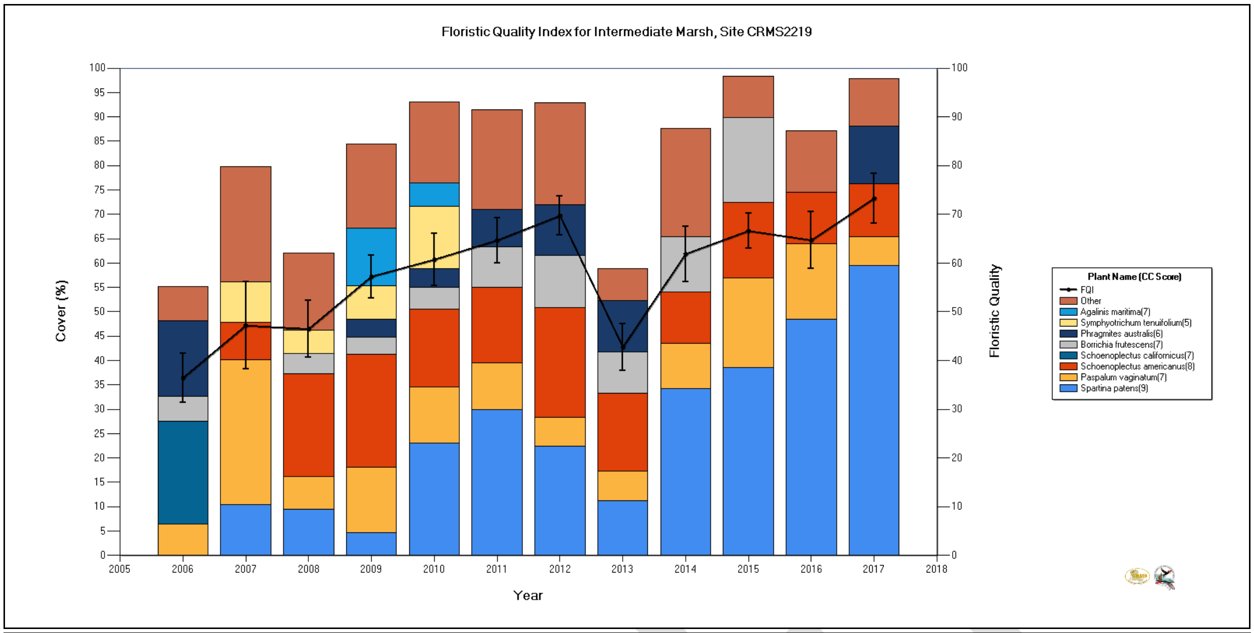


Figure 14c. Percent coverage and floristic quality index of species collected from CRMS reference site 2219 in years 2006 – 2017. Values are means of 10 stations within the site; therefore, the sum of % coverage of individual species can be greater than 100%.

<u>Porewater Salinity:</u>

In the 2002 and 2004 surveys, mean interstitial water salinity data was nearly identical inside the project area at just over 3 ppt. Due to the hardness of the ground in 2003, data wasn't collected. Mean salinity in 2005 following Hurricane Rita rose to approximately 16.5 ppt. We could only obtain data at 2 stations in 2006. These stations had a mean of 13.2 ppt. Salinities in 2007 dropped to around 8.5 ppt. Following Hurricane Ike, salinities again rose to 16.5 ppt but dropped to 8.5 ppt by 2009 (Figure 15a).

Salinities at CRMS0680 (project) and 2219 (reference) both sites rose to near 15 ppt following Hurricane Ike but slowly dropped to near pre-hurricane levels at the 10 cm by 2010 (15a). The project site saw spikes in salinity in 2012 and 2015, but has generally remained below 10 ppt through the end of the data collection period. The 30 cm salinities at both project and reference sites remained around 15 ppt through 2011 (15b). Data was not available for the project site in 2012 and 2013, but the reference station showed a decrease in salinity through 2013 to near 12 ppt. The project area site hovered around 15 pt in 2014-2016, dropping below 10 ppt in 2017. These data show that large over wash events and droughts can have lasting effects on soil salinities for several years following the event and translate to an impact to the vegetation as well. In the subsequent year following the over wash event, vegetation showed a decrease in cover, followed by a shift to more salt tolerant species in later years. Though salinities in the upper 10 cm of the soil responded fairly quickly to changing climatic conditions, salinities were still high at 30 cm by 2016 even though surface water salinities had been below 3 ppt since 2012.

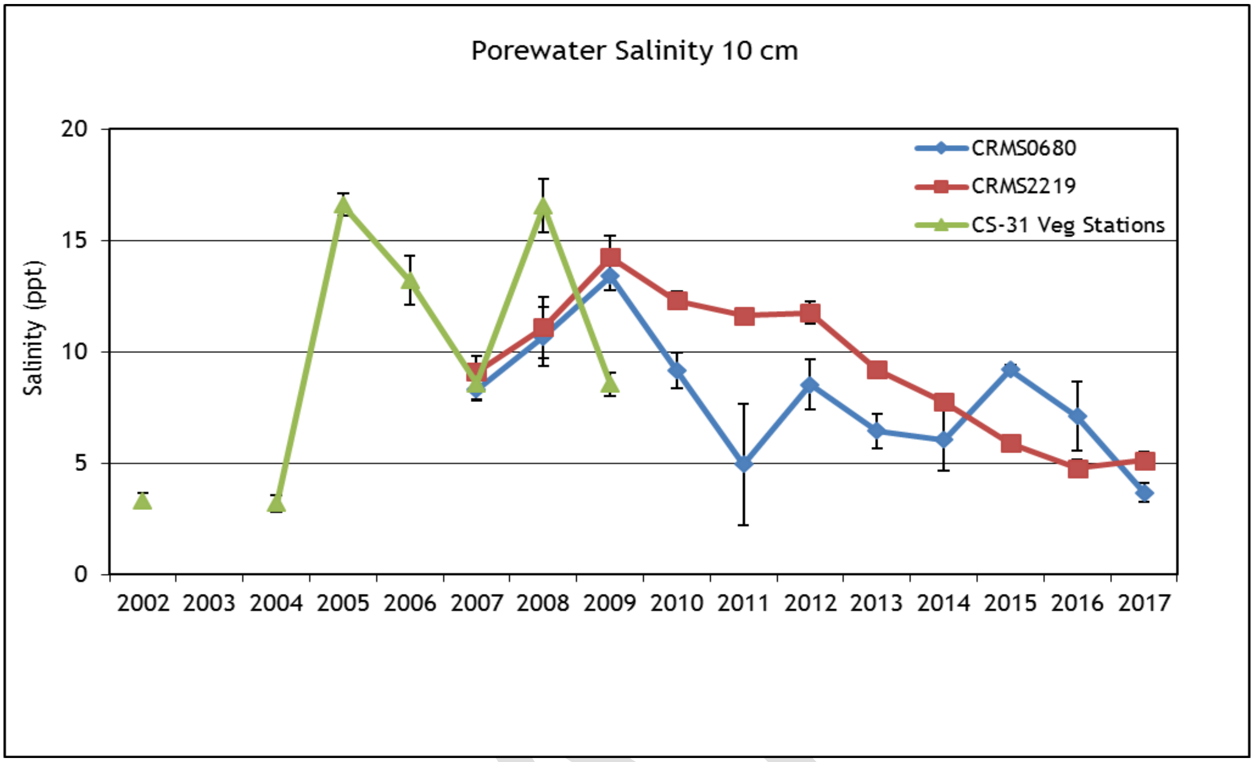


Figure 15a. Annual means for interstitial water salinity at 10 cm below the soil surface for project emergent vegetation stations, CRMS project station 680 and reference station 2219. Error bars, where present, represent the mean of stations for that year ± 1 Std Err.

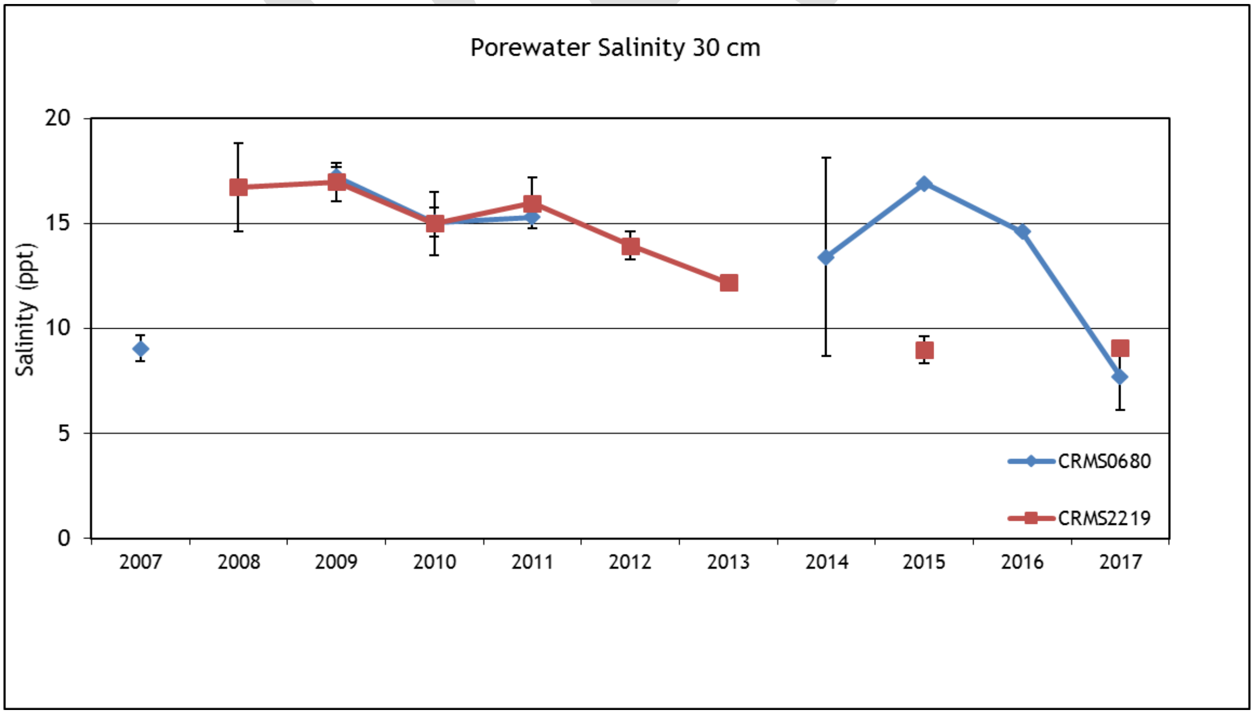


Figure 15b. Annual means for interstitial water salinity at 30 cm below the soil surface for CRMS stations 680 and 2219. Error bars, where present, represent the mean of stations for that year ± 1 Std. Err.

CRMS Supplemental:

Soils:

Soil samples were collected in 2007 at CRMS0680 in the project area and in 2009 at CRMS2219 in the reference area. The soil properties data were sampled in 4 cm increments at CRMS2219. Since the soil at CRMS0680 was too fluid to be sliced, three 16cm cores were analyzed for the site. Figures for mean bulk density and organic matter are presented in Figures 16a and 16b. The project area station had a higher mean bulk density (~0.8 g/cm^3) than the reference area station (<0.6 g/cm^3 throughout the core). Percent organic matter was also very low at the project area station (~10%).

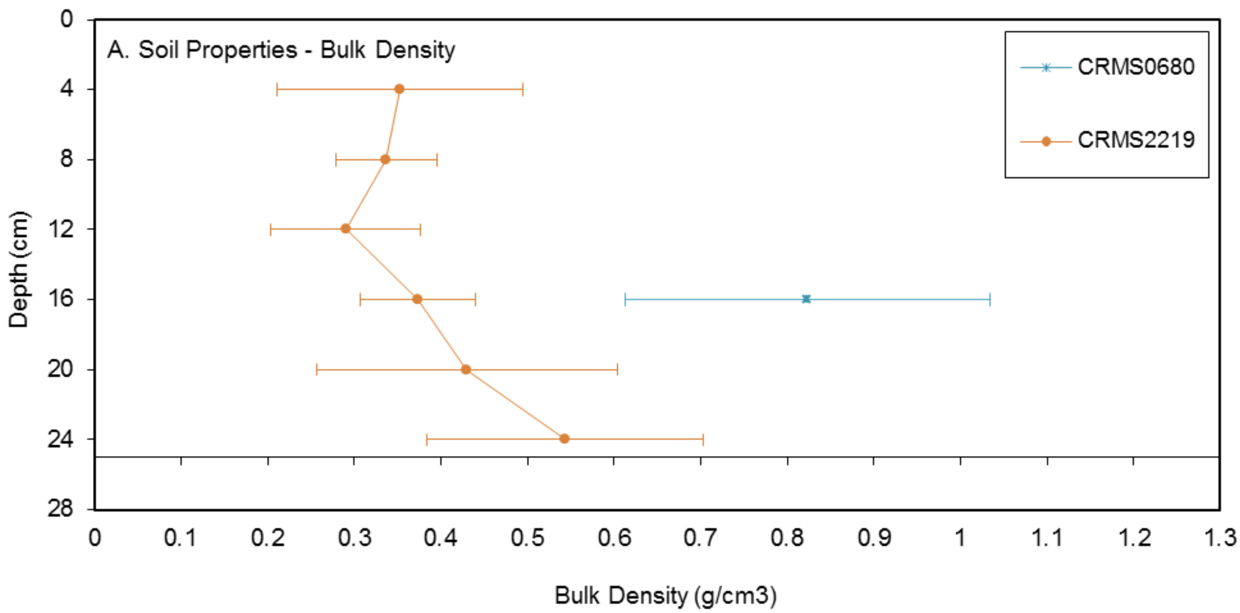


Figure 16a. Mean ± 1 Standard error of soil bulk density collected at CRMS 0680 and CRMS2219.

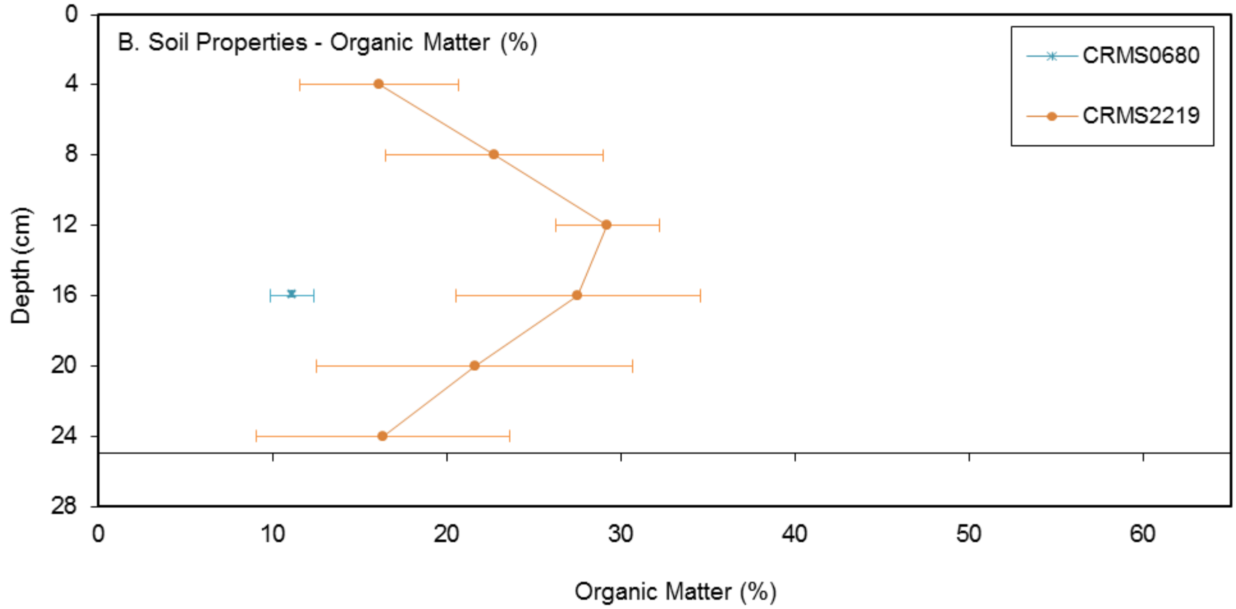


Figure 16b. Mean ± 1 Standard error of soil organic matter content collected at CRMS 0680 and CRMS2219.

<u>Soil Surface Elevation Change:</u>

Project station CRMS0680 (Figure 17a) showed a negative elevation change rate of over -0.32 cm/yr through 2017. The elevation at the site appeared to be increasing prior to 2011. The introduction of cattle to the area as well as a drought in 2011 likely caused compaction and possibly erosion as a result of the grazing activity. The site again appears to be gaining elevation since 2015, though, after several years of average to above average rainfall allowing repair from the drought and grazing. The site had a high SVI score of 77.69 and given the current trend, would not be vulnerable to submergence within 5 years (Figure 17c). Reference site CRMS2219 showed a slightly positive elevation change rate of 0.5 cm/yr (Figure 17b). The reference site did not show the loss in elevation that CRMS0680 had, but also lacks the cattle grazing activity. CRMS2219 also had a very high SVI score of 99.86 (Figure 17d)

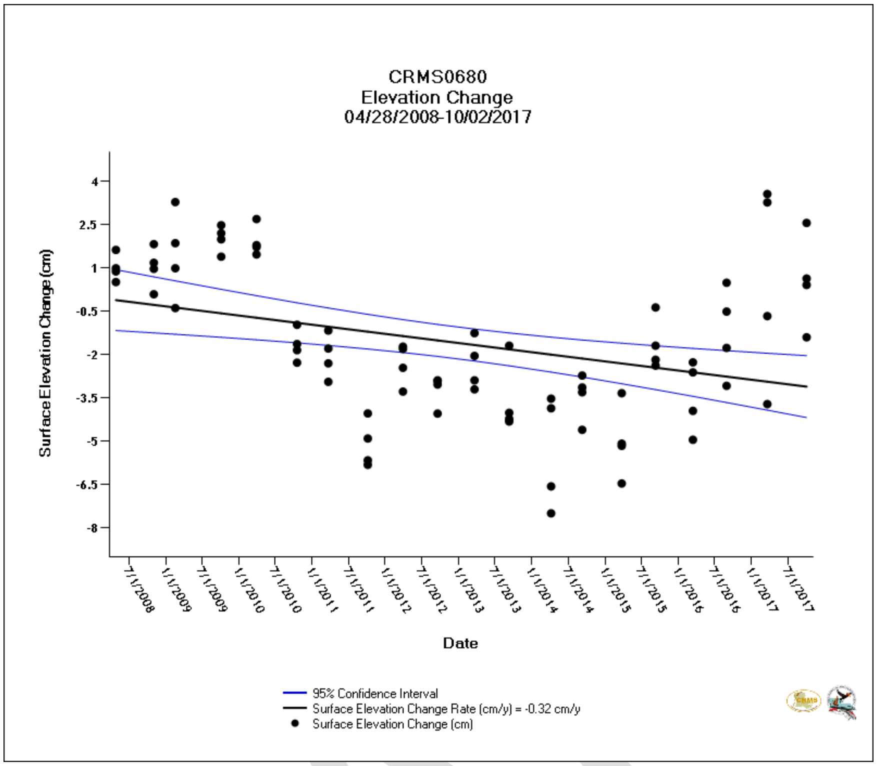


Figure 17a. Accretion and Elevation change for project station CRMS0680 for the period July 2007 to October 2017.

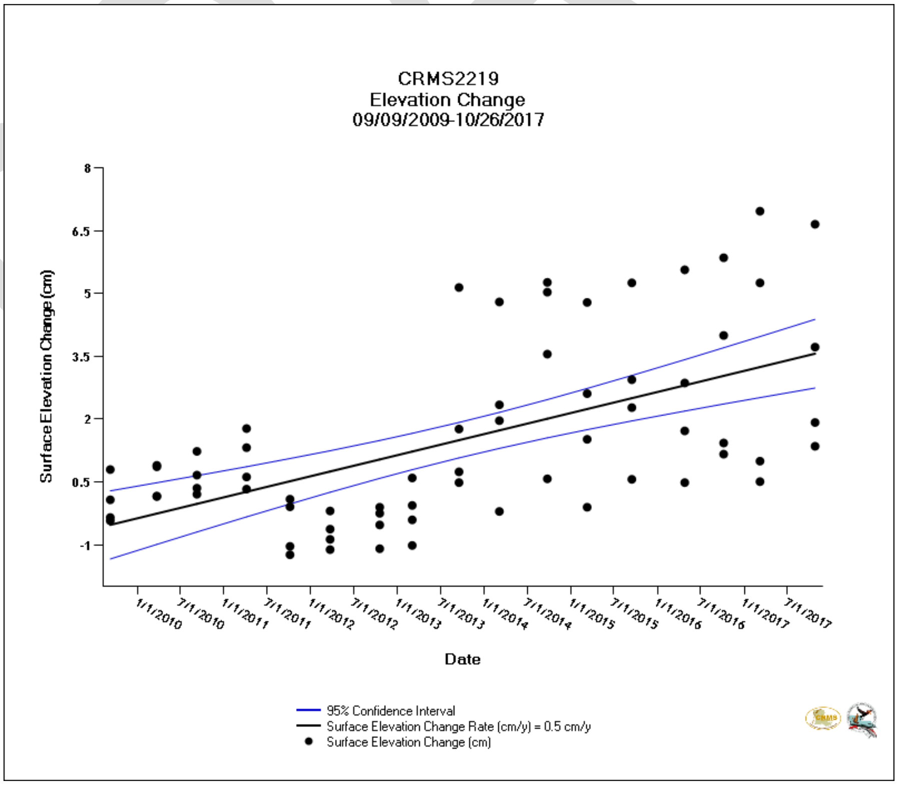


Figure 17b. Accretion and Elevation change for project station CRMS2219 for the period September 2009 to October 2017.

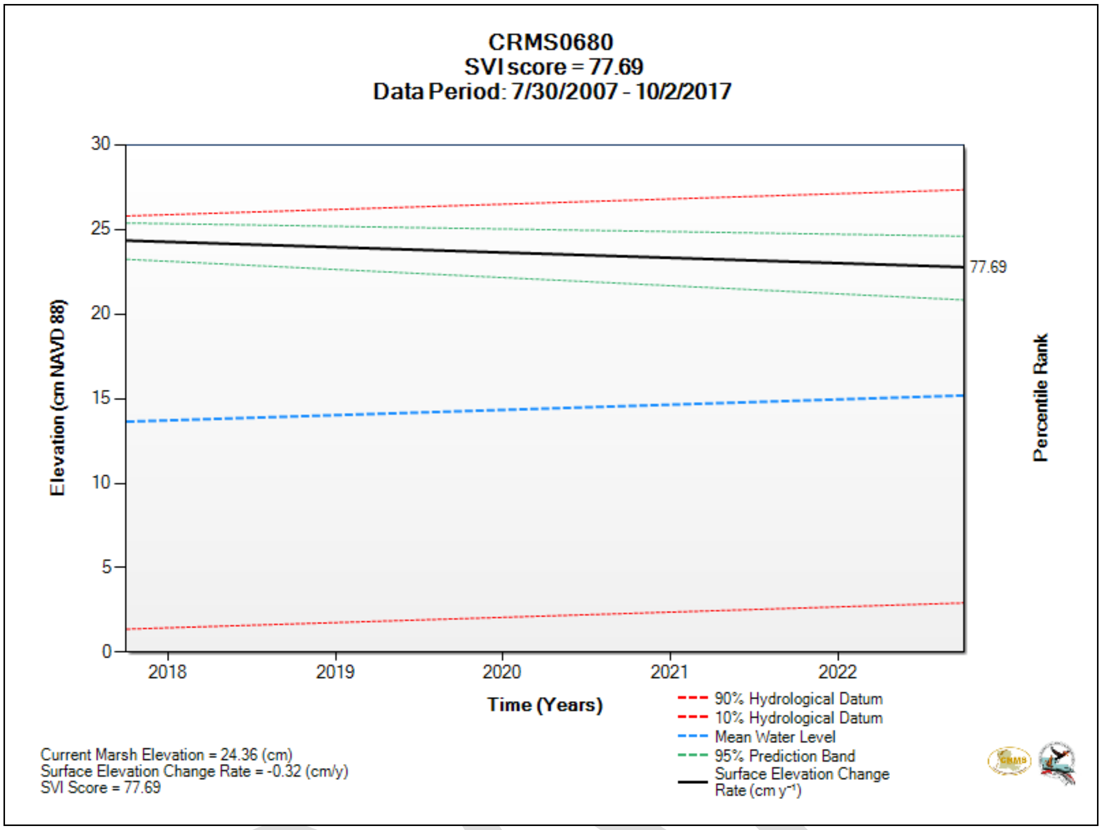


Figure 17c. Submergence Vulnerability Index for CRMS0680.

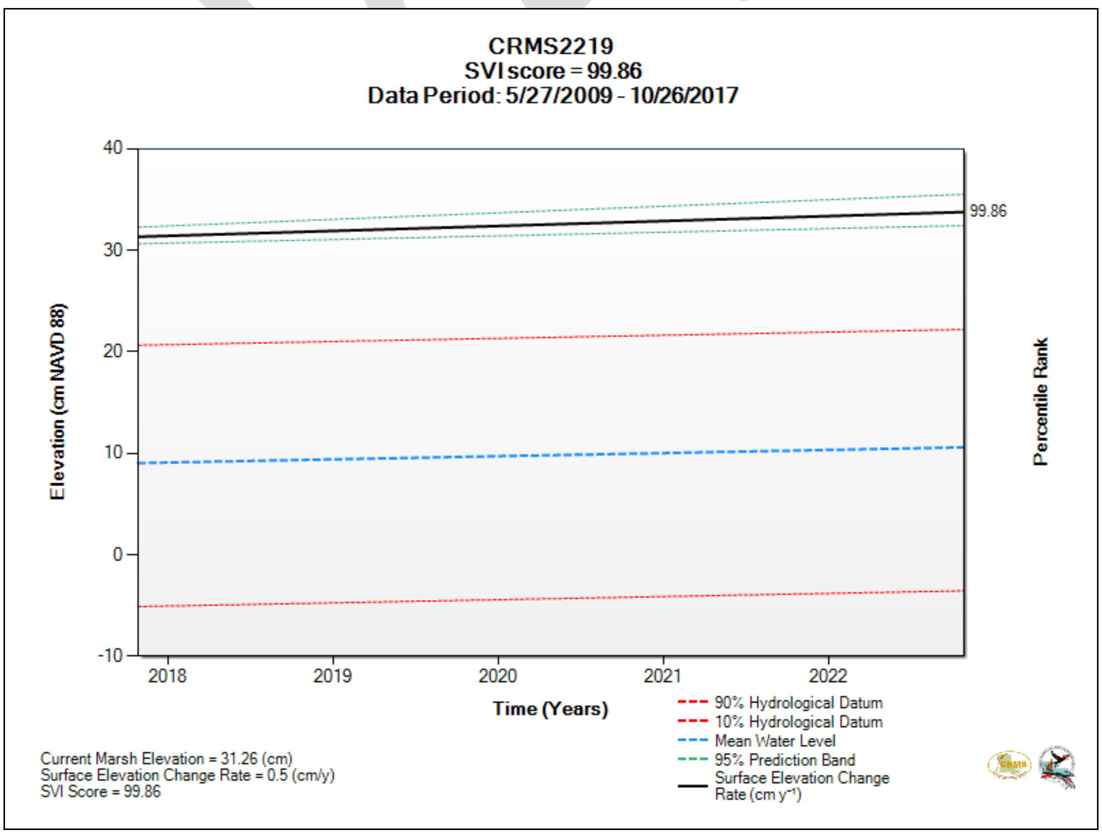


Figure 17d. Submergence Vulnerability Index for CRMS2219.

V. Conclusions

a. Project Effectiveness

Overall, the project has met its objective to protect the wetlands north of the chenier/beach ridge in the project area. The Land:Water analyses have shown that less than 1% of the project area's land was lost since construction, occurring mostly along the shoreline as a result of Hurricanes Rita and Ike. The percent land change analysis shows an increase in percent land through time since construction of the project, even with the land loss from these storms.

Topographic/Bathymetric surveys completed in the project area indicated much higher erosion rates than the rates found by Byrnes et al. (1995) in their study of historical shoreline dynamics along Louisiana's Gulf of Mexico shoreline (-3.9 ft/yr average with a maximum retreat of -8.2 ft/yr). However, the topo/bathy surveys were only done following Hurricanes Rita and Ike. Shoreline surveys completed by CPRA as well as analysis of BICM shoreline data showed retreat rates very near the rates found by Byrnes et al, particularly during non-hurricane periods. Overall, the BICM analysis showed the project area fared better than the reference area, even with the impacts of two major storms. However, there was a substantial loss of the constructed beachhead during these events.

The *Panicum amarum* plantings and fencing were effective in creating dunes but were damaged or destroyed during the hurricanes or when routinely subjected to wave energy. Very little of the plantings or fencing remain.

The project has been effective in maintaining salinities within the intermediate to brackish range. Yearly salinities at project stations were within the target range 95% of the time since construction as opposed to 45% at the reference stations. Interstitial salinities rose to high levels following hurricane Ike but dropped to within the target range at the 10 cm level by 2010 and have remained low since then due to the absence of over wash events.

The marsh vegetation is meeting the goal of maintaining intermediate to brackish vegetation. The project area showed a shift toward more salt tolerant species following the drought of 2011, but has seen the appearance of more intermediate species in recent years of increased rainfall.

The surface elevation change at the project area CRMS site has been negative, due largely to disturbance from cattle and drought. Since 2015, though, the site has seen a gain in elevation due to consistent rainfall.

b. Recommended Improvements

Additional beach nourishment could benefit the shoreline as wind and wave action are scouring sections of the beach and encroaching on LA Highway 82. At this time, there is no economical borrow area for beach fill. All near shore borrow sites have been depleted.

The fence posts left from damaged or destroyed sand fence may need to be removed. The project team will visit the site to assess the current site condition and determine if a maintenance event is necessary for removal of damaged fence and posts.

c. Lessons Learned

Future monitoring efforts on similar projects should focus more on BICM data rather than DGPS surveys for shoreline monitoring. This would allow for a more accurate determination of loss or gain in ft/yr.

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APPENDIX A
(Inspection Photographs)

Photo No. 1, Double section of sand fence on western end of project. The section of fence closest to the water is no longer intact, due to tidal action, while the section further away from the water has successfully created a dune.

Photo No. 2, Double section of sand fence on western end of project. The section of fence closest to the water is no longer intact, due to tidal action, while the section further away from the water has successfully created a dune.

Photo No. 3, Little to no sand fence remains on the eastern end of the project.

Photo No. 4, Little to no sand fence remains on the eastern end of the project.

APPENDIX B
(Three Year Budget Projection)

HOLLY BEACH SAND MANAGEMENT/ CS-31 / PPL 11

Three-Year Operations & Maintenance Budgets 07/01/2017 - 06/30/2020

Project Manager	O & M Manager	Federal Sponsor	Prepared By
Dion Broussard	*Dion Broussard*	*NRCS*	*Dion Broussard*

	2017/2018 (-15)	2018/2019 (-16)	2019/2020 (-17)
Maintenance Inspection	$ 7,269.00	$ 7,487.00	$ 7,712.00
Structure Operation			
State Administration			$ -
Federal Administration			$ -
Maintenance/Rehabilitation			

13/14 Description:

	2017/2018 (-15)
E&D	
Construction	
Construction Oversight	
Sub Total - Maint. And Rehab.	$ -

14/15 Description:

	2018/2019 (-16)
E&D	
Construction	
Construction Oversight	
Sub Total - Maint. And Rehab.	$ -

15/16 Description:

	2019/2020 (-17)
E&D	$ -
Construction	$ -
Construction Oversight	$ -
Sub Total - Maint. And Rehab.	$ -

	2017/2018 (-15)	2018/2019 (-16)	2019/2020 (-17)
Total O&M Budgets	**$ 7,269.00**	**$ 7,487.00**	**$ 7,712.00**

O &M Budget (3 yr Total)	**$ 22,468.00**
Unexpended O & M Budget	**$ 98,453.00**
Remaining O & M Budget (Projected)	**$ 75,985.00**

OPERATION AND MAINTENANCE BUDGET WORKSHEET

HOLLY BEACH SAND MANAGEMENT / PROJECT NO. CS-31 / PPL NO. 11 / 2017/2018 (-15)

DESCRIPTION	UNIT	EST. QTY.	UNIT PRICE	ESTIMATED TOTAL
O&M Inspection and Report	EACH	1	$7,269.00	**$7,269.00**
General Structure Maintenance	LUMP	0	$0.00	**$0.00**
Engineering and Design	LUMP	0	$0.00	**$0.00**
Operations Contract	LUMP	0	$0.00	**$0.00**
Construction Oversight	LUMP	0	$0.00	**$0.00**

ADMINISTRATION

LDNR / CRD Admin.	LUMP	0	$0.00	$0.00
FEDERAL SPONSOR Admin.	LUMP	0	$0.00	$0.00
SURVEY Admin.	LUMP	0	$0.00	$0.00
OTHER				$0.00
			TOTAL ADMINISTRATION COSTS:	**$0.00**

MAINTENANCE / CONSTRUCTION

SURVEY

SURVEY DESCRIPTION:

Secondary Monument	EACH	0	$0.00	$0.00
Staff Gauge / Recorders	EACH	0	$0.00	$0.00
Marsh Elevation / Topography	LUMP	0	$0.00	$0.00
TBM Installation	EACH	0	$0.00	$0.00
OTHER				$0.00
			TOTAL SURVEY COSTS:	**$0.00**

GEOTECHNICAL

GEOTECH DESCRIPTION:

Borings	EACH	0	$0.00	$0.00
OTHER				$0.00
			TOTAL GEOTECHNICAL COSTS:	**$0.00**

CONSTRUCTION

CONSTRUCTION DESCRIPTION:

Rip Rap	LIN FT	TON / FT	TONS	UNIT PRICE	
	0	0.0	0	$0.00	$0.00
	0	0.0	0	$0.00	$0.00
	0	0.0	0	$0.00	$0.00
Filter Cloth / Geogrid Fabric		SQ YD	0	$12.00	$0.00
Navigation Aid		EACH	0	$0.00	$0.00
Signage		EACH	0	$0.00	$0.00
General Excavation / Fill		CU YD	0	$0.00	$0.00
Dredging		CU YD	0	$0.00	$0.00
Sheet Piles (Lin Ft or Sq Yds)			0	$0.00	$0.00
Timber Piles (each or lump sum)			0	$0.00	$0.00
Timber Members (each or lump sum)			0	$0.00	$0.00
Hardware		LUMP	0	$0.00	$0.00
Materials		LUMP	0	$0.00	$0.00
Mob / Demob		LUMP	0	$0.00	$0.00
Contingency		LUMP	0	$0.00	$0.00
General Structure Maintenance		LUMP	0	$0.00	$0.00
OTHER				$0.00	$0.00
OTHER				$0.00	$0.00
OTHER				$0.00	$0.00
				TOTAL CONSTRUCTION COSTS:	**$0.00**

TOTAL OPERATIONS AND MAINTENANCE BUDGET: **$7,269.00**

OPERATION AND MAINTENANCE BUDGET WORKSHEET

HOLLY BEACH SAND MANAGEMENT / PROJECT NO. CS-31 / PPL NO. 11 / 2018/2019 (-16)

DESCRIPTION	UNIT	EST. QTY.	UNIT PRICE	ESTIMATED TOTAL
O&M Inspection and Report	EACH	1	$7,487.00	**$7,487.00**
General Structure Maintenance	LUMP	0	$0.00	**$0.00**
Engineering and Design	LUMP	0	$0.00	**$0.00**
Operations Contract	LUMP	0	$0.00	**$0.00**
Construction Oversight	LUMP	0	$0.00	**$0.00**

ADMINISTRATION

LDNR / CRD Admin.	LUMP	0	$0.00	$0.00
FEDERAL SPONSOR Admin.	LUMP	0	$0.00	$0.00
SURVEY Admin.	LUMP	0	$0.00	$0.00
OTHER				$0.00
			TOTAL ADMINISTRATION COSTS:	**$0.00**

MAINTENANCE / CONSTRUCTION

SURVEY

SURVEY DESCRIPTION:

Secondary Monument	EACH	0	$0.00	$0.00
Staff Gauge / Recorders	EACH	0	$0.00	$0.00
Marsh Elevation / Topography	LUMP	0	$0.00	$0.00
TBM Installation	EACH	0	$0.00	$0.00
OTHER				$0.00
			TOTAL SURVEY COSTS:	**$0.00**

GEOTECHNICAL

GEOTECH DESCRIPTION:

Borings	EACH	0	$0.00	$0.00
OTHER				$0.00
			TOTAL GEOTECHNICAL COSTS:	**$0.00**

CONSTRUCTION

CONSTRUCTION DESCRIPTION:

Rip Rap	LIN FT	TON / FT	TONS	UNIT PRICE	
	0	0.0	0	$0.00	$0.00
	0	0.0	0	$0.00	$0.00
	0	0.0	0	$0.00	$0.00
Filter Cloth / Geogrid Fabric		SQ YD	0	$12.00	$0.00
Navigation Aid		EACH	0	$0.00	$0.00
Signage		EACH	0	$0.00	$0.00
General Excavation / Fill		CU YD	0	$0.00	$0.00
Dredging		CU YD	0	$0.00	$0.00
Sheet Piles (Lin Ft or Sq Yds)			0	$0.00	$0.00
Timber Piles (each or lump sum)			0	$0.00	$0.00
Timber Members (each or lump sum)			0	$0.00	$0.00
Hardware		LUMP	0	$0.00	$0.00
Materials		LUMP	0	$0.00	$0.00
Mob / Demob		LUMP	0	$0.00	$0.00
Contingency		LUMP	0	$0.00	$0.00
General Structure Maintenance		LUMP	0	$0.00	$0.00
OTHER				$0.00	$0.00
OTHER				$0.00	$0.00
OTHER				$0.00	$0.00
				TOTAL CONSTRUCTION COSTS:	**$0.00**

TOTAL OPERATIONS AND MAINTENANCE BUDGET: **$7,487.00**

OPERATION AND MAINTENANCE BUDGET WORKSHEET

HOLLY BEACH SAND MANAGEMENT / PROJECT NO. CS-31 / PPL NO. 11 / 2019/2020 (-17)

DESCRIPTION	UNIT	EST. QTY.	UNIT PRICE	ESTIMATED TOTAL
O&M Inspection and Report	EACH	1	$7,712.00	**$7,712.00**
General Structure Maintenance	LUMP	0	$0.00	**$0.00**
Engineering and Design	LUMP	0	$0.00	**$0.00**
Operations Contract	LUMP	0	$0.00	**$0.00**
Construction Oversight	LUMP	0	$0.00	**$0.00**

ADMINISTRATION

LDNR / CRD Admin.	LUMP	0	$0.00	$0.00
FEDERAL SPONSOR Admin.	LUMP	0	$0.00	$0.00
SURVEY Admin.	LUMP	0	$0.00	$0.00
OTHER				$0.00
			TOTAL ADMINISTRATION COSTS:	**$0.00**

MAINTENANCE / CONSTRUCTION

SURVEY

SURVEY DESCRIPTION:					
	Secondary Monument	EACH	0	$0.00	$0.00
	Staff Gauge / Recorders	EACH	0	$0.00	$0.00
	Marsh Elevation / Topography	LUMP	0	$0.00	$0.00
	TBM Installation	EACH	0	$0.00	$0.00
	OTHER				$0.00
				TOTAL SURVEY COSTS:	**$0.00**

GEOTECHNICAL

GEOTECH DESCRIPTION:					
	Borings	EACH	0	$0.00	$0.00
	OTHER				$0.00
				TOTAL GEOTECHNICAL COSTS:	**$0.00**

CONSTRUCTION

CONSTRUCTION DESCRIPTION:						
	Rip Rap	LIN FT	TON / FT	TONS	UNIT PRICE	
		0	0.0	0	$0.00	$0.00
		0	0.0	0	$0.00	$0.00
		0	0.0	0	$0.00	$0.00
	Filter Cloth / Geogrid Fabric		SQ YD	0	$12.00	$0.00
	Navigation Aid		EACH	0	$0.00	$0.00
	Signage		EACH	0	$0.00	$0.00
	General Excavation / Fill		CU YD	0	$0.00	$0.00
	Dredging		CU YD	0	$0.00	$0.00
	Sheet Piles (Lin Ft or Sq Yds)			0	$0.00	$0.00
	Timber Piles (each or lump sum)			0	$0.00	$0.00
	Timber Members (each or lump sum)			0	$0.00	$0.00
	Hardware		LUMP	0	$0.00	$0.00
	Materials		LUMP	0	$0.00	$0.00
	Mob / Demob		LUMP	0	$0.00	$0.00
	Contingency		LUMP	0	$0.00	$0.00
	General Structure Maintenance		LUMP	0	$0.00	$0.00
	OTHER				$0.00	$0.00
	OTHER				$0.00	$0.00
	OTHER				$0.00	$0.00
					TOTAL CONSTRUCTION COSTS:	**$0.00**

TOTAL OPERATIONS AND MAINTENANCE BUDGET: **$7,712.00**

APPENDIX C
(Field Inspection Notes)

MAINTENANCE INSPECTION REPORT CHECK SHEET

Project No. / Name: CS-31 Holly Beach

Date of Inspection: November 01, 2016 Time: 12:00 pm

Structure No.

Inspector(s): Dion Broussard
Brandon Samson (NRCS)
Daryl Clark (USFWS) for other inspections

Structure Description: Sand fencing and beach fill.

Type of Inspection: Annual

Weather Conditions: sunny & mild temp

Item	Condition	Physical Damage	Corrosion	Photo #	Observations and Remarks
Steel Bulkhead / Caps	N/A				
Steel Grating	N/A				
Stop Logs	N/A				
Hardware	N/A				
Timber Piles	N/A				
Timber Wales	N/A				
Vegetation	Poor			1-4	Most plants were lost to high water. In places of higher elevation, the plants are flourishing.
Sand Fencing	Poor			1-4	Most sections of fence damaged due to high water.
Signage /Supports	N/A				
Sand (fill)	Poor			1-4	Beach fill has receded significantly over time.
Earthen Embankment	N/A				

What are the conditions of the existing levees?
Are there any noticeable breaches?
Settlement of rock plugs and rock weirs?
Position of stoplogs at the time of the inspection?
Are there any signs of vandalism?