State of Louisiana
Coastal Protection and Restoration Authority of Louisiana

2024 Operations, Maintenance, and Monitoring Report

for

West Lake Boudreaux Shoreline Protection and Marsh Creation (TE-0046)

State Project Number TE-0046
Priority Project List 11

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Terrebonne Parish

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2024 Operations, Maintenance and Monitoring Report
For
TE-0046 West Lake Boudreaux Shoreline Protection and Marsh Creation (TE-0046)

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Preface

This report includes monitoring data collected through December 2021, and the most recent annual Maintenance Inspection completed in March 2023. The West Lake Boudreaux Shoreline Protection and Marsh Creation project (TE-0046) is sponsored by the United States Department of Interior/Fish and Wildlife Service (FWS) under the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA, Public Law 101-646, Title III, Priority List 11).

The 2024 report is the second report in a series of reports since the end of construction on this project in October 2009. This Operations, Maintenance, and Monitoring Report as well as future reports in this series will be posted on the Coastal Protection and Restoration Authority (CPRA) website at *http://coastal.louisiana.gov/*.

I. Introduction

The West Lake Boudreaux Shoreline Protection and Marsh Creation (TE-0046) project area is located in the Terrebonne Basin on the western rim of Lake Boudreaux in Terrebonne Parish, LA (Figure 1). It encompasses 1,220 acres (494 ha), most of which is open water with only 80 acres (32 ha) of intermediate marsh prior to construction of the project. It is bounded on the east by Lake Boudreaux, on the north by a private canal adjacent to Bayou Butler, on the west by Bayou Grand Caillou, and on the south by an unnamed drainage canal.

The project area is on the Teche Ridge, a feature of the Terrebonne delta plain which is a result of landforms produced by the Teche-Mississippi delta cycle 4500 to 3500 years ago (Gagliano and Wicker 2002). Lake Boudreaux was created as a result of fault events between the early to middle 1800's when the area's fresh marshes and swamps reached maximum development and the marsh was continuous and unbroken. A severe flood in 1903 prompted the construction of a dam across the head of Bayou Lafourche at Donaldsonville (completed in 1904), effectively cutting off all sediment flow from the Mississippi River. Since the turn of the 20th century a combination of natural and anthropogenic alterations within the Terrebonne delta plain has contributed to its deterioration (Gagliano and Wicker 2002).

The western shoreline of Lake Boudreaux has experienced erosion and high marsh loss rates due to factors such as exposure to wind-generated wave energy, subsidence, turbidity detrimental to submerged aquatic vegetation (SAV) populations, and saltwater intrusion (USFWS 2005a). The United States Geological Survey (USGS) has estimated that between 1983 and 1990 interior marsh loss rates in the Lake Boudreaux area were approximately 3.68 % (USGS 2001). An analysis of shoreline erosion rates by the USGS using 2001 through 2004 aerial photography indicated shoreline erosion rates ranged from 10 ft per year (3 m per year) along the southwest

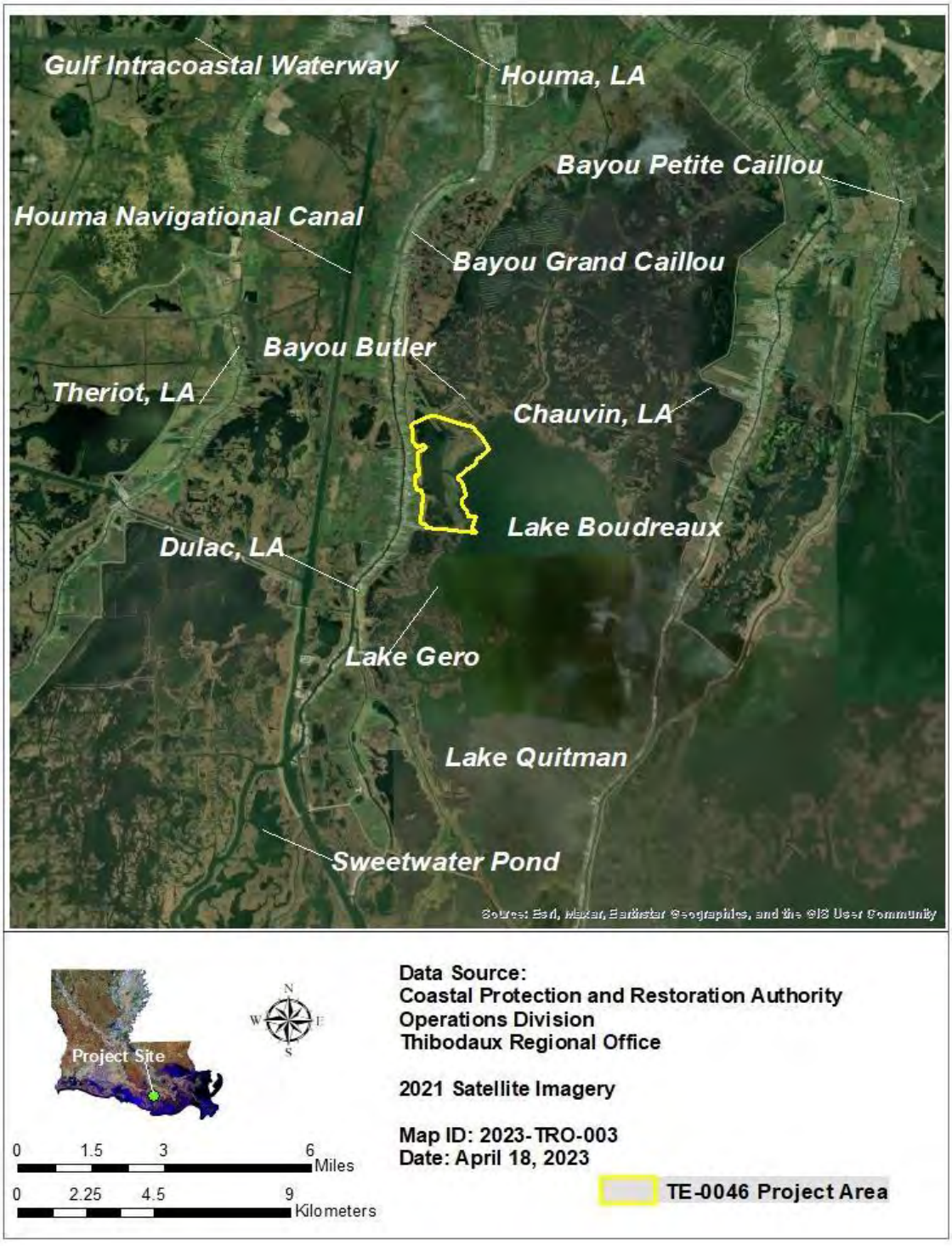

Figure 1. Location map of the West Lake Boudreaux Shoreline Protection and Marsh Creation (TE-0046) project.

shoreline to 91 ft per year (27.7 m per year) along the northwest shoreline, with a total weighted average shoreline erosion rate of 42 ft per year (12.8 m per year) (USFWS 2005b). Additionally, based upon a 2004 survey by Professional Engineering and Surveying Company, Inc. (PENSCO) as much as 600 ft (182.88 m) of shoreline erosion had occurred since the baseline aerial photo utilized for the project plan was taken on February 4, 1998 (Hill and Brass 2005). Concerns are that the erosion will convert the productive shallow, open water areas behind the eroding shoreline to a less productive open lake habitat and the interior marsh and adjacent infrastructure will be compromised.

The purpose of the project is to reduce shoreline erosion and to create additional marsh along the southwest shoreline of Lake Boudreaux while protecting shallow aquatic grass beds adjacent to the shoreline.

Constructed features have a twenty-year (20-yr) project life that began when construction was completed in October 2009.

Project features include (CPRA 2012):

- Construction of three segments of foreshore rock dike totaling 12,447 linear ft. (3,794 m) along the western shoreline of Lake Boudreaux (Figure 2) - Northern Segment is 5,350 linear ft. (1,630.6 m), Central Segment is 2,140 linear ft. (652.2 m), and Southern Segment is 4,957 linear ft. (1,510.8 m). The dikes were constructed using rock riprap (ASTM D 6092-97 Riprap R-300) to an elevation of +3.5 feet NAVD88 on top of a geotextile fabric base. The rock dikes had a vertical tolerance of +0.5 feet and a 3-foot crest width with 2.5 to 1 side slopes for the northern segment and 2 to 1 side slopes for the central and southern segment. Galvanized steel settlement plates were installed within the rock dike segments at various locations. Construction of 24,553 linear ft. (7,483.7 m) of earthen containment dike with 10 tidal openings. 10,160 feet (3,097 m) of the earthen containment dikes were degraded in May 2012. (Figure 2).

- Construction of an earthen plug located in the northwest corner of an oil and gas access channel off of Lake Boudreaux at the north end of the project area (Figure 2). It was constructed using dredged material from the oil and gas access channel. The plug was constructed to an elevation of +4.0 feet NAVD88 with an 8-foot top width and 3 to 1 side slopes. The plug is approximately 75 linear ft. (22.8 m).

Figure 2. Map indicating the locations and types of constructed features inside the boundary of the West Lake Boudreaux Shoreline Protection and Marsh Creation (TE-0046) project.

- Construction of a choke down section located between the southernmost extent of the northern rock dike segment and the northernmost extent of the central rock dike segment (Figure 2). It consists of a 2-foot thick layer of rock riprap (ASTM D 6092-97 Riprap R-300) constructed across the opening in the shoreline between the northern and central marsh creation areas. The choke down section is approximately 150 linear ft. (45.7 m) (direction along the shoreline) by approximately 75 ft. (22.8 m) wide and was constructed to reduce scour in that area.

II. Maintenance Activity

a. Project Feature Inspection Procedures

The purpose of the annual inspection of the West Lake Boudreaux Shoreline Protection and Marsh Creation (TE-0046) project is to evaluate the constructed project features in order to identify any deficiencies. The inspection results are used to prepare a report detailing the condition of the project features and recommending any corrective actions considered necessary (CPRA 2012). Should it be determined that corrective actions are needed, the CPRA shall provide, in the report, a detailed cost estimate for engineering, design, supervision, inspection, construction, and contingencies, as well as an assessment of the urgency, of such repairs. The annual inspection report also contains a summary of maintenance projects 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 C. A summary of past operation and maintenance projects completed since construction of the West Lake Boudreaux (TE-0046) project is outlined in part d of this section.

The annual inspection of West Lake Boudreaux (TE-0046) project took place March 28, 2023. In attendance were Brian Babin, Brandon Carreras, and Elaine Lear with CPRA, and Robert Dubois with the U.S. Fish and Wildlife Services. The attendees met at the public boat launch in Houma behind the Terrebonne Parish Jail, and traveled to the project area by boat. The inspection began around 09:00 am at the most northern marsh creation area and rock dike, and concluded around 10:15 a.m. at the most southern marsh creation area and rock dike. The trip included a visual inspection of the project features, structures and outer edges of the marsh creation areas. Photographs of the inspection are located in Appendix B.

b. Inspection Results

<u>North Segment – Rock Dike</u>

The northern segment of the rock dike appeared to be in fair to good condition with some isolated areas showing signs of settlement. Considering the hurricanes and tropical events of the past several years, the rock structure is showing no signs of rock displacement or distortion

of the designed rock section. The very northern end of the rock dike structure has moderate shadowing as reported on previous inspections. The shadowing effect or erosion of marsh where the rock structure abruptly ends is common and will require monitoring on future inspections. The marsh behind the northern segment was very healthy and well vegetated. To evaluate the full length of the rock dike and identify low areas a survey was performed in June 2023. (See Appendix B, Photos 1 through 8)

Central Segment – Rock Dike

The central segment of the rock dike appeared to be in good condition with not as much visual settlement as the northern segment. There are no obvious signs of rock displacement or shifting of the rock section along length of the central segment. At the pipeline channel between the central and southern segments, there is a warning marker with a missing sign. It is recommended that the sign and metal sheet pile cap on the piling of this marker be replaced during next maintenance event. As a result of this inspection we recommended that a survey profile be conducted to determine if any corrective actions were needed. The survey was performed in June 2023. (See Appendix B, Photos 9 and 10)

Southern Segment – Rock Dike

The southern segment of the rock dike from the choke down section to the southern termination point appear to be in fair to good condition with possible settlement in isolated areas. The rock section was in good condition with no noticeable rock displacement or change in the section. We did notice that the sign on the warning marker at the keyway location was missing. It was also evident that the marsh erosion at the very southern end of the structure has increased since the previous inspection. Approximately 275 feet of the structure was protruding into the lake compared to the estimated 150 feet documented in 2016. As a result of this inspection we recommended that a survey profile be conducted to determine if any corrective actions were needed. The survey was performed in June 2023. (See Appendix B, Photo 11 through 26)

c. Maintenance Recommendations

All segments (northern, central and southern) of the rock dike along the West Lake Boudreaux Shoreline Protection and Marsh Creation (TE-46) project appear to be in fair to good condition with visual settlement in isolated areas of the northern and southern segments. The rock dike consolidation and shape appear to be consistent along all segments with no noticeable rock displacement or distortion of the rock section. Overall, the rock dike structure has held up well since construction considering the number of tropical events that has occurred since construction of the project. The marsh, in the marsh creation area, behind the structure was plentiful and healthy with no measurable erosion other than the area at the termination point of the southern segment. Although we are not recommending any maintenance to the rock dike at this time, we will continue to monitor

the condition of the rock dike and other project features for the remainder of the 20 year life of the project which ends in November of 2029. We are also recommending that signs and warning markers that are missing or damaged be refurbished and/or replaced prior to project close-out.

d. Maintenance History

To date, there have been no maintenance events or project features that required routine maintenance or operations. This section will be used to reference all maintenance activities on future inspection reports.

III. Operation Activity

As of now there are no project features that require routine operation.

IV. Monitoring Activity

Pursuant to a CWPPRA Task Force decision on August 14, 2003 to adopt the Coastwide Reference Monitoring System-*Wetlands* (CRMS) for CWPPRA, the TE-0046 Monitoring Plan has been merged with CRMS to provide more useful information for modeling efforts and future project planning while maintaining the monitoring mandates of the Breaux Act. There are no CRMS stations located inside the TE-0046 project area.

Two CRMS sites, CRMS0390 and CRMS0392, are located approximately 2 miles north of the project boundary (Figure 3), and will be used as references for purposes of data analysis. Site CRMS0390 was established in June 2006 and site CRMS0392 was established in July 2007. Both sites are classified as oligohaline wiregrass marsh communities (Sasser and Visser 2008; CPRA 2023). The marsh classification at CRMS0390 and CRMS0392 has shifted from intermediate to brackish since construction of the TE-0046 project in 2009. Mean salinity at sites CRMS0390 and CRMS0392 is approximately 7.0 ppt. CRMS0390 and CRMS0392 are experiencing land loss rates of -2.38% and -1.63% per year respectively (CPRA 2023). Data collected from both sites will be used to document monitoring variables such as land-water classification, annual vegetation, and continuous water level and salinity.

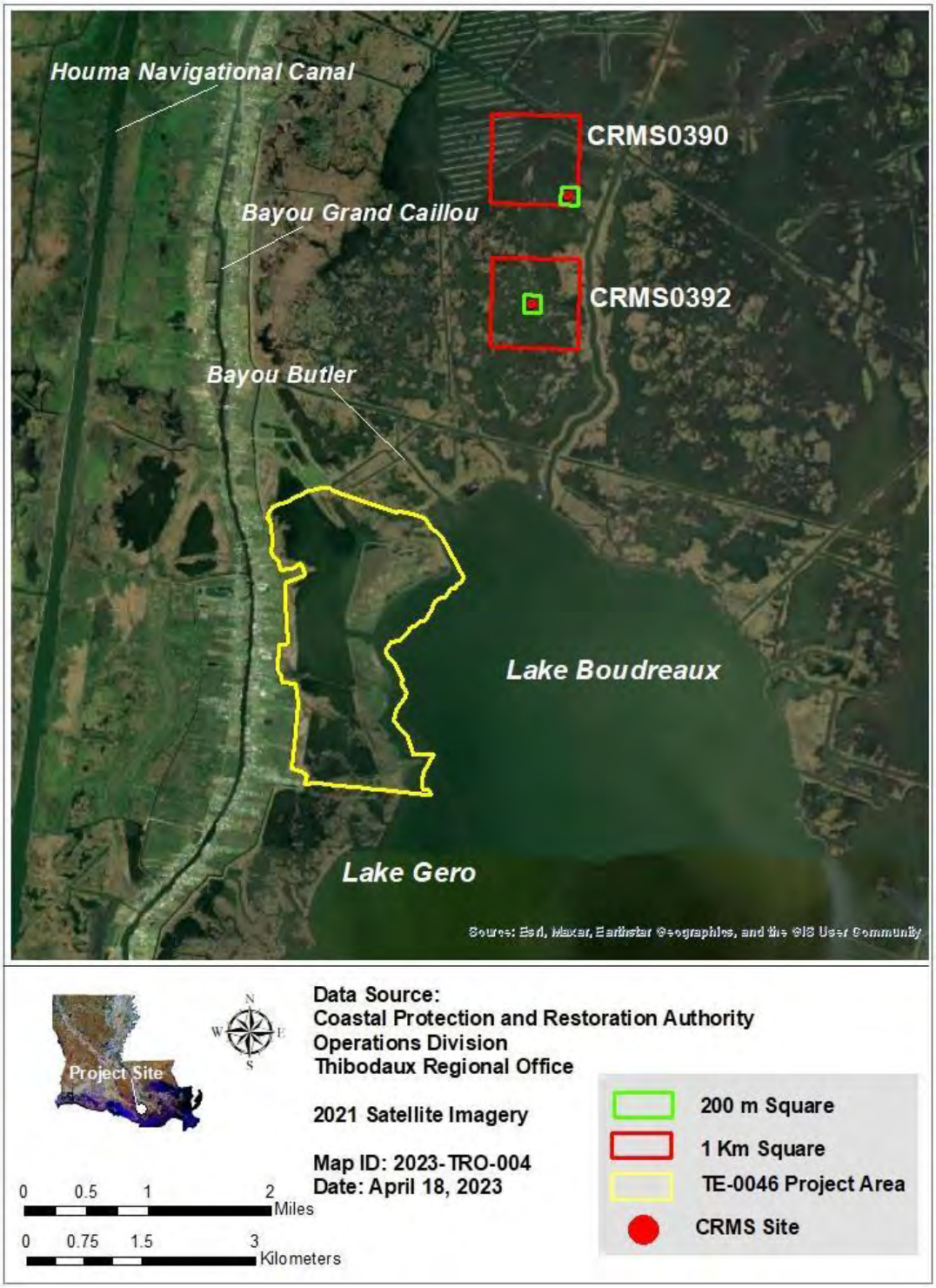

Figure 3. Location map for CRMS sites just north of the West Lake Boudreaux Shoreline Protection and Marsh Creation (TE-0046) project.

a. Monitoring Goals

The project's objective is to reduce erosion of the west Lake Boudreaux shoreline, which in turn will protect interior low salinity marshes and aquatic grass beds from the high wave energy and turbidity found in Lake Boudreaux; it will create emergent marsh along the southwestern shoreline of Lake Boudreaux and at interior marsh sites through the deposition of material dredged from the Lake bottom.

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

1. Stop shoreline erosion along approximately 12,447 linear ft. (3,794 m) of the western shoreline of Lake Boudreaux over the 20-year project life.

2. Initially create 220 acres (89 ha) of marsh by the completion of project construction with intertidal marsh developing after year 3 of the project's life.

3. Reduce erosion rates by 50%, from 3.68% per year to 1.84% per year, in the created and nourished marsh over the 20-year project life.

4. Reduce erosion rates by 25%, from 3.68% per year to 2.76% per year, in the non-directly affected marsh over the 20-year project life.

b. Monitoring Elements

Aerial Photography:

Near-vertical color-infrared aerial photography (1:20,000 scale) was used to measure land to open water ratios and land change rates for the project area as well as the marsh creation areas inside the project boundary. The CRMS coastwide flight photography was obtained three years post-construction in 2012, and twelve years post-construction in 2021. Aerial photography will be captured again for year eighteen (2027). The 2021 aerial photography was checked for flight accuracy, color correctness, and clarity, and was scanned, mosaicked, and geo-rectified by United States Geological Survey/Wetland and Aquatic Research Center (USGS/WARC) personnel according to standard operating procedures (Langlois 2021).

Historic data was assessed utilizing the CRMS spatial viewer for land-water quantification in the project area as well as in reference CRMS sites. The years analyzed were 1956, 1978, 1988, 2004, 2006, 2008, 2009, 2013, and 2016 (Barras et al. 2008; CPRA 2023). The large spatial scale of the data did not lend itself to the calculation of exact acreages however, the land-water changes were assessed in terms of trends.

Shoreline position data were analyzed to estimate shoreline changes inside the TE-0046 project area using the Digital Shoreline Analysis System (DSAS version 5.1) extension of ArcView® GIS (Himmelstoss et al. 2018). Pre-construction and post-construction change rates were calculated for shorelines behind the foreshore rock shoreline protection structure. Shoreline positions were determined by digitizing aerial photographs at a 1:800 scale as per the Steyer et al. (1995) method, which defines shoreline position as the edge of the live emergent vegetation. The resulting polylines established the shoreline positions in UTM NAD 83 coordinates. Pre-construction and post-construction aerial photographs were acquired over a twenty-two year period to discern the foreshore rock shoreline protection structure's effect on shoreline erosion rates.

Pre-construction aerial photographs were collected on February 4, 1998, January 25, 2004, and November 1, 2005 while post-construction aerial photographs were captured on October 30, 2008, October 28, 2012, November 16, 2018, and November 30, 2021. All images were georectified using UTM NAD 83 horizontal datum. The map scale for all aerial photographs was 1:16,000.

The February 1998, January 2004, and November 2005 shorelines were examined in ArcView® GIS software to establish pre-construction shoreline change rates, and the October 2008 (as-built), October 2012, November 2018, and November 2021 shorelines were examined to establish post-construction shoreline change rates. An offshore baseline was established for the project area and the DSAS attribute editor was populated by identifying shorelines and the baseline and dating shorelines. Next, 3000 m (9,842 ft.) simple transects were cast from the baseline at 50 m (164 ft.) intervals producing shoreline change, intersect, and transect shapefiles. These shapefiles were edited by eliminating transects that intersect the shorelines at irregular angles. Shoreline change data were then imported into Excel® to calculate average and annual erosion rates for each period. Shoreline change rates were assessed and graphed for the ensuing periods February 1998-January 2004, February 1998-November 2005, January 2004-November 2005, October 2008-October 2012, October 2012-November 2018, and November 2018-November 2021 for the area behind the 3,794 m (12,447 ft.) TE-0046 foreshore rock shoreline protection structure.

Emergent Vegetation:

Species composition and relative abundance were evaluated inside the project marsh creation areas using a modification of the Braun-Blanquet method (Mueller-Dombois and Ellenberg 1974). The stations originally consisted of 42 randomly selected replicate 2m × 2m plots located along 14 east-west transects divided amongst the three marsh creation areas. Sampling occurred in year 3 (2012), and year 12 (2021), and will again be collected in year 18 (2027). Species composition and relative abundance were also evaluated at CRMS sites (CRMS0390 and CRMS0392) pictured in figure 2. These two sites will serve as reference sites in the analysis

of vegetation data. The 1 km^2 CRMS sites contained a 200 m^2 data collection area, which in turn had ten (10) randomly placed replicate 2m x 2m stations located along a single transect. Vegetation species composition and relative abundance were evaluated annually from 2006 through 2021 using the modified Braun-Blanquet methodology.

Floristic Quality Index (FQI) was determined for the project. The FQI is used to quantitatively determine the condition of a particular habitat using the plant species composition (Cretini et al. 2009). It has been regionally modified for coastal Louisiana by a panel of local plant experts in order to determine changes in wetland conditions based upon the presence of non-native, invasive and disturbance-prone species across community types. The coefficient of conservatism (CC) score is a score from 0 to 10 assigned by the panel to flora and is used to calculate the FQI. Species are scored higher if they are dominant (9-10) or common (7-8) in vigorous coastal wetland communities, not as high if they occur primarily in less vigorous coastal wetland communities (4-6), even lower if they are opportunistic users of disturbed sites (1-3), and lowest if they are invasive plant species (0). The panel did not assign CC scores to 1) submerged aquatic vegetation, 2) parasitic species, 3) plants identified only to genus or family, or 4) unidentifiable plants. Non-native species were assigned a score of 0 by the panel. Plants identified only to genus were assigned a CC score for the species if only one species was on the list for that genus. The mode of the species scores was assigned to a plant if it was identified only to genus and more than one species for the genus was listed, provided the CC scores for those species were within a 3 point range. No CC score was assigned to a plant within the genus if the CC scores for the species had a wider range than 3 points. If *Distichlis spicata* (seashore saltgrass) was present, it was assigned a community-specific CC score; a high score in healthy brackish and salt marshes where it is a codominant, and a low score in fresh and intermediate marshes where its presence is indicative of a disturbance.

CRMS Supplemental

In addition to the project specific monitoring elements listed above, a variety of other data is collected at CRMS stations which can be used as supporting or contextual information (Figure 3). Data types collected at CRMS sites include hydrologic from continuous recorders, vegetative, physical soil characteristics, discrete porewater salinity, surface elevation change, vertical accretion and land-water analysis of a 1 km^2 area encompassing the station (Folse et al. 2020). Project-specific data collection does not occur for all of these CRMS variables therefore, for this report, hydrologic, vegetation, and land-water data were used to assess project goals. Data was utilized from two reference sites outside the project area (CRMS0390 and CRMS0392).

c. Monitoring Results and Discussion

Aerial photography - Land –Water Analysis

A comparison of the 2012 and 2021 land-water classifications indicate that the overall project area did not change much between 2012 and 2021 (USGS 2012; USGS/WARC 2021). Land acreage slightly increased from 39.7% (484 acres) to 40.2% (490 acres) (Table 1). The marsh creation areas comprised much of the land acreage inside the project boundary in both years; 44% (213 acres) and 44.1 % (216 acres) respectively. Conversely, they contained only 2.1% (16 acres) and 1.8% (13 acres), respectively, of the project area water acreage.

The 2012 and 2021 land-water maps are located in appendix A of this report.

Table 1. 2012 and 2021 Land-Water acreages from USGS/WARC aerial photography.

Project Area Designation	2012			2021		
	Land (Acres)	Water (Acres)	Total (Acres)	Land (Acres)	Water (Acres)	Total (Acres)
TE-0046 Project Creation Areas	213	16	229	216	13	229
North Creation Area	114	11	125	117	8	125
Central Creation Area	38	2	40	38	2	40
South Creation Area	61	3	64	61	3	64
Outside Project Creation Areas	271	720	991	274	717	991
TE-0046 Project Area	**484**	**736**	**1220**	**490**	**730**	**1220**

Notes: (1) The Project Area Acreage includes the North, Central, and South Creation Areas. (2) Total Creation Areas Acreage is the sum of the North, Central, and South Creation Area Acreages.

CRMS Land-Water:

Assessment of the project area as well as CRMS reference sites utilizing the CRMS spatial viewer was conducted for data through 2018. Since this assessment is on a larger scale than that used for the project- specific 2012 and 2021 land-water classifications by USGS (USGS 2012; USGS/WARC 2021), the results are presented in terms of trends and provide a different perspective of the land to water changes over a period of decades (Figure 4). From 1956 to 1988 CRMS0392 retained 100% land, while TE-0046 and CRMS0390 shifted from land loss to land gain. Between 1988 and 2006 all three areas experienced a steady downward trend. TE-0046 experienced approximately 15% land gain between 2006 and 2008, due to construction of the marsh creation areas in 2007, while CRMS0390 and CRMS0392 continued a steady downward trend of land loss.

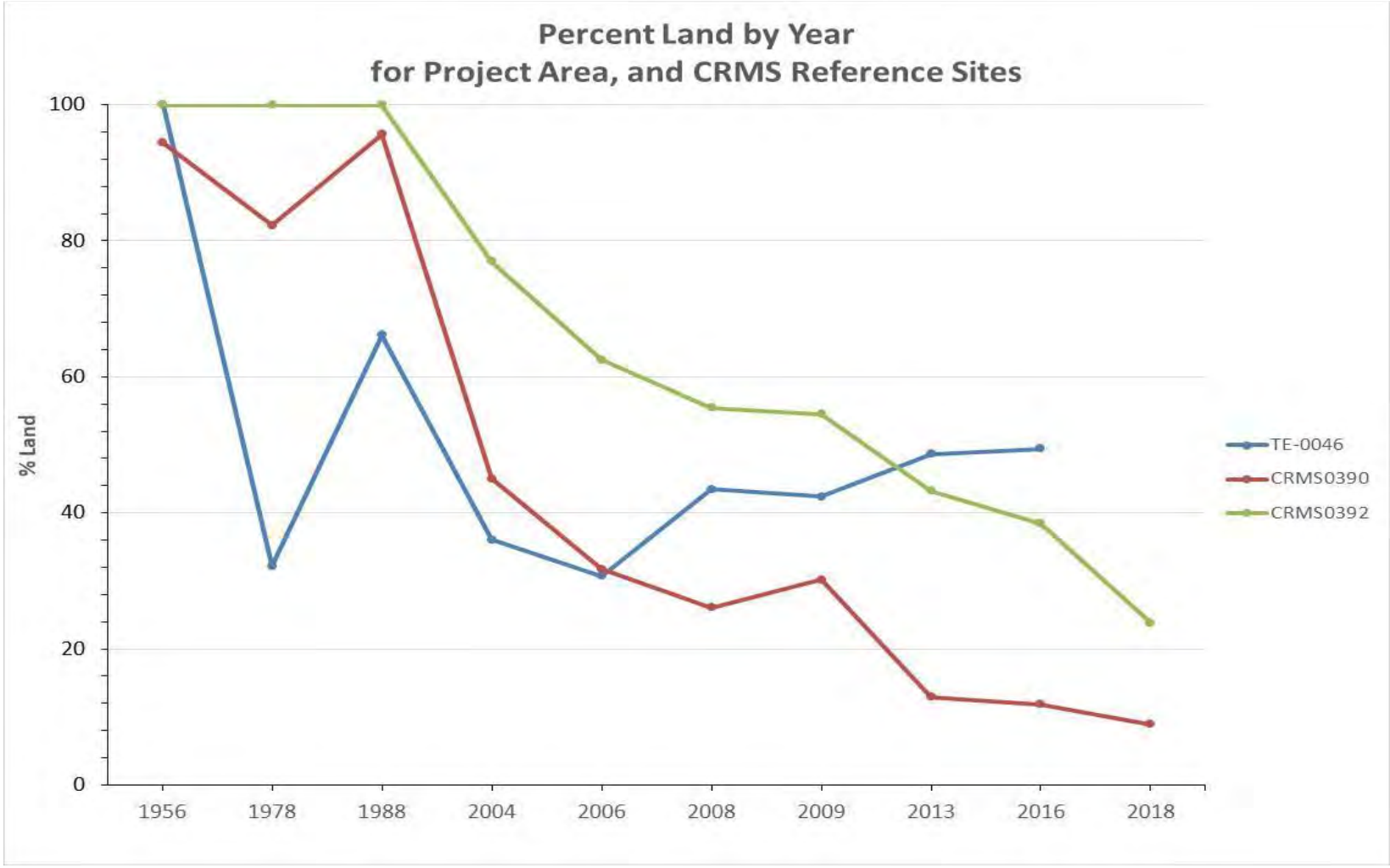

Figure 4. Percent land by year in the TE-0046 project marsh compared to CRMS reference marsh sites (CRMS0390 and CRMS0392). No project area data was available for year 2018. Note that the data displayed above is on a different spatial scale than the data in figures 1 and 2 in appendix A and is for trend examination (CRMS spatial viewer land/water, Barras et al. 2008; CPRA 2023).

The largest amount of land loss, approximately 70% of its original land, occurred between 1956 and 1978 for TE-0046. The largest conversion of land to water occurred between 1988 and 2004 for both of the CRMS sites. The lowest land to water conversion for the CRMS sites as well as TE-0046 occurred between 2013 and 2016. By 2018 land loss continued a downward trend for the CRMS sites, whereas the TE-0046 project area had increased and maintained its acreage since construction.

Aerial Photography - Shoreline Change:

Pre-construction data reveals that the TE-0046 shoreline was transgressing at a rapid rate. The shoreline erosion rates for this 1998-2005 interval averaged -13.58 m/yr (-44.55 ft/yr) (Figure 5). During the ~8-year pre-construction interval, the project area shoreline receded -105 m (-344 ft). Subsequent pre-construction analyses of the TE-0046 shorelines produced erosion rates of -17.26 m/yr (-56.64 ft/yr) for the interval from 1998-2004 and -19.77 m/yr (-64.85 ft/yr) for the interval from 2004-2005 (Figure 5). Approximately, 1,200 m (3,937 ft) of the pre-project shoreline were converted to open water during 1998-2005 interval. As a result, no shoreline change data could be generated for these reaches. Figure 5 illustrates the declining population of shoreline replicates over the pre-construction intervals and indicate that the shoreline was breaking up in place at this time. Although the shoreline erosion rate was exceptionally high for the 1998-2005 interval, the erosion estimates are probably underestimated due to the loss of shoreline reaches. The large erosion values and the small number of shoreline replicates reported for the 2004-2005 interval (Figure 5) reveal that erosion and land-loss rates increased for this interval. Indeed, several narrow shoreline reaches were transformed to open water habitat during the 2004-2005 interval. Therefore, it is evident from the shoreline erosion data that the 2005 hurricane season altered and reshaped the project area shorelines (Figure 5). The passage in quick succession of Hurricane Cindy (Jul 2005), Hurricane Katrina (Aug 2005), and Hurricane Rita (Sep 2005) in close proximity to the project area likely eroded large sections of shoreline. Therefore, the 2005 hurricanes hastened the shoreline retreat in the pre-construction project area and intensified the land-loss and fragmentation of the Lake Boudreaux shorelines.

Since construction, the marsh edge erosion rate has declined in the project area. The average shoreline change rate behind the rock shoreline protection structure was 0.01 m/yr (0.03 ft/yr) from Oct 2008 to Oct 2012 (Figure 5). The post-construction interval from Oct 2012 to Nov 2018 showed a minimal loss of -0.04 m/yr (-0.12 ft/yr). From Nov 2018 to Nov 2021 the change rate was 0.34 m/yr (1.13 ft/yr). Visual inspections of the aerial photographs confirmed that the slight differences in shoreline position are likely the result of fluctuations in vegetation colonization of mudflat areas in the immediate lee of the structure. The combination of the

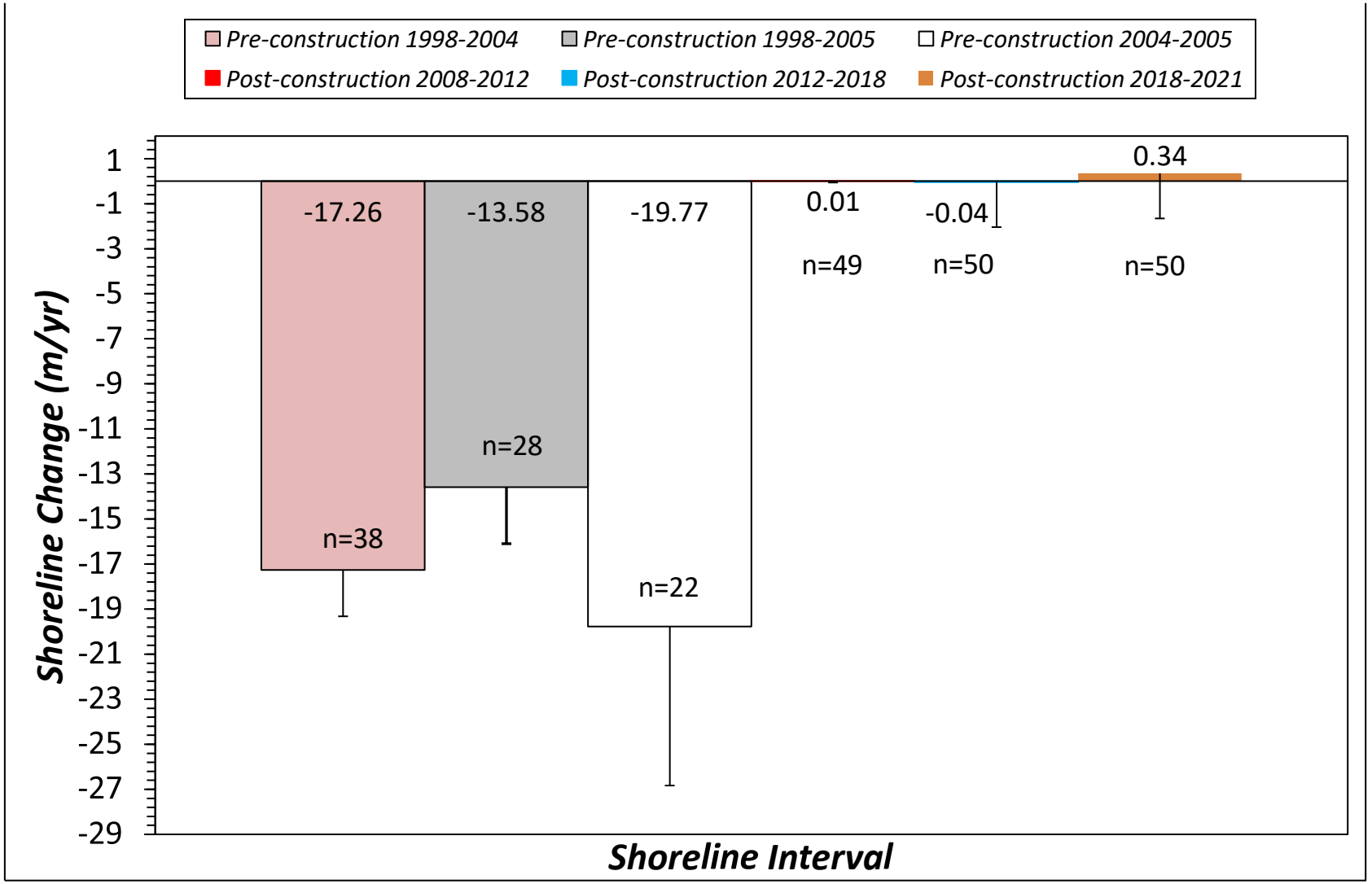

Figure 5. Shoreline change rates for the area behind the foreshore rock protection structure for various time intervals both pre-construction and post-construction.

foreshore rock shoreline protection structure, sediment additions to the marsh creation area shoreline, and the small fetch behind the rock shoreline protection structure likely facilitated the low post-construction erosion rate. This grouping of shoreline protection and marsh creation features has proven to minimize shoreline transgressions on other restoration projects (Curole and Ledet 2012).

Emergent Vegetation:

Project-Specific Vegetation Data Analysis and Results:

Data collection for the TE-0046 project area occurred in October 2012 (3 years post-construction) and October 2021 (12 years post-construction). CPRA personnel originally collected percent cover and species composition data from 42 randomly selected stations located along 14 east-west transects inside the three marsh creation areas in 2012 (Figure 6). In 2021, the three southermost stations in the north creation cell were not sampled. Dense stands of woody shrubs and impenetrable undergrowth made airboat and foot traffic impossible therefore, data from these three stations were not utilized in the project-specific analysis for this report. In addition to mean percent cover, the mean Floristic Quality Index (FQI) for the project area was estimated using the Cretini et al. protocol (2011). Vegetation composition in the project's marsh creation areas included a mix of *Spartina alterniflora* (smooth cordgrass), *Distichalis spicata*, *Iva frutescens* (bigleaf sumpweed), *Bolboschoenus robustus* (sturdy bulrush), as well as other species indicative of a mainly saline marsh habitat (Figure 7). *S. alterniflora* and *D. spicata* were the species with the greatest mean cover values, with *S. alterniflora* as the dominant species. The project FQI improved between 2012 and 2021. FQI was 57 and 68 respectively, (Figure 7).

It is interesting to note that the dominant species in the natural marshes outside the creation areas was *Spartina patens* (marshhay cordgrass), while the dominant species inside the creation areas was *S. alterniflora*. CPRA observed large expanses of *S. alterniflora* throughout the creation areas, and though *S. patens* was documented it was sparse (<1%) and not in large continuous swaths. Investigations into the construction phase of this project yielded information that the non-profit group Barataria Terrebonne National Estuary Program (BTNEP) sponsored a group of volunteers to install plantings within the boundaries of the marsh creation areas in July 2009. The plantings consisted of approximately 5,500 bareroot *S. alterniflora* plugs. Most of the plugs were installed along the toe of the earthen containment dikes facing the foreshore rock shoreline protection structure. In the northern marsh creation area some were installed just inside the earthen containment dike along the northern portion as well as in a shallow interior pond approximately 100-150 feet in from the dike. Some of the plantings were installed at the toe of the earthen containment dikes on either side of the fishing access between the north and central marsh creation areas. These plantings would partially explain the successful recruitment of *S. alterniflora* on the created marsh platform for all three creation areas.

Figure 6. Location of the randomly selected project-specific vegetation stations inside the three marsh creation areas for the TE-0046 project. The three southernmost stations in the north creation area were not sampled in 2021.

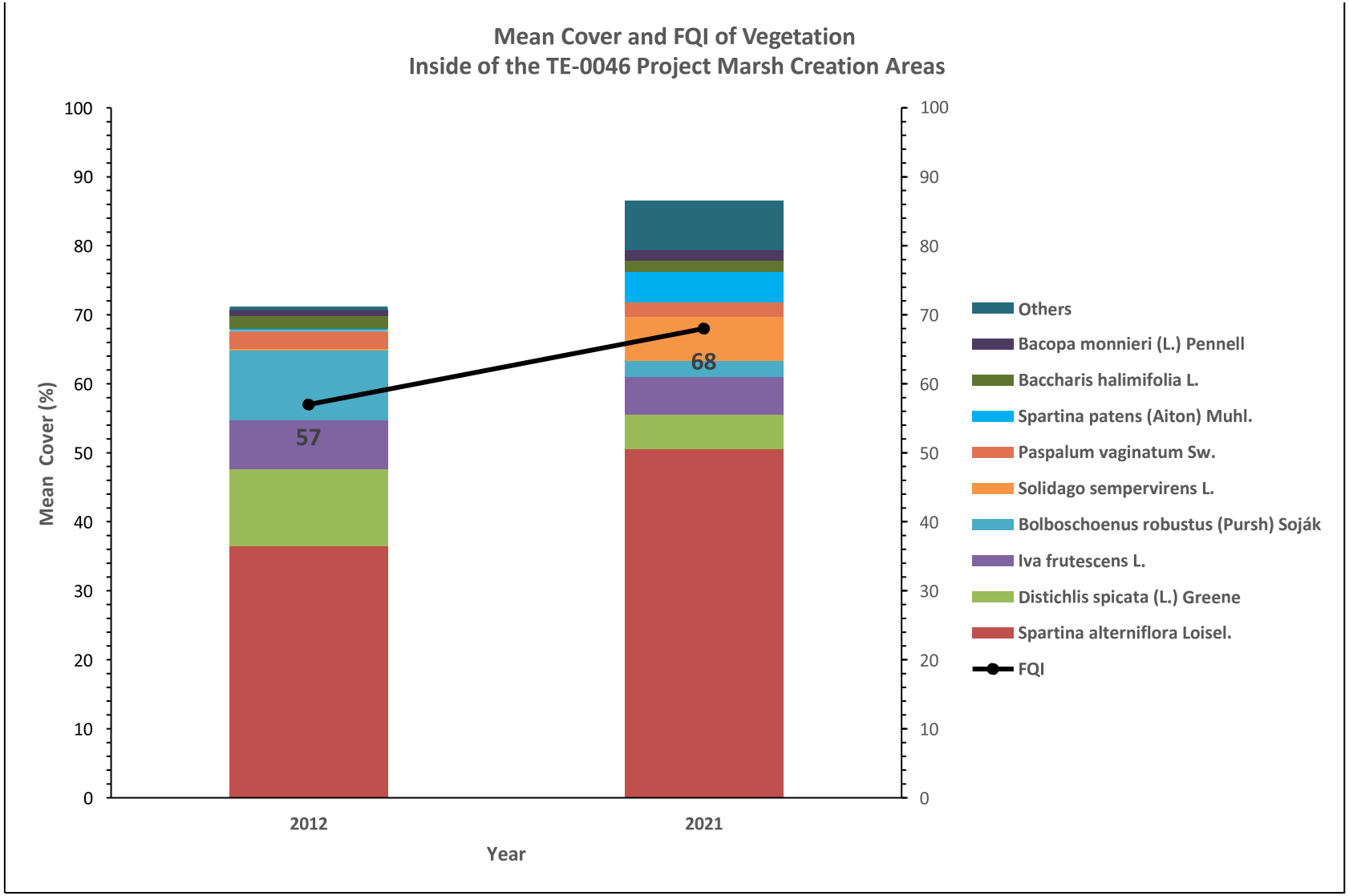

Figure 7. Mean percent cover and Floristic Quality Index for the TE-0046 project-specific vegetation stations in the marsh creation areas.

CRMS Vegetation Analysis and Results:

For CRMS reference sites CRMS0390 and CRMS0392, data were retrieved from the Coastal Information Management System (CIMS) database (CPRA 2023) prior to data analysis as stated in Folse et al. (2020). The charting tool from the CRMS website, based upon the Cretini and Steyer protocol (2011) was utilized to determine mean percent cover and FQI within each CRMS reference site for each year of data collection (Figures 8 & 9). The charting tool was also used to generate box charts which depict a comparison of the 2021 FQI of each reference CRMS site to all other CRMS sites coastwide, and to all sites within the same hydrologic basin within the same marsh type (Figures 10 & 11). Finally, the FQI scores for each year of data for each site were compared against a box plot of all scores for all sites coastwide within the same marsh types (Figures 12 & 13).

In 2021 reference site CRMS0390 was classified as a brackish marsh and the dominant species was *S. patens* for all 16 years of data collection (Figure 8). The FQI and mean cover of *S. patens* generally exhibited a downward trend throughout those years. Species cover and FQI were at their peak in 2010 and at their lowest levels in 2021. The low 2006 score was likely a response to the damage from the impacts of hurricanes Cindy and Katrina in 2005. It is interesting to note that a vegetation shift occurred by 2010, in which species with lower cc scores like *Bacopa monnieri* (coastal waterhyssop) and *Eleocharis parvula* (dwarf spikesedge) disappeared, and *D. spicata*, which had a higher cc score for this marsh type naturally colonized the area. By 2016 *D. spicata* cover dwindled. By 2021 the FQI score for this site (15.96) was noticeably lower than all CRMS sites within the same marsh type, hydrologic basin, and across the entire Louisiana coastal zone (Figure 10). Additionally, CRMS0390 shifted from an intermediate marsh classification to a brackish marsh classification by 2009 and has remained a brackish marsh through 2021 (Figure 12).

Reference site CRMS0392 was classified as an intermediate marsh in 2021 and the dominant species was *S. patens* for the majority of the 16 years of data collection (Figure 9). This site was more diverse in terms of the species composition, likely due to the response to frequent disturbance from large tropical systems throughout the years, coupled with rapid land loss. The FQI, species diversity, and mean cover species present exhibited a drastic downward trend since the site was established. FQI scores were at their peak in 2007 and at their lowest levels in 2016. By 2021 the FQI score for this site (6.05) was exceptionally lower than all CRMS sites within the same marsh type, hydrologic basin, and across the entire Louisiana coastal zone (Figure 11). CRMS0392 has shifted between intermediate and brackish marsh type throughout this time, but for the majority of this time it has been classified as intermediate marsh (Figure 13).

It is important to note that the FQI for these two CRMS reference sites were substantially lower than the TE-0046 project area FQI for project-specific data collection years 2012 and 2021 (Table 3). The increase in exposure to large tropical systems coupled with rapid interior marsh loss and shoreline loss, as well as the less than favorable hydrologic conditions which are discussed later in this report have likely contributed to these low FQI scores.

Table 3. FQI for TE-0046 project area and CRMS reference sites during project-specific data collection years.

Location	2012	2021
CRMS0390	36.2	15.96
CRMS0392	6.6	6.05
TE-0046 Project Area	56.68	68

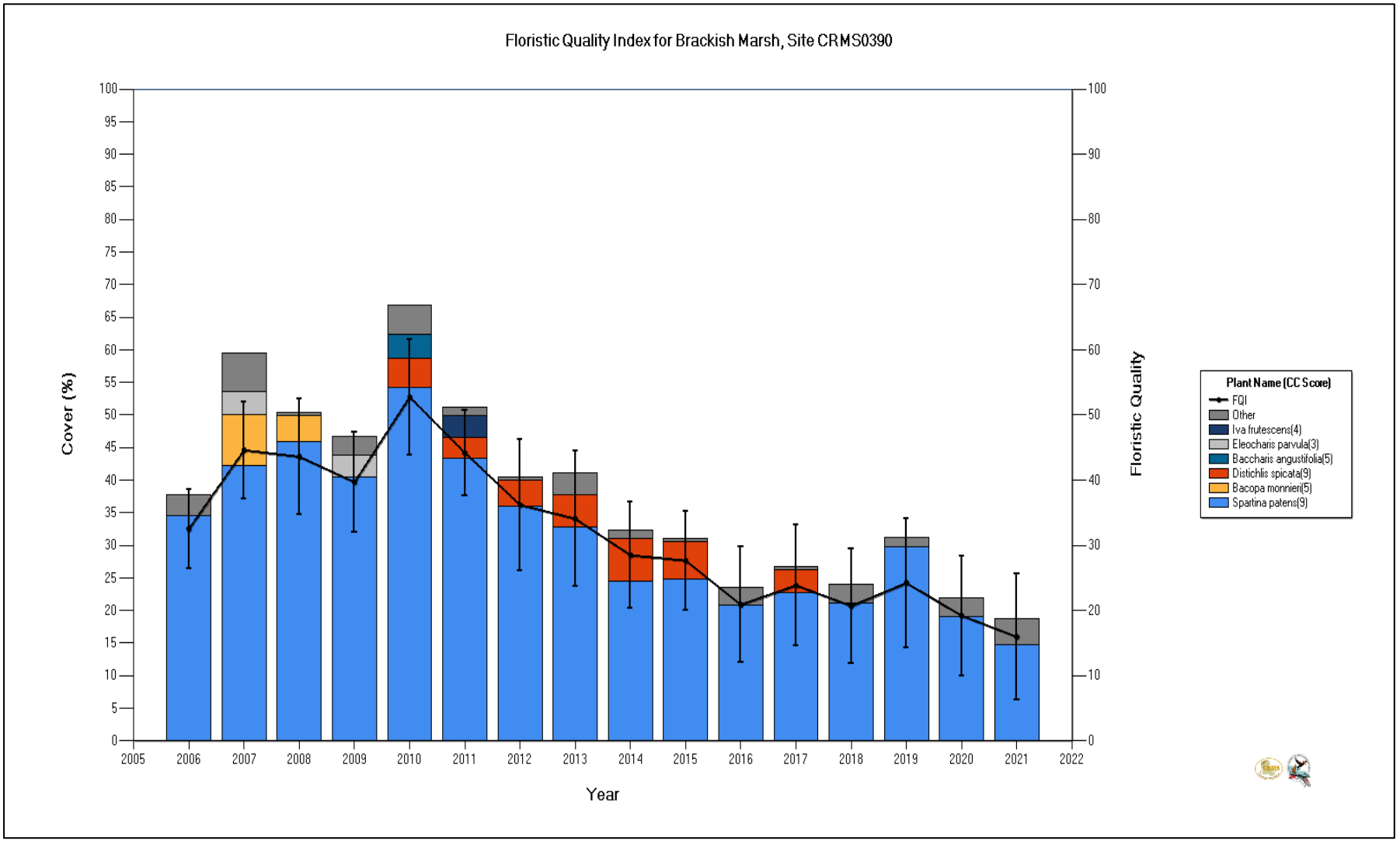

Figure 8. FQI and species composition with mean cover for brackish marsh site CRMS0390.

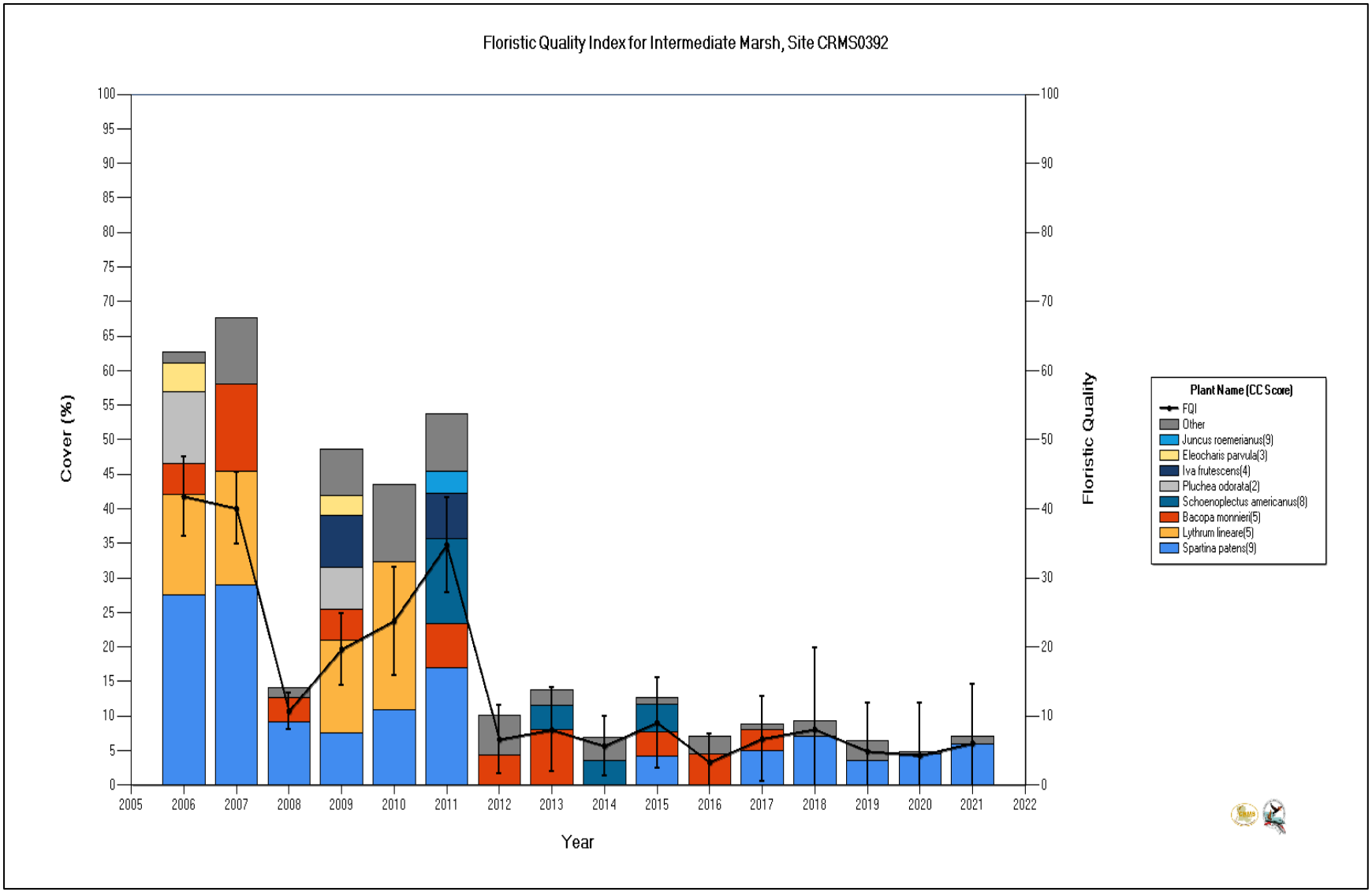

Figure 9. FQI and species composition with mean cover for intermediate marsh site CRMS0392.

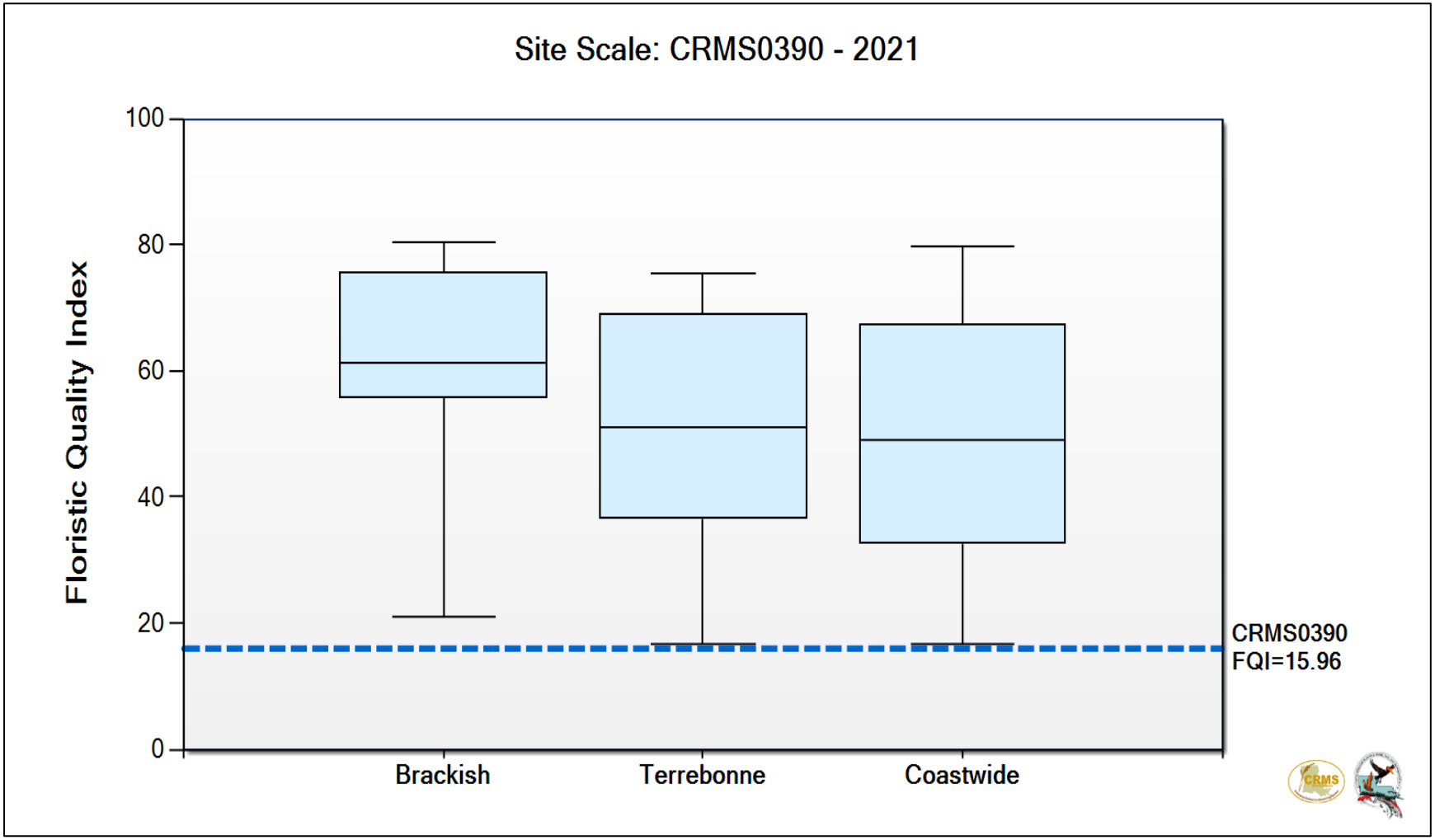

Figure 10. Box plot indicating the CRMS0390 site FQI score for 2021 compared to the distribution of scores for all coastwide CRMS sites within the same marsh type, within the same hydrologic basin, and across the entire LA coastal zone.

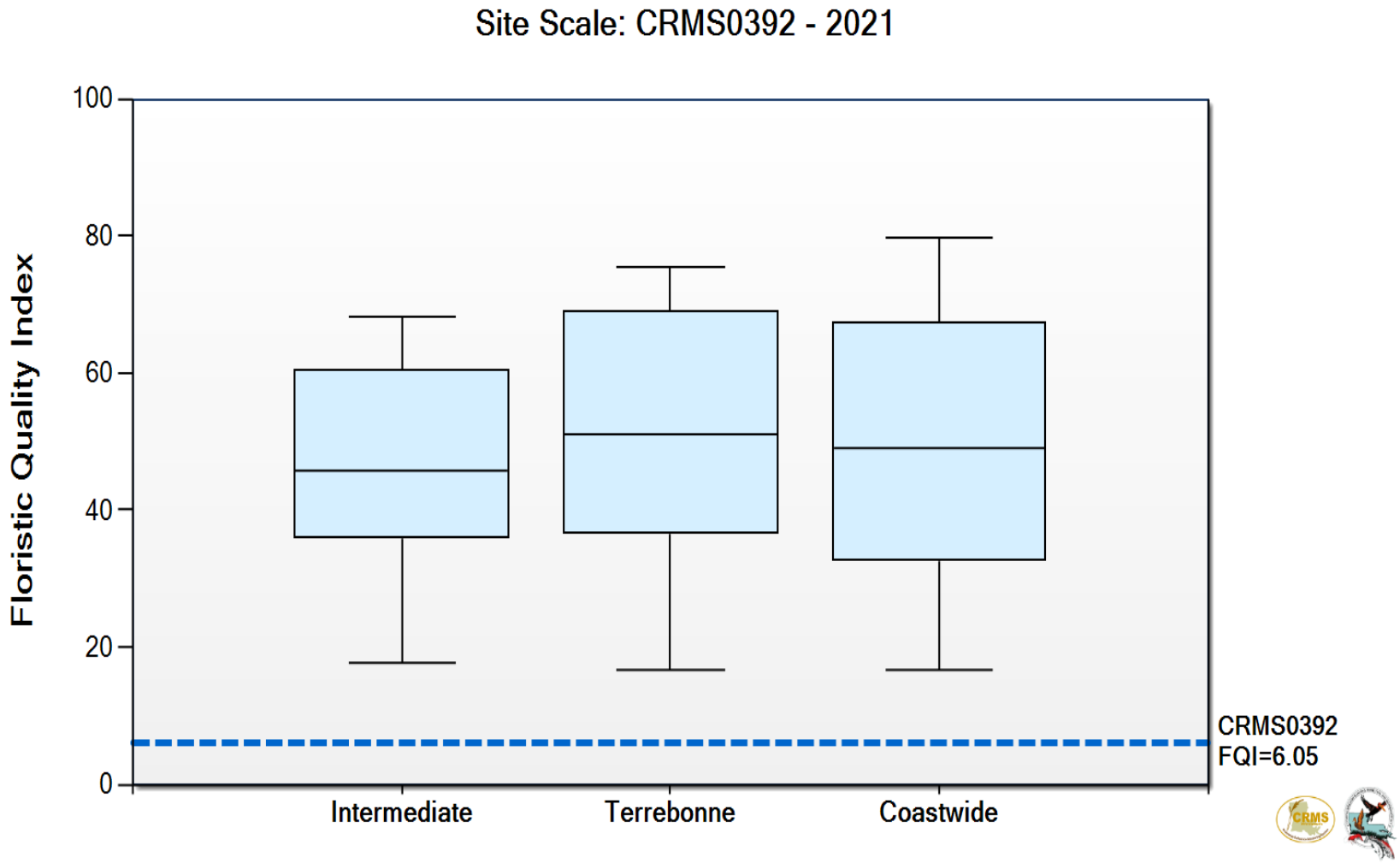

Figure 11. Box plot indicating the CRMS0392 site FQI score for 2021 compared to the distribution of scores for all coastwide CRMS sites within the same marsh type, within the same hydrologic basin, and across the entire LA coastal zone.

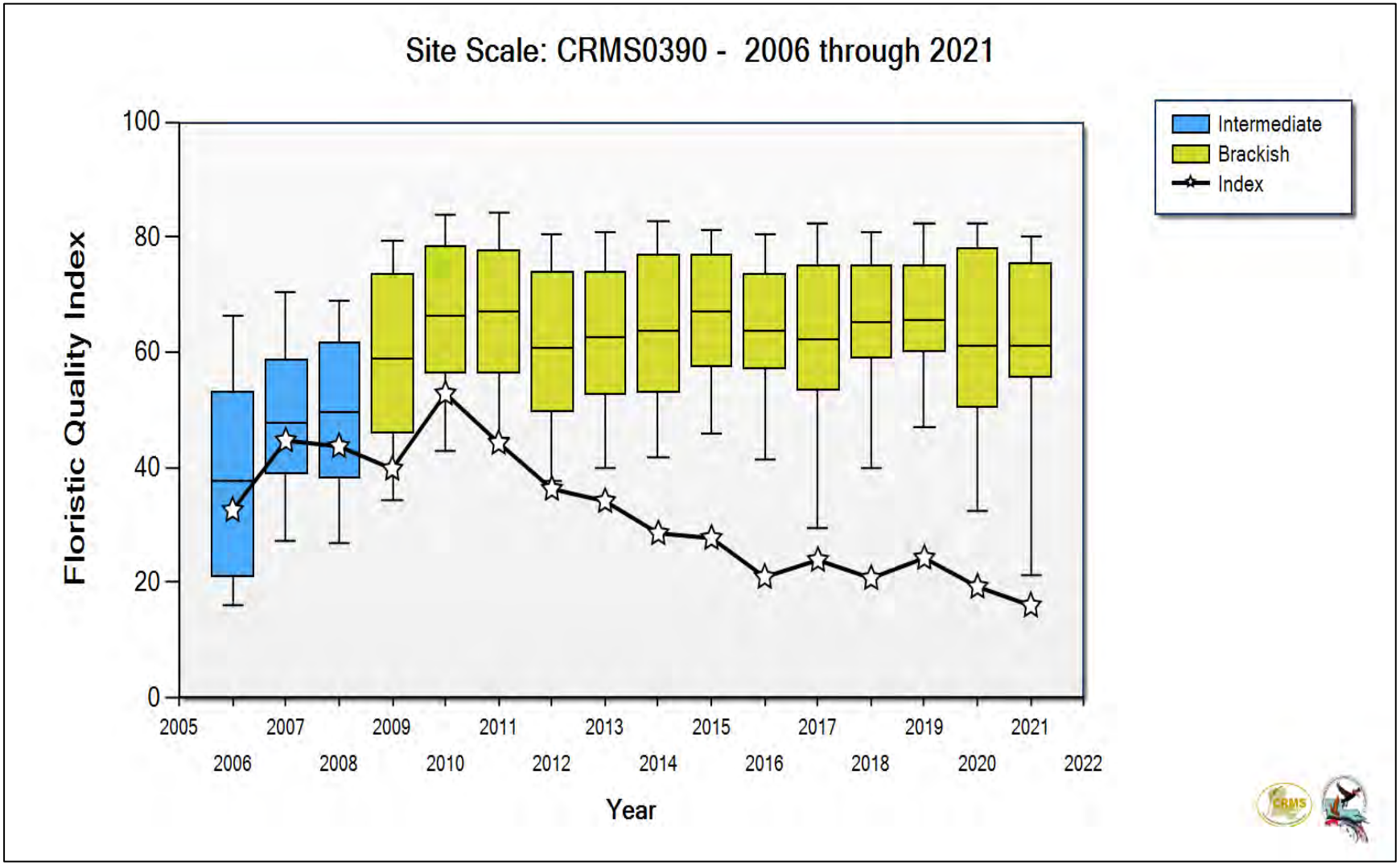

Figure 12. A time series of FQI scores for CRMS0390 relative to a box plot of scores for all the CRMS sites within the same marsh type each year. Marsh type classifications for each year are based on species composition data for that year at the specific CRMS site.

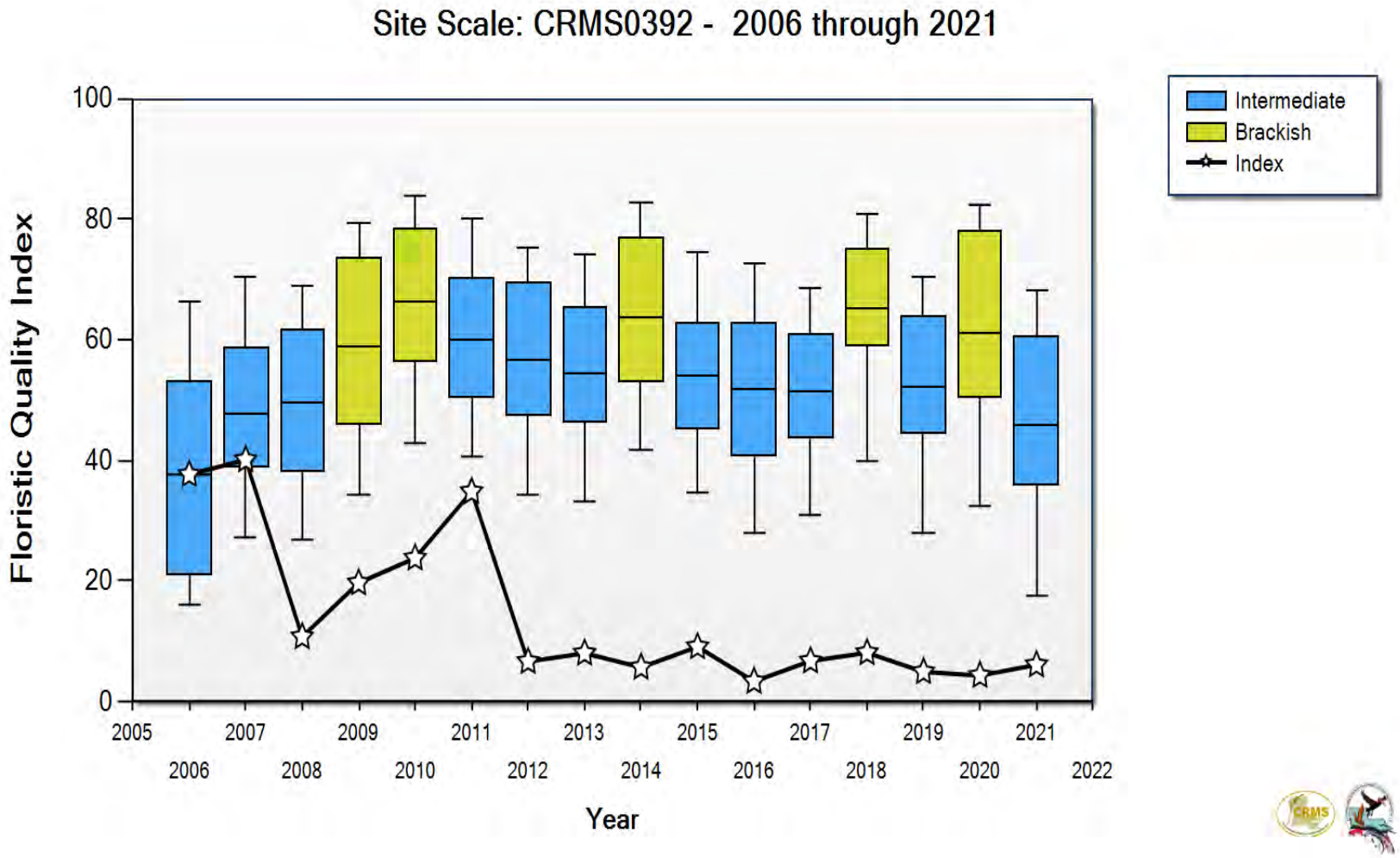

Figure 13. A time series of FQI scores for CRMS0392 relative to a box plot of scores for all the CRMS sites within the same marsh type each year. Marsh type classifications for each year are based on species composition data for that year at the specific CRMS site.

CRMS Supplemental:

There are no CRMS sites inside of the TE-0046 boundary, however nearby sites CRMS0390 and CRMS0392 will be used as references to help characterize the water level, salinity, and as previously presented in this report, vegetation, and land-water conditions in this area of the Terrebonne basin utilizing the CRMS spatial viewer and charting capabilities (CPRA 2023).

Salinity:

Adjusted salinity data presented in this section covers a yearly means time series beginning concurrently in July 2007 for continuous recorder stations at CRMS0390 and CRMS0392 and ending in December 2021 (Figure 14). Mean surface water salinity at the two sites is very similar and they track each other closely. Interestingly, the overall trend for both sites has been a gradual lowering of surface water salinity in the fourteen years of data collection. This drop corresponds to the construction of the Morganza to the Gulf of Mexico Project (MTG). The MTG project straddles portions of Terrebonne and Lafourche parish and consists of a series of robust earthen levees, floodgates, pump stations, and locks designed to protect coastal communities from storm damage and surge inundation. Some of the levee reaches join up with already existing parish levees. Lake Boudreaux in the Terrebonne basin has essentially been contained and the area has freshened up, most likely due to some impoundment.

Concurrent interstitial soil porewater salinities trended toward a gradual but noticeable freshening, similar to surface water data, and likely for the same reasons. The salinity data at the reference CRMS sites were collected from 2007 through 2021 (Figure 15). Salinities were measured at 10 cm and 30 cm depths. The yearly mean porewater salinity for reference CRMS locations ranged from approximately 12 to slightly above 6 ppt, with variation from year to year. For most of this time span CRMS0392 had slightly higher salinities than CRMS0390 at both depths.

Water Level:

Adjusted water level data presented in this section covers a yearly means time series beginning concurrently in July 2007 for continuous recorder stations at CRMS0390 and CRMS0392 and ending in December 2021 (Figure 16). The water level patterns at each recorder station were very similar, and like the salinity data, they track each other very closely. CRMS0392 had consistently slightly higher adjusted water levels than CRMS0390 until 2020 when both stations experienced very similar water levels. There was a noticeable gradual increase in water levels at both stations, likely due to impoundment from the MTG project levees. The trend of higher water levels with lower salinities suggests that the MTG levees are preventing the movement of high salinity Gulf water and storm surges from inundating the area, while impounding the freshwater that enters the system from rainfall.

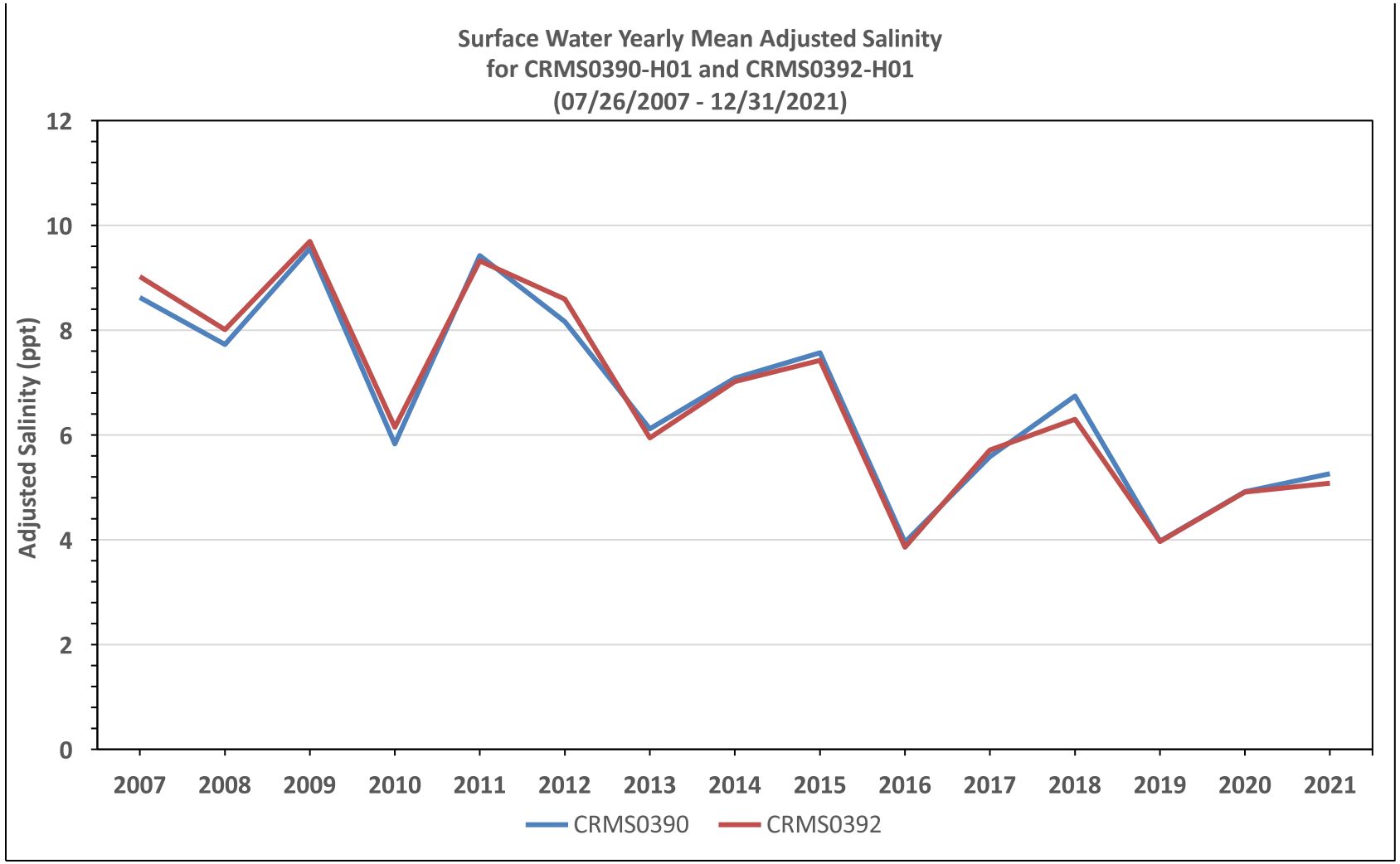

Figure 14. Yearly mean salinity at reference hydrographic stations (CRMS0390-H01 and CRMS0392-H01) from 2007 through 2021. Note: Year 2007 represents only 5 months of data.

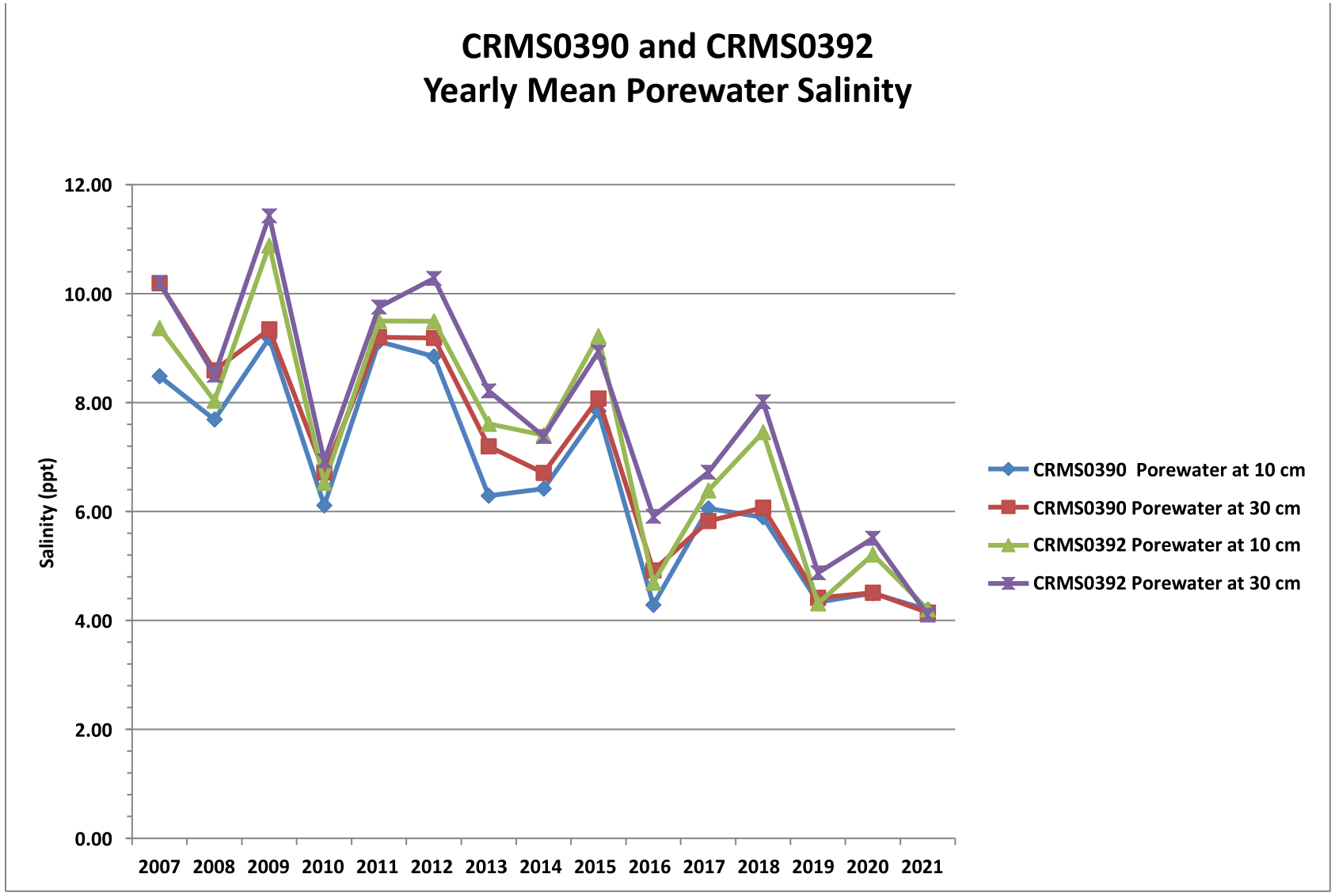

Figure 15. Yearly mean interstitial porewater salinities for reference CRMS sites from 2007 through 2021.

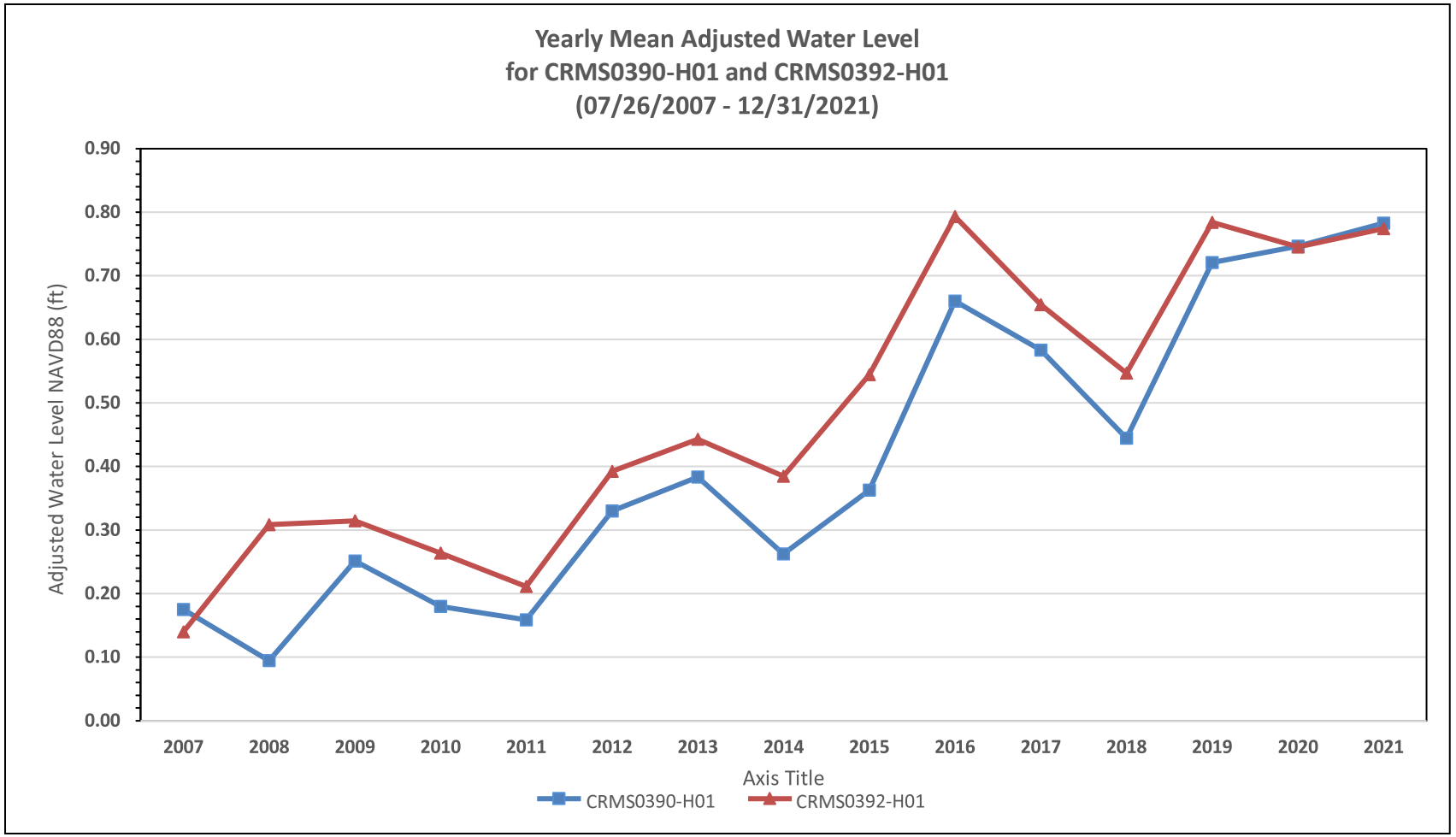

Figure 16. Yearly mean adjusted water levels at reference hydrographic stations (CRMS0390-H01 and CRMS0392-H01) from 2007 through 2021. Note: Year 2007 represents only 5 months of data.

Hydrologic Index:

The Hydrologic Index (HI) score was developed by CRMS analytical teams based upon parameters collected at CRMS sites from 2006 through 2009 across the Louisiana coast from which they developed a baseline distribution. The index assesses the suitability of a coastal Louisiana marsh site's average salinity and percent time flooded in maximizing vegetation primary production (CPRA 2024). HI was designed to help better understand the condition of coastal wetlands at various time and spatial scales. A site was classified as good if the score was greater than 75% of all CRMS site scores calculated during this baseline period, fair if it fell within the 25% to 75% range, and poor if did not exceed 25%. The HI score is calculated by year, and requires greater than 70% data completeness for a particular year in order to obtain a score. The HI scores for the CRMS reference sites are presented in Figures 17 and 18. The box plots indicate a comparison of the HI scores from 2007 through 2021 to scores from all the Louisiana coastal zone CRMS sites within the same marsh type.

Due to the lack of data completeness for water years 2008 and 2009 for CRMS0390, comparisons to all other CRMS sites were not available (Figure 17). The box plot indicates the change in marsh classification from intermediate to brackish only two years after data collection began. The CRMS0390 HI scores dipped and peaked mutiple times througout this time series indicating the variability of the conditions at this site. HI scores for CRMS0390 were almost equally divided above and below the comparative CRMS site scores through the years. The last three years indicated lower scores than comparative sites.

The HI scores for CRMS0392 are not shown for water year 2007 because the data sets did not meet the data completeness threshold (Figure 18). Marsh classifications transitioned between intermediate and brackish in some years, but the majority of the time this site was classified as intermediate marsh. The majority of the HI scores for CRMS0392 were lower than comparative CRMS sites, with the exception of 2014 and 2018. The large amount of land loss at this site has likely contributed to the lower scores.

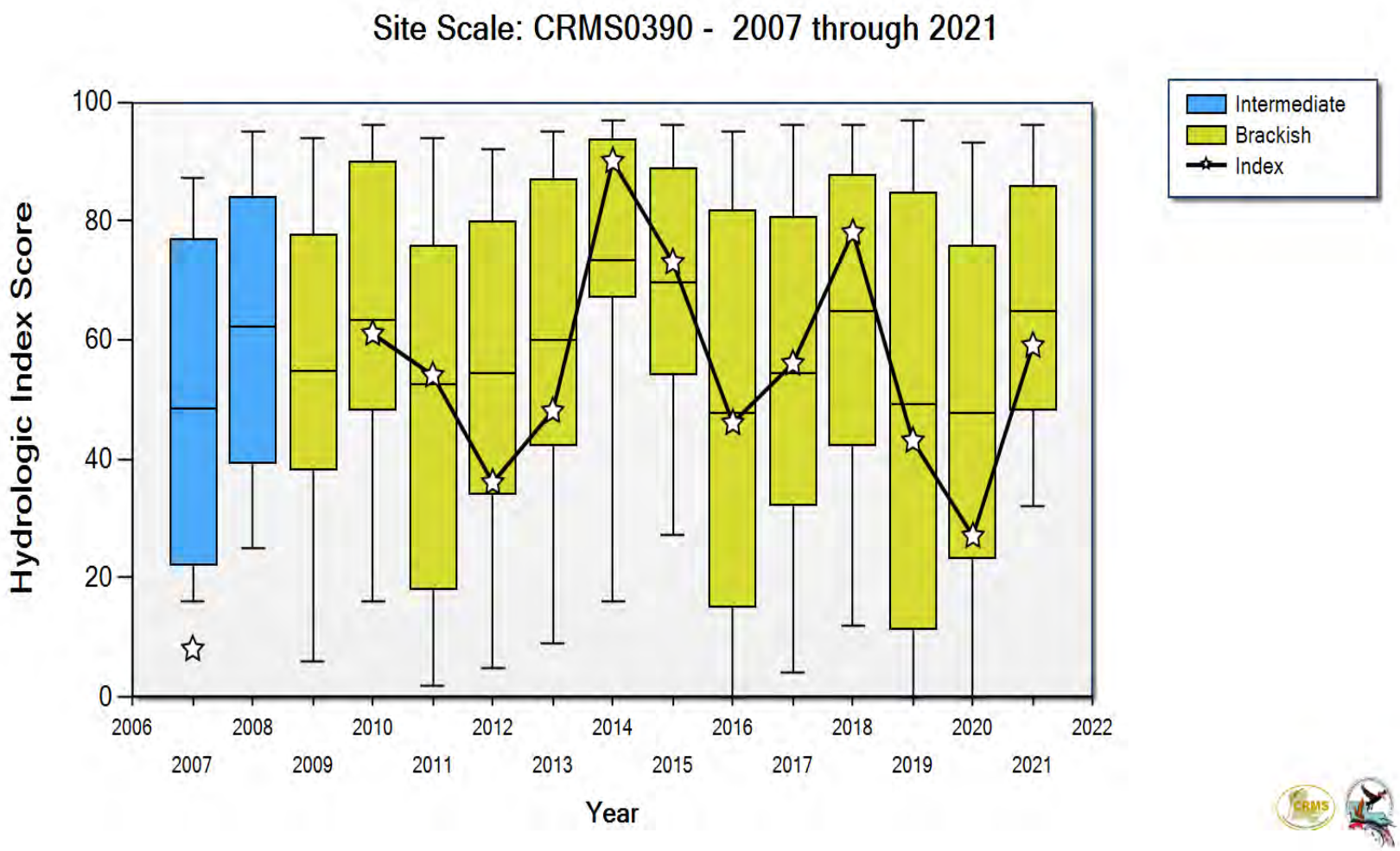

Figure 17. A time series of Hydrologic Index scores for CRMS0390 relative to the boxplot of the scores for all the sites within the same marsh type each year. The HI score for CRMS0390 is not shown for 2008 and 2009 because the data set for those water years did not meet the data completeness threshold of >70%.

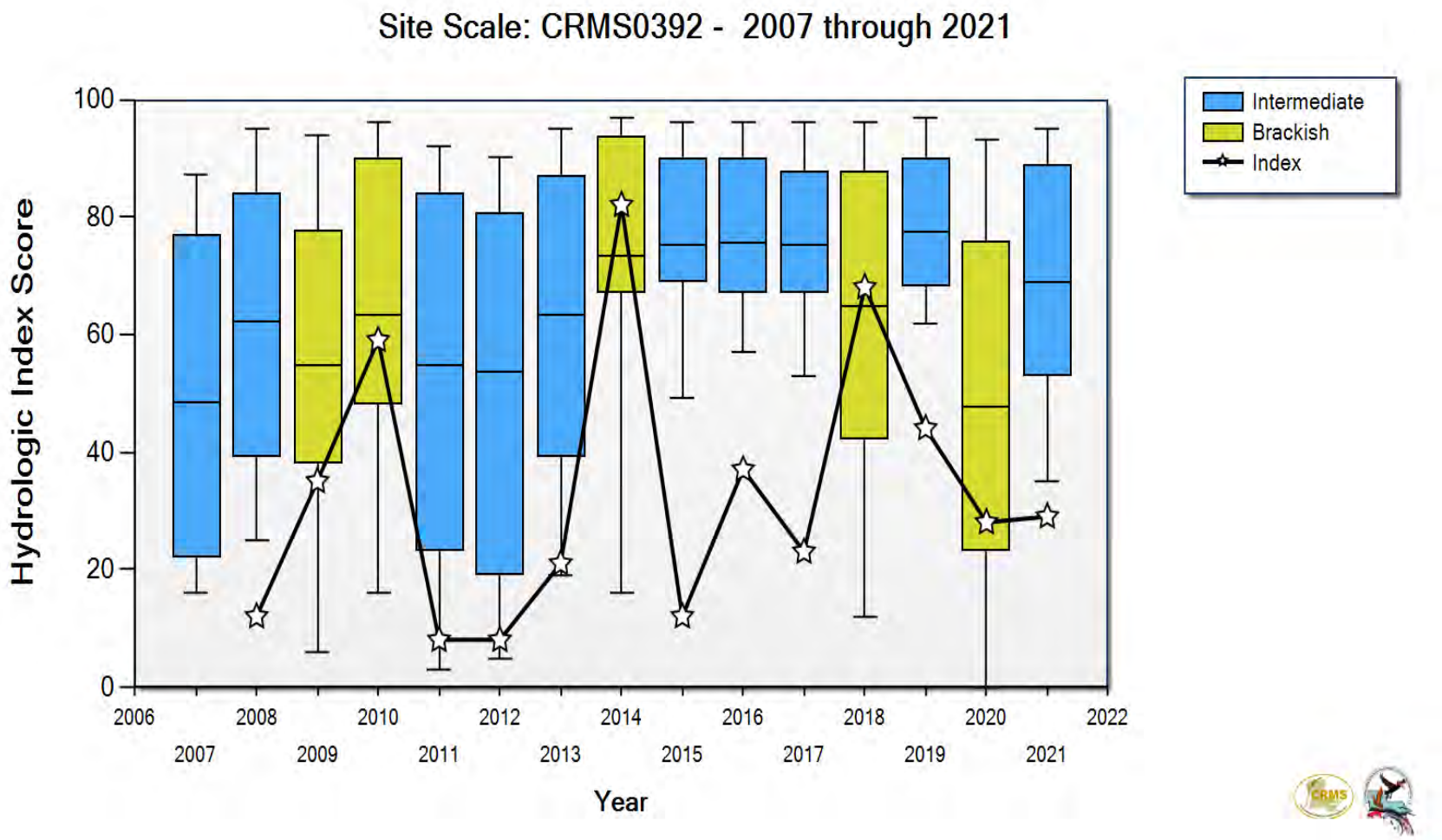

Figure 18. A time series of Hydrologic Index scores for CRMS0392 relative to the box plot of the scores for all the sites within the same marsh type each year. The HI score for CRMS0392 is not shown for 2007 because the data set for this water year did not meet the data completeness threshold of >70%.

V. Conclusions

a. Project effectiveness

The 20 year project life for TE-0046 began in October 2009. Since construction was completed only two data collection events have occurred; 1) aerial photography in October 2012 and November 2021, and 2) vegetation data collection in the marsh creation areas in October 2012 and October 2021. Past CRMS photography and historical land loss data have aided in characterizing what the area near TE-0046 has experienced. It is midway into the project life and the following information aids to inform if the project goals are being met.

1. **Stop shoreline erosion along approximately 12,447 linear ft (3,794 m) of the western shoreline of Lake Boudreaux over the 20-year project life.**
   Twelve years post-construction the project features have essentially halted shoreline transgression. Pre-construction change rates were excessive, with shoreline erosion rates at their highest {-19.77 m/yr (-64.85 ft/yr)} from 2004-2005, when several shoreline reaches were completely converted to open water due to powerful tropical storms. Post-construction rates by comparison were substantially less dramatic. The only interval with a slight shoreline transgression was from 2012-2018 for -0.04 m/yr (-0.12 ft/yr). Three years later the shoreline had prograded at a rate of 0.34 m/yr (1.13 ft/yr). Interestingly, this shoreline gain occurred despite impacts from category 5 hurricane Ida's landfall in August 2021. Placement of the rocks directly onto the shoreline dampened wave energy and left little to no area for waves to generate behind them, halting shoreline transgression. Any shoreline gain was mainly due to former mud flats experiencing natural vegetation recruitment.

2. **Initially create 220 acres (89 ha) of marsh by the completion of project construction with intertidal marsh developing after year 3 of the project's life.**
   The land acreage inside the project area has been successfully maintained with virtually no change between the 2012 and 2021 land-water analyses. Both the 2012 (three years post-construction) and 2021 (nine years post-construction) land-water analyses showed that the TE-0046 project area contained approximately 40% land to 60% water. In 2021 the marsh creation areas comprised approximately 44% (216 acres) of the overall land area inside the project boundary and only 1.7% (13 acres) of the water. Additionally, while the project area has maintained its acreage, the nearest CRMS sites have increasingly and steadily continued to lose land acreage.

Vegetation composition in the project's marsh creation areas included a mix of species indicative of a mainly saline marsh habitat dominated by *S. alterniflora* and *D. spicata.* The project FQI improved from 57 in 2012 to 68 in 2021. Nearby reference CRMS sites were dominated by *S. patens* and by 2021 were classified as brackish (CMRS0390) and

intermediate (CRMS0392) marsh sites respectively. Both of these sites have experienced shifts to a less saline marsh type between 2006 and 2021. Surface and soil salinity data collected from the CRMS reference sites support the growth of brackish marsh vegetation.

Several CRMS sites were identified with similar vegetative composition to that of the TE-0046 project area. All of these sites have a relatively high percent cover (25-40%) of *S. alterniflora*. Most of these sites are in the Terrebonne basin and are, perhaps not surprisingly, saline coastal marsh. Additional vegetative sampling will determine whether the TE-0046 project area transitions to an intermediate/brackish marsh similar to the geographically proximate CRMS0390 and CRMS0392 sites or whether it remains similar to saline coastal marsh.

3. **Reduce erosion rates by 50%, from 3.68% per year to 1.84% per year, in the created and nourished marsh over the 20-year project life.**
   Marsh erosion, as evaluated by percent land loss inside of the created areas, has reversed loss trends and increased by 2.8%.

4. **Reduce erosion rates by 25%, from 3.68% per year to 2.76% per year, in the non- directly affected marsh over the 20-year project life.**
   Marsh erosion, as evaluated by percent land change inside of the project area as a whole, has likewise decreased, and land gain between 2012 and 2021 was 0.49%.

b. Recommended improvements

All project features are in good shape. It is recommended that the missing warning sign on the lake side of the choke down section be replaced as it is the only indicator of the submerged structure for vessels traveling in that direction.

c. Lessons learned

When there are goals such as to initially create 220 acres (89 ha) of marsh by the completion of project construction with intertidal marsh developing after year 3 of the project's life then there needs to be some form of capturing land water just prior to construction and immediately post- construction. When areas of construction have a mixture of open water and existing marsh, goals and objectives need to be clearly defined and discussion taking place on how these acres will be measured to determine if the goal is met

Without having marsh elevation surveys or, at a minimum, elevation at the vegetation stations, it is difficult to assess if the marsh creation areas are settling into the intertidal zone. The vegetation data implies that a majority of the project may be intertidal by the

presence of *Spartina alterniflora.* However; the presence of *Solidago sempervirens* and the statement that 3 of the stations in the southern end of the northern most marsh creation area could not be sampled in 2021 due the abundance of woody species indicates there are areas that may be supratidal. By having elevation surveys to determine marsh surface elevations and by using nearby CRMS hydrologic stations, depth and duration of flooding could be performed to determine if the marsh surface is within the tidal zone.

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VII. Appendices

Appendix A
(Land-Water Maps)

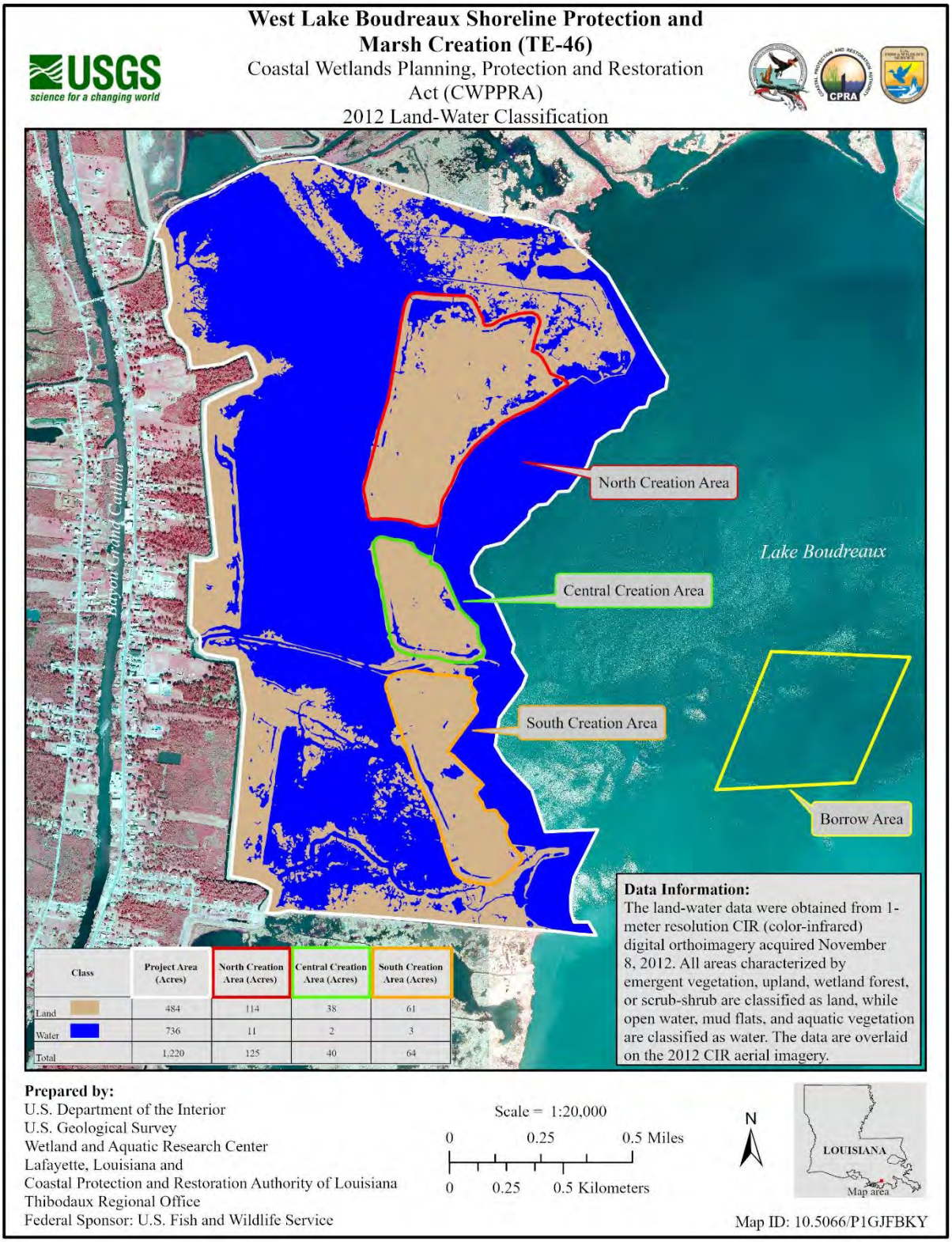
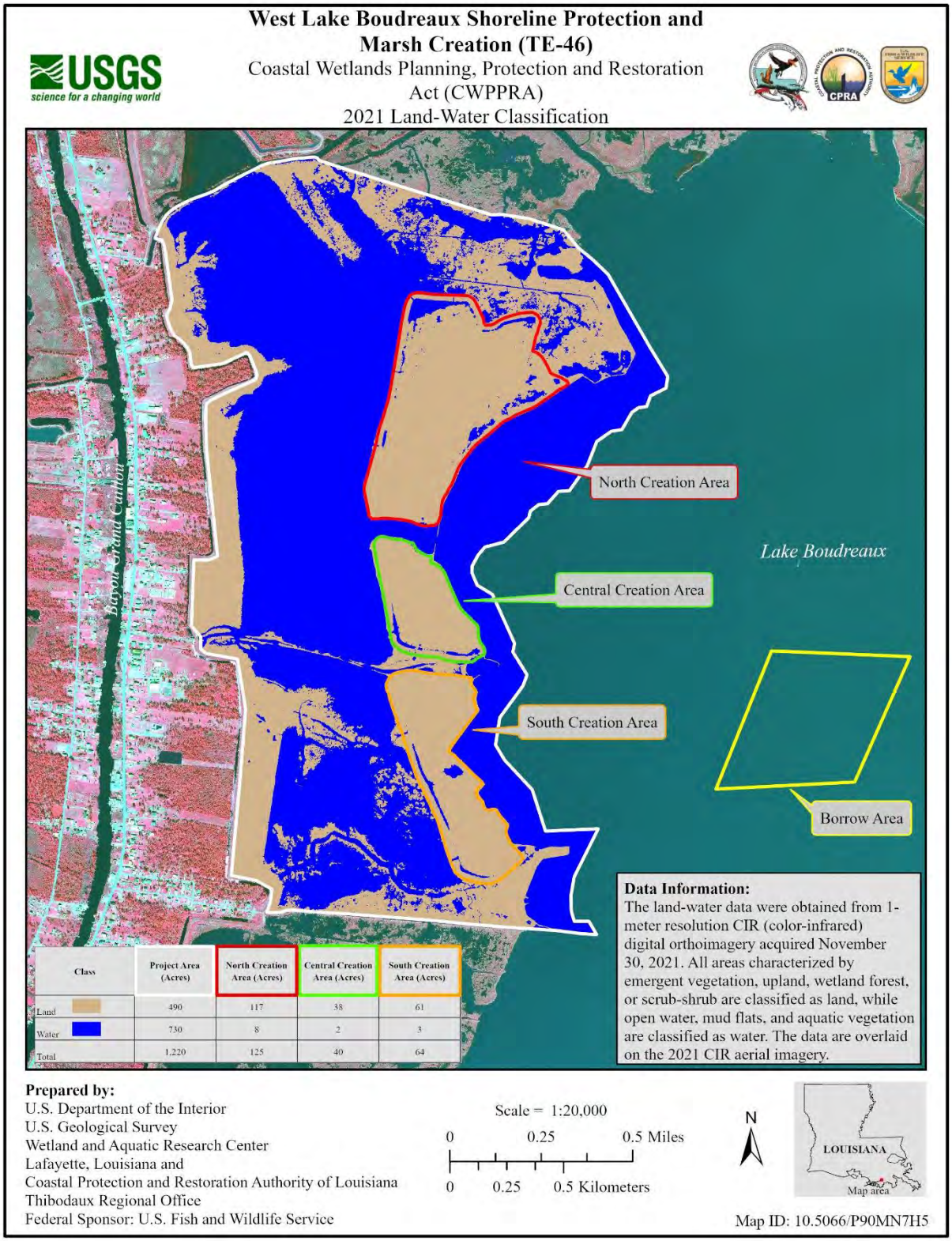


Figure 1. Land-water analysis of aerial photography collected October-November, 2012.



Class	Project Area (Acres)	North Creation Area (Acres)	Central Creation Area (Acres)	South Creation Area (Acres)
Land	490	117	38	61
Water	730	8	2	3
Total	1,220	125	40	64

Figure 2. Land-water analysis of aerial photography collected November, 2021.

APPENDIX B
(Inspection Photographs)

Photo No.1 (8291) – near Sta. 110+00 – rock dike shoreline (Northern Segment).

Photo No.3 (8295) – near Sta. 111+00 – rock dike shoreline (North Segment).

Photo No.2 (8292) – near Sta. 110+00 – rock dike shoreline (North Segment)

Photo No.4 (8296) – near Sta. 116+00 – rock dike shoreline (North Segment).

Photo No.5 (8297) – near Sta. 120+00 – rock dike shoreline (North Segment).

Photo No.7 (8301) – near Sta. 150+00 – rock dike shoreline near bank opening (end of North Segment).

Photo No.6 (8299) – near Sta. 130+00 – Low section of rock dike shoreline (North Segment).

Photo No.8 (8302) – near Sta. 154+00 – rock dike gap with warning signs (End of North and Beginning of Central Segment).

Photo No.9 (8303) – near Sta. 154+00 and 300+00 – missing sign at rock dike gap (End of North and beginning of Central Segment).

Photo No.11 (8309) – near Sta. 400+00 – rock dike gap near pipeline channel (Southern Segment).

Photo No.10 (8305) – near Sta. 305+00 – rock dike shoreline (Central Segment).

Photo No.12 (8311) – near Sta. 406+00 – rock dike shoreline (Southern Segment).

Photo 13 (8312) – near Sta. 412+00 – rock dike shoreline (Southern Segment).

Photo No. 15 (8315) – near Sta. 417+00 – rock dike shoreline (Southern Segment).

Photo 14 (8313) – near Sta. 415+00 – rock dike overgrown with vegetation with sediment buildup in front of structure (Southern Segment).

Photo No. 16 (8316) – near Sta. 423+00 – rock dike shoreline (Southern Segment).

Photo No. 17 (8317) – near Sta. 423+00 – rock dike shoreline (Southern Segment).

Photo No. 19 (8320) – near Sta. 432+00 – rock dike shoreline (Southern Segment).

Photo No. 18 (8318) – near Sta. 430+00 – rock dike shoreline (Southern Segment).

Photo No. 20 (8322) – near Sta. 438+00 – missing sign at marsh keyway (Southern Segment).

Photo No.21 (8324) – near 438+00 missing sign at rock dike opening/marsh keyway (Southern Segment).

Photo No.23 (8328) – near Sta. 447+00 – warning sign at rock dike gap (Southern Segment).

Photo No.22 (8326) – Rock Dike near Sta. 443+00 – rock dike shoreline (Southern Segment).

Photo No. 24 (8330) – near Sta. 447+00 – rock dike gap (Southern Segment).

Photo No.25 (8331) – near Sta. 447+00 – warning sign location (Southern Segment).

Photo No.26 (8335) – rock dike termination point near Sta. 453+00 (Southern Segment).

Appendix C
(Three Year Budget Projection)

West Lake Boudreaux Shoreline Protection and Marsh Creation (TE-46)			
Three-Year Operations & Maintenance Budgets 07/01/2023- 06/30/26			
Project Manager	O & M Manager	Federal Sponsor	Prepared By
	Babin	*USFWS*	*Babin*
	2023/2024	**2024/2025**	**2025/2026**
Maintenance Inspection	$ 20,823.00	$ -	$ 21,430.00
Structure Operation	$ -	$ -	$ -
Administration	$ 10,000.00	$ -	$ -
COE Administration	$ -	$ -	$ -
Maintenance/Rehabilitation			
23/24 Description:			
E&D	$ 26,000.00		
Construction	$ -		
Construction Oversight	$ -		
Sub Total - Maint. And Rehab.	$ 26,000.00		
24/25 Description			
E&D		$ -	
Construction		$ -	
Construction Oversight		$ -	
	Sub Total - Maint. And Rehab.	$ -	
25/26 Description:			
E&D			$ -
Construction			$ -
Construction Oversight			$ -
		Sub Total - Maint. And Rehab.	$ -
	2023/2024	**2024/2025**	**2025/2026**
Total O&M Budgets	**$ 56,823.00**		**$ 21,430.00**
O&M Budget (3 Yr Total)			**$ 78,253.00**
Unexpended O&M Funds			**$ 1,637,327.00**
Remaining O&M Funds			**$ 1,559,074.00**

OPERATIONS & MAINTENANCE BUDGET WORKSHEET

Project: West Lake Boudreaux Shoreline Protection and Marsh Creation (TE-46)

FY 23/24 –

Administration					$ 0
O&M Inspection & Report				**$ 20,823**	
Operation:					$ 0
Maintenance:					$ 0
E&D:		$ 0			
Construction:		$ 0			
Construction Oversight:	$ 0				

CPRA Direct Costs

Inspection:				
CPRA Engineer 3 – 12 hrs@ $60/hr.:	$ 720			
CPRA Engineer 6 – 12 hrs @ $73/hr.		$ 876		
CPRA Scientist 4 – 10 hrs @ $50/hr.		$ 500		
			$ 2,096	
Report:				
CPRA Engineer 6 – 60 hrs. @ $73/hr.	$ 4,380			

Total Direct CPRA Costs: $ 6,476 x 3% Inflation = **$ 6,670**

CPRA Indirect Costs

Inspection:				
CPRA Engineer 3 – 12 hrs@ $127.30/hr.:	$ 1,528			
CPRA Engineer 6 – 12 hrs @ $154.88/hr.	$ 1,859			
CPRA Scientist 4 – 10 hrs @ $106.08/hr.	$ 1,061			
			$ 4,448	
Report:				
CPRA Engineer 6 – 60 hrs. @ $154.88/hr.	$ 9,293			

Total Indirect CPRA Costs: $13,741 x 3% Inflation =**$14,153**

FY 24/25 –

Administration					$ 0
O&M Inspection & Report				$ 0	
Operation:					$ 0
Maintenance:					$ 0
E&D:		$ 0			
Construction:		$ 0			
Construction Oversight:	$ 0				

FY 25/26 –

Administration					$ 0
O&M Inspection & Report				**$ 21,430**	
Operation:					$ 0
Maintenance:					$ 0
E&D:		$ 0			
Construction:		$ 0			
Construction Oversight:	$ 0				

CPRA Direct Costs

Total Direct CPRA Costs: $ 6,476 x 6% Inflation = **$ 6,865**

CPRA Indirect Costs

Total Indirect CPRA Costs: $13,741 x 6% Inflation =**$14,565**

O&M Accounting:

Total O&M Budget:		$1,664,815.00
OCPR Expenditures to Date:	$ 27,488.11	
Unexpended O&M Budget:	$1,637,326.89	