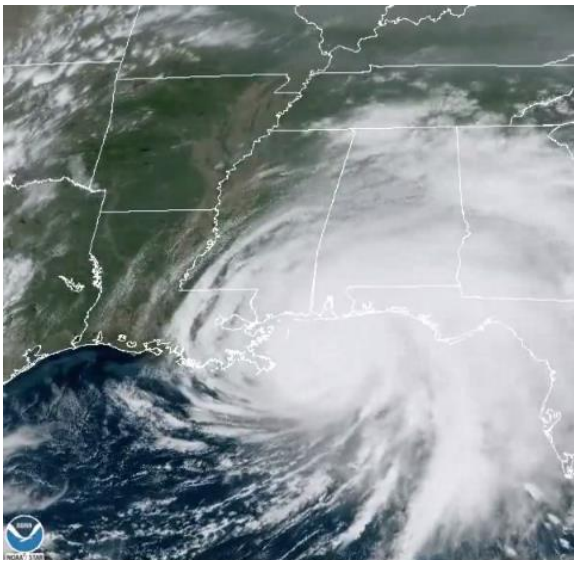

2020 Damage Assessment for Hurricane Sally and Monitoring Report

CITY OF GULF BREEZE DEADMAN'S ISLAND RESTORATION PROJECT

for

The City of Gulf Breeze

and

U.S. Army Corps of Engineers

ESTUARY HABITAT RESTORATION PROGRAM

GULF BREEZE, SANTA ROSA COUNTY, FLORIDA

By Heather Reed, Project Manager

Ecological Consulting Services, Inc.

2020

EXECUTIVE SUMMARY

Ecological Consulting Services Inc. performed a Damage Assessment and monitoring of the Deadman's Island Restoration Project in Gulf Breeze, FL. on September 30th and the month of October 2020, after sustaining impact from Hurricane Sally and Zeta. The assessment included evaluating debris, shorelines, breakwaters, dunes, dredged material disposal sites, previous restoration projects, some areas of Gilmore Bayou, and storm debris. The assessment included evaluating the above and underwater components of the wave attenuator's structural and functional features. This report was conducted at the request of the City of Gulf Breeze and the U.S. Army Corps of Engineers in Mobile, Alabama.

The purpose of the report is to identify the damage, the effectiveness of the environmental and structural stability of the final breakwater design, and provide recommendations based on the science. In addition, the reports identify other areas of impact and compares the difference between the protected regions of Deadman's Island and the non-protected areas. This is the fourth year of a five-year monitoring period for Deadman's Island Part II.

Overall, the restoration areas sustained themselves during the storm and protected the areas most vulnerable to impact. The east and north sides of Deadman's Island sustained significant damage primarily due to wind and water surges. A significant amount of wood and metal debris from damaged docks washed onshore and inshore. Thirty-five units of the breakwater offshore from Deadman's Island are in critical condition due primarily to the collapse of the first two tiers of the structures. One hundred feet out of the four hundred and forty feet riprap barrier along the shoreline and the living shoreline protecting the isthmus are damaged and in critical need of repair. The rock barrier protected the isthmus as designed but received considerable damage. The east end of the rock revetment showed the most impact. In addition, well established vegetation and the protective berm were also damaged.

The vegetation on the north end was entirely covered with one to two feet of sand. The vegetation under the sand over-wash may not survive due to the excessive sand. If the wind does not uncover the vegetation over time, the vegetation will need to be replanted to help restore the site. The most devastating damage was on the west side of Deadman's Island. The western side of Deadman's Island contains dunes that protect the historic Juncus saltmarsh. Pilot restoration projects that were implemented to determine the best method to restore the dunes are also gone. The original ten-foot tall dunes were severely impacted and scarped in some areas to a length of forty-five feet from the dune's original toe line. This scarping exposed and in some cases uprooted trees deep in the ground and removed all surface vegetation. The tree trunks were uncovered four feet in some areas and three feet in most areas. This Dune section is in serious condition, with significant wear and section loss. This needs to be repaired as soon as possible before the next storm or the protected area will be breached.

Thirty-five of the 371 units of the breakwater offshore from Deadman's Island were impacted. The 35 units have two tiers completely broken, and the pilings are exposed. The missing portion of the breakwater will allow massive wave surge to impact the shoreline and cause serious erosion.

The dredged material disposal site, where sandy dredged material is stored and used for restoration purposes, received minimal impact along with the living shoreline located on the back side of the dredged material disposal site facing Gilmore Bayou.

Biological monitoring of the reef did not occur this year due to the COVID-19 pandemic and concern for sharing masks, dive gear and other equipment. In addition, there was a lack of boat access due to the new construction and closure of the three-mile bridge.

Contents

1.0 Project Overview

The Deadman's Island restoration project protected the unmarked cemetery, Juncus sp. salt marsh, living shorelines, the bluffs and the residential homes during the storm. However, the site needs significant repairs to continue this protection over the long term. All restoration project components were damaged, but environmental and cultural resources, along with residential areas, would have been compromised and damaged without the restoration project's protective measures.

The site has been categorized in Section A-E.

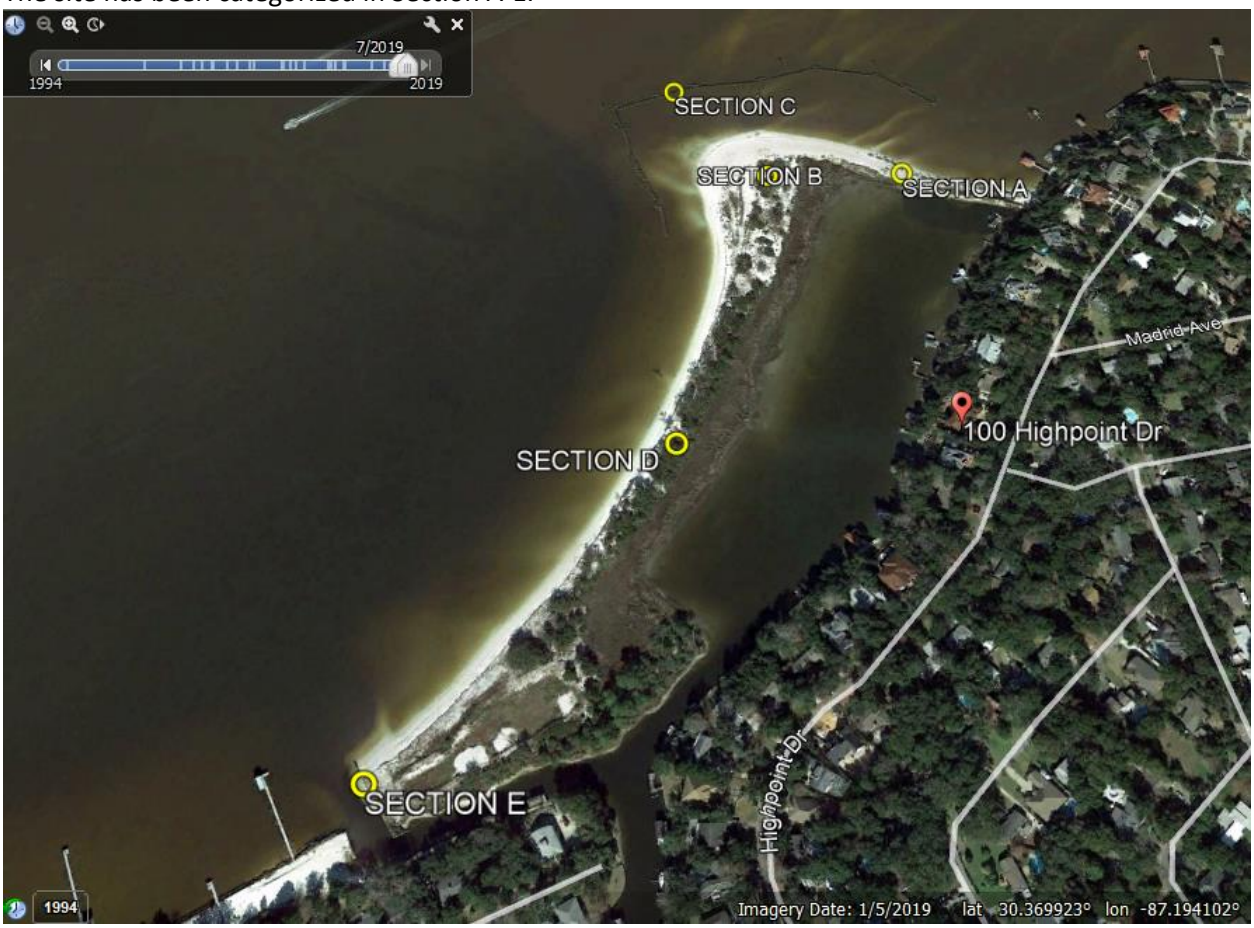

Figure 1: Deadman's Island separated into Damaged Sections A-E

1.1 Project History

Deadman's Island has been a victim of erosion since the beginning of the hardening of the shorelines through seawalls and the construction of the three-mile bridge in the 1940s. The three-mile bridge interrupts the natural littoral sand movement and blocks the sediment transport where the land on the west side of the bridge is not receiving the sand which generally re-nourishes the shorelines. The seawalls continue to scour the adjacent property owners who do not have a seawall, and the homeowners of the impacted property have no choice but to build a seawall to protect their

land and start a "domino effect" of erosion to another adjacent property. A shoreline change has been observed throughout the years and has been described in detail in earlier U.S. Army Corps of Engineers (ACOE) monitoring reports and presentations (Reed 2013, 2015).

Deadman's Island is listed as John H. Chafee Coastal Barrier Resources System (CBRS) in the State of Florida. As a recognized conservation CBRS and Historic site, it is essential to preserve the natural wildlife and unique characteristics of this coastal ecosystem and 1000-year-old Juncus salt marsh inside an open bay system. The site is considered a migratory bird drop zone and a juncus sp. salt marsh (wetland). Deadman's Island is a conservation area for five endangered species and one critical habitat. Over 48 different species of birds, including many migratory species, reptiles, fish, mammals, and amphibians occupy the site over various times of the year (IPaC 2020 and Appendices).

In 2005, Hurricane Dennis exposed several coffins and human remains. The State Historic Preservation Office informed the City of Gulf Breeze that they needed to start preventing the erosion that was causing unearthing of historic structures and human remains. To stop the decline and avoid further exposure of human remains, 850 feet of the oyster breakwater (ReefBLKS) were placed within the 1,450 linear feet permitted footprint in 2008. The oysters flourished on the Reefblk and created an effective breakwater until 2011, when the structures fell apart.

In 2011 and 2012, a new design of breakwater called "Ecosystems" made by Reefmakers was constructed on site. Including the outer breakers, 530 feet of the 1,450-foot modified footprint was placed on the southwest and northeast location. A 250-foot opening on the northwest end was left to complete the entire breakwater footprint. In 2013, a square shape prototype of the Ecosystem breakwater filled 50 feet of the remaining 250 feet opening.

Not anticipating a complete die-off of oysters, the ReefBLKS continued to lose 90% of the shells inside of the plastic mesh bags during 2012. The loss occured from the shells tumbling by wave actions and falling through the mesh containing the oysters shells. This die-off caused the 850 feet of Reefblk breakwater to become non-functional as a wave attenuator. This non-functional reef caused 16,000 cubic yards of newly placed sand from the summer of 2012 to shift and slowly erode. Barriers placed to contain the sand were displaced and broken up. A combination of all these failures caused the sand to displace and wash away from the inside of the project area. In 2015, the old breakwater was removed, disposed of, and replaced with the newer Ecosystems. This stacked vertical breakwater along with 200 feet of the breakwater located in the barren area was deployed to finish the permitted 1,450-foot footprint of the
State land lease.

In late 2016 and early 2017, an additional 16,000 cubic yards of sand was moved from the existing dredged disposal area located on Deadman's Island and placed on the northern point areas where the sand had shifted and eroded back in 2012. In addition to the breakwater project, an osprey nest platform was relocated on the signage reef pilings at Deadman's Island. Note: The ACOE did not fund this project.

The 2017 eastern shoreline protection project protects the remainder of Deadman's Island. This project addresses the easterly section of the isthmus only. The isthmus is the sandbar between the mainland and the larger landmass of Deadman's Island (Figure 1). The breaching of the isthmus was caused when the isthmus shifted past the existing seawall. Once the upland sandbar eroded south past the seawall, the erosion rate increased and scoured the adjacent living shorelines. This erosion caused the isthmus connection to breach. This breach event created an emergency situation and was repaired by the City of Gulf Breeze in 2017.

In 2018, maintenance plantings continued as well as coastal/underwater cleanups and reef monitoring. The additional project and funding which rebuilt the isthmus with sand and rock became a successful project to date. The storms did knock over some large riprap, but overall the vegetated berm placed behind the rock held up well with only a few intense water blowouts of the established root systems.

In 2019, the monitoring continued, and a small volunteer planting event funded by the National Fish and Wildlife foundation focused on dune restoration on the south end of Deadman's Island.

In 2020, full biological monitoring of the reef was not conducted due to COVID-19 restrictions, lack of site access and cancellation of community volunteer events. However, monitoring of the changes to the north end sand transport project and isthmus rebuilding site were completed along with a detailed account of the Hurricane Sally damage.

1.2 Project Purpose for Restoration

This restoration project was designed to protect the 10-acre peninsula and an existing salt marsh habitat while increasing the biological productivity of the Gulf Breeze aquatic area. An incidental benefit of this project was to protect numerous cultural resources and artifacts identified at the site. The recently placed 16,000 cubic yards of sandy material and vegetation protects and covers historical resources and created a small peninsula that adjoins the land separated by small dunes. In addition, the project created approximately 1.04 acres of an emergent salt marsh for shoreline protection and an additional 0.046 acres of a coastal dune. All of these structures protect the area by reducing the amount of wave energy that reaches the shoreline.

1.3 Project Goals 2011-2020

1. Repair the indirect impact during the oil spill timeframe and place 16,000 cubic yards of sand and stabilize with vegetation. (completed 2017)
2. Remove the degraded 850-foot long oyster ReefBLK ™ structure. Complete the remaining breakwater by installing new breakwater units (Ecodiscs and pilings) to decrease the wave energy, reduce erosion, and stabilize the site. (completed 2015)
3. Protect exposed cultural resource site by covering them with sand and minimizing future erosion. (completed 2016)
4. Create a nearshore island wetland using a local sand source. (completed 2016)
5. Protect, conserve, and restore seagrass beds. (completed 2017)
6. Create sand dunes by constructing them on the nearshore island. (completed 2014)

7. Install Gulf sturgeon monitoring equipment. (no longer present on site)
8. Increase the overall biological productivity of the Gulf Breeze aquatic and shoreline area. (ongoing since 2011)
9. Repair south end dunes to protect *Juncus* salt marsh (2018 and 2019 and severely damaged in 2020).
10. Control erosion and stabilize the shoreline by planting emergent vegetation. (Ongoing)
11. Monitor, maintain and study the site for five years. Breakwater project completed in 2015 (2020 monitoring end date) and sand transport project completed 2017 (2022 monitoring end date).
12. Replace broken tier units from 2018 Hurricane Michael. Note: The main damage is leaning pilings.
13. Replace riprap, replant vegetation, remove debris, repair dunes, repair or replace broken and missing multiple tier units from 2020 Hurricane Sally.

1.4 Status of erosion control structures, breakwater conditions, and vegetation

In 2017, the tides continued to rise higher than the tide charts predicted (Reed 2017). The tides are now higher than initially predicted in the 2007 permitting process. This higher tide caused a portion of the breakwater to be submerged longer than normal. The wave height did not allow the breakwaters to attenuate the wave action and left the shoreline vulnerable. The shoreline's vulnerability caused the shifting of the newly placed sand and washed out some of the new vegetation planted on the north end. A few of the Ecosystem units were manually reset to match the height of the entire breakwater system. We continue to monitor the effectiveness of the vertical wave attenuation system. The storm episodes caused a change in the tidal height, allowing more sand, scouring, and washing away vegetation. This washout is especially apparent on the northwest point of the project site. Some breakwaters were placed to an even height as the other breakwaters were raised to provide better wave attenuation during higher tides.

Comparing the 2013-2020 tides and monitoring reports, the tide charts show an increase in sea-level rise. The field monitoring shows validation where the predicted tides are much lower than the actual tides. This fluctuation causes daily field planning problems, especially for boat launching, since Deadman's Island is boat access only. In 2018, Hurricane Michael generated strong winds from the north for a long period of time. These strong winds damaged and caused some of the offshore breakwater pilings to lean over. In addition, there was excessive shoreline erosion and vegetaton was covered with wind blown sand.
After Hurricane Sally in 2020, a small portion of the breakwater tiers were cracked, broken and lying on the sandy bottom leaving exposed pilings. The unit damage was worse from Hurricane Sally than Hurricane Michael. Hurricane Michael only caused a few of the units to lean. After Hurricane Sally,broken and missing units were observed in several areas. Hurricane Sally did not cause any additional pilings to lean over.

2020 Summary of monitoring results

2.1 Description of Field Work Summary and Results

No underwater monitoring counting the vertebrates and invertebrates were performed this year due to COVID-19.

2.1.1 Oyster Spat Settlement, recruitment, growth rates, predation, and health inspection

No underwater monitoring counting the vertebrates and invertebrates were performed this year due to COVID-19. However, a swim assessment showed an abundance of oysters observed on the reef.

2.1.2 Shoreline vegetation monitoring

In 2020, there was a 10% loss of shoreline and 75% loss of vegetation due to being covered with sand and debris from Hurricane Sally. The shoreline of the isthmus remained stable except for a 100-foot section behind the breakwater that was scoured.

2.1.3 Finfish surveys

No underwater monitoring counting the vertebrates and invertebrates were performed this year due to COVID-19. However, a swim assessment showed an abundance of fish observed on the reef.

2.1.4 Wetland creation

Did not meet the criteria. Hurricane Michael smothered the Sporrey wetland bogs and filled the depressions created for the bogs with sand.

2.1.5 Reef Structural Integrity

Overall, the structural integrity of the reef has been ideal as an offshore oyster reef/fish habitat. However, Hurricane Sally damaged 35 out of the 371 units. Hurricane Sally further impacted the units that were damaged by Hurricane Michael by causing some of the pilings to lean at a steeper angle.

2.0 Abiotic Factors affecting the project

3.1 Storm Events- Number of high- water events/ significant storms 2020

In contrast to the 2019 season, 2020 was the most active year of hurricanes and tropical storms for the project and Gulf Coast to date. The storms that created the most activity were Hurricane Cristobal, Delta, Hanna, Laura, Marco, Sally, Delta, Zeta, and Tropical Storm Bertha*, TS Beta. The two storms that impacted Deadman's Island the most were Hurricane Sally and Hurricane Zeta. The other storms will be discussed regarding sea-level rise, but Deadman's Island's primary visible damage was from Hurricane Sally.

3.1.1 Hurricane Sally

On September 16, 2020, Hurricane Sally made landfall as a Category 2 at 4:45 am in Gulf Shores, Alabama causing catastrophic and life-threatening flooding along portions of the North-central coast. The Category 2 Hurricane had a maximum sustained winds of 105 mph with a low barometric pressure

of 28.50 inches (Figure 2, WS NHC Miami FL, AL192020, September 16, 2020). Hurricane Sally significantly damaged the beach at Deadman's Island due to storm surge and extreme wave action. Deadman's Island sustained significant damage to the east, west and north sides. The well-established restoration project protected the unmarked cemetery, Juncus sp. salt march, living shorelines, the bluffs and residential homes during the storm. The island now needs repairs to continue this long-term protection. The following components were damaged; rock revetment with sand and vegetation, dunes, beaches and the offshore breakwater protecting a living shoreline. In addition, heavy construction debris washed onshore which included lumber, and metal debris from damaged docks. Thirty-five units of the breakwater offshore were damaged. The vegetation on the north end of the island was entirely covered with one to two feet of sand.

Several days before Hurricane Sally crossed the Gulf Coast, water levels along the Escambia and Santa Rosa County area began to rise above normal levels. On September 10, the waters levels began rising to above normal tide levels; the ground speed of the storm traveled at a slow 2 -3 MPH NNE, which cause the 60+MPG winds at Deadman's Island and the surrounding Gulf Breeze area to continually be impacted by winds, rain, and flooding. By the afternoon of September 14, 2020, the water level in front of Deadman's Island was about 2 feet above average tide level (Figure 3). The disparity had increased to more than 3 feet on September 15, 2020. Shortly after this time, the storm's principal winds began to shift into the west area of Deadman's Island causing the well-established dunes to wash away.

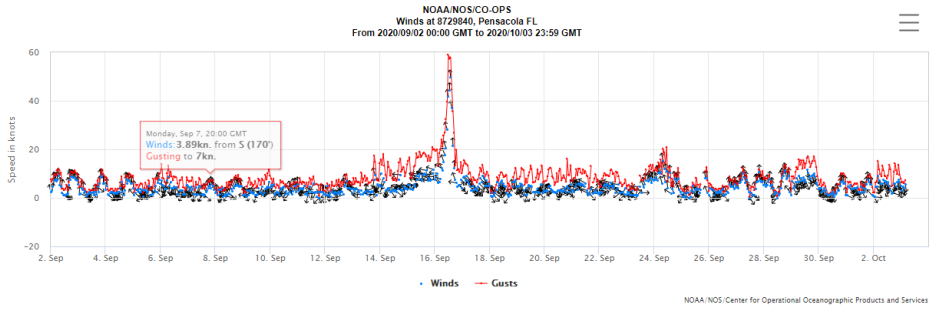

Figure 2: September 2020 wind data

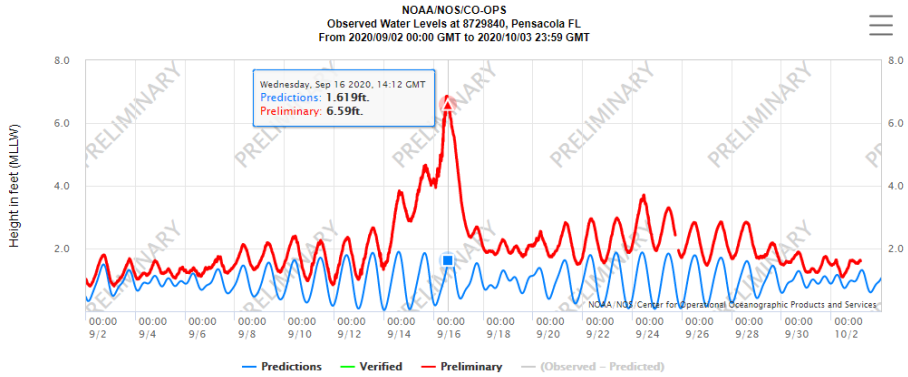

Figure 3:Tide levels for Pensacola Bay in September 2020

3.1.2 Hurricane Zeta

Hurricane Zeta made landfall in Louisiana, moved northeast, and impacted Pensacola/Gulf Shores on October 29, 2020. The Gulf Breeze area was hit with winds gusts of 43 mph with a ground speed of 31.07 mph (Figure 4, NOAA.gov 2020). Unfortunately, there is no NOAA tide data or flyover data for this time period. Zeta was a fast storm, and the high winds caused minimal new damage but did impact various areas that had previous damage from Hurricane Sally.

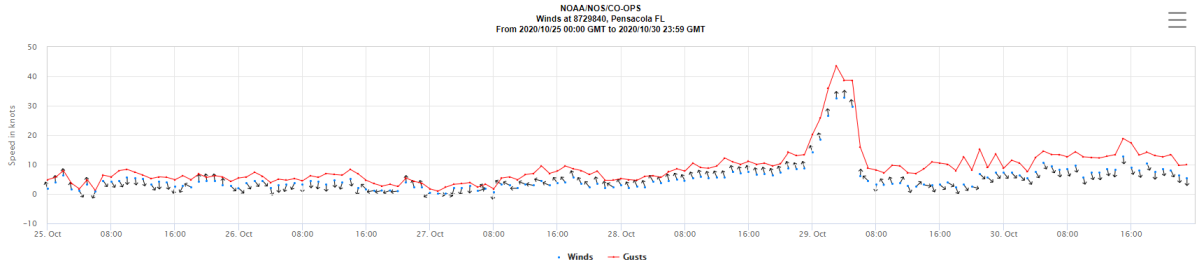

Figure 4: Winds gusts and direction for Hurricane Zeta Oct. 29, 2020

3.0 Project Damage Assessment – Hurricane Sally

Section A- The Isthmus Restoration Project

Introduction

Hurricane Sally brought in high winds, rising tides, and massive storm surges. This hurricane scattered and leveled 100 feet of riprap on the northeast end of Deadman's Island from 09/14/2020 to 09/17/2020. The riprap was buried in the sand, cannot be retrieved and needs to be replaced. The storm's impact threatened the stable sand berm and caused a near breach of the isthmus. This near breach currently threatens nearby homes and other natural resources if it is not repaired before the next hurricane season.

Project Background

The Isthmus project on the northeast end was constructed in 2017. This project was needed due to a breach in the isthmus during 2016 which caused massive damage to waterfront properties, bluffs, Deadman's Island, and the living shorelines. The Juncus salt marsh was also on the verge of becoming threatened due to rising salinity levels. A total of 6,500 CY of sand was pumped and transported to the north end, and riprap was placed to protect the fresh sand from washing out.

There were five strategies to prevent additional erosion on Deadman's Island: #1 Riprap/oyster shells over geo-fabric. This method has been used for many years for breakwater projects. The oyster shell was needed for permitting purposes only to have a hybrid breakwater. There were breaks in the riprap design for permitting purposes only. The rocks provided a barrier, and for future planning, if the erosion continued, the rocks would provide a breakwater. #2 Vegetation. The vegetation behind the rock and along the rock's edges would act as a natural dissipater for mild wave action and build sand. #3 Berm. A berm was created as a back-barrier if water inundated the ground or washed out the plants. #4 Plants.

Deep-rooted and shallow-rooted plants were planted to keep the berm stabilized by a robust rhizome root system—#5 Living Shoreline. Living shorelines along the backside of the berm along the north end of Gilmore Bayou. The root system of wetland plants are robust when entwined together and are tolerant of saltwater and flooding if the berm with the semi-upland plants happened to wash out. Maintenance is recommended as needed, but until the storm impact, it has required little maintenance.

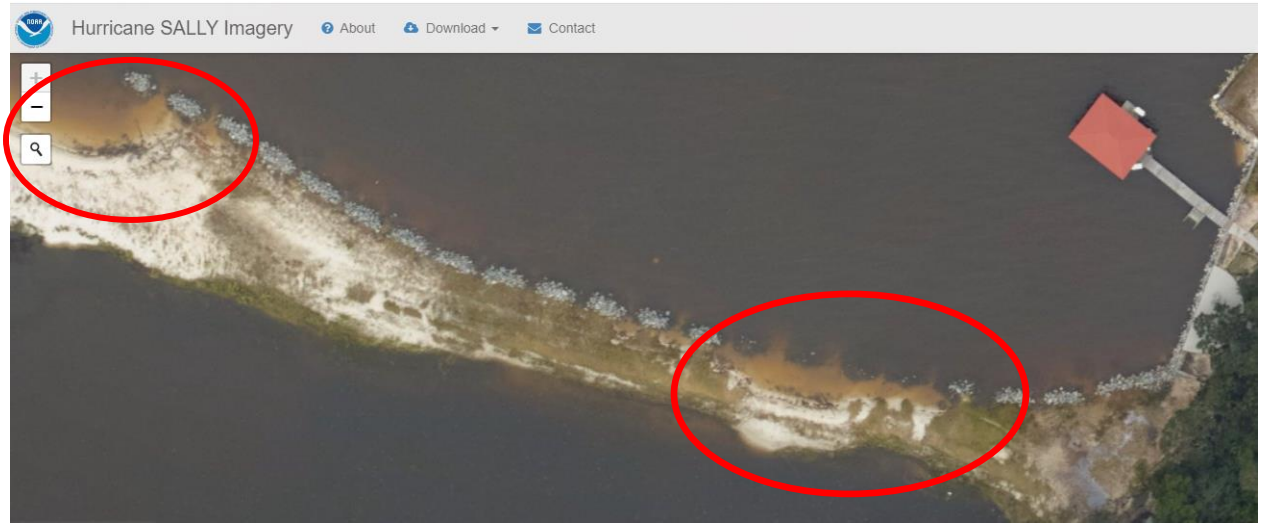

Figure 5: Section A- Isthmus Project - circled in red are areas of impact from Hurricane Sally September 16, 2020. Aerial photo taken September 19, 2020.

Figure 6:Section A- Area impacted behind the revetment (green) overall polygon of project area of Isthmus (Yellow), July 2019.

The first component of damage is the 500ft rock revetment on the east-west part of the isthmus (Figure 6). Prior to Hurricane Sally, the rock revetment stabilized the isthmus protecting homes with living shorelines and unique natural wildlife resources. The design consisted of class II riprap and sand, and plants. The rock revetment is 500 feet long from the east end (30.368035°,-87.184701°), and the west end was (30.368391°,- 87.186174°). The storm impacted and destroyed approximately one hundred feet of the project. This replacement will restore the riprap to the existing footprint of 100 feet x 6 feet x 5 feet (30.368058°/- 87.185266°). The City of Gulf Breeze will replace the riprap by placing 111 cubic yards (150 tons) of Class II riprap on top of the existing rock to bring back the project as pre-storm design.

Vegetation and sand behind the revetment

The second component of damage is the mixed species of vegetation which stabilized the sand. This was also destroyed. The polygon plotted shows a total of 2,832 SF/315 SY (30.367978°,-87.185314°) and 611 SF/67.9 SY (30.368310°,-87.186115°) area impacted behind the revetment. One hundred and twenty-seven cubic yards (3,443/27= 127 CY) of sand was also lost along with numerous plants that helped stabilize the area. The total area of sand and vegetation loss was 3,443 SF/382.9 SY (Figure 6).

Summary

Overall, this project held up exceptionally well during Hurricane Sally considering the strength and duration of the storm. However, during Hurricane Sally, 100 feet of the isthmus rocks restacked from Hurricane Michael scattered and blew out. (Figure 6). In 2017, the riprap was placed upland (Figure 7) to anticipate additional erosion from the lack of sediment transport (starvation of sand) from the bridge construction project nearby. The gap in the riprap and loss of riprap has caused scarping behind the rocks, created a "washing machine" effect, and caused significant loss in vegetation and sand. The erosion pins used before construction and were buried two feet below the surface are now exposed (Figure 8).

Recommendation:

The berm will need repair. The City of Gulf Breeze is responsible for the repair of the isthmus since this was not part of the Deadman's Island Part I or II project that the U.S. Army Corps of Engineers funded. Additional riprap will be required to secure the isthmus one again. Scattered riprap is sinking in the sand and the water. We know from previous work that it is more costly to remove than to replace the riprap. This type of hazard mitigation would be considered an emergency action since the environmental, historical, and residential property is threatened if the isthmus is fully breached. It would be more cost-effective to repair the damage now than wait for a similar situation and more costly solution in 2016. Hurricane Zeta increased the tide height for about 16 hours, but overall, the water level did not rise as high as Hurricane Sally.

Scope of Work

Deadman's Island is a boat access only site with no public entrance from the mainland. The riprap will be trucked and loaded onto the barge, deployed with offloading equipment, and stacked on the existing riprap. The contractor will supply materials, labor and the appropriate barge and offloading equipment to deploy 111 CY of Class II riprap on the Northeast end of Deadman's Island (Section A) in Gulf Breeze. Staging of the heavy equipment is by barge only and not on land. Once deployed, the riprap will be shaped either by hand using labor or machine. A turbidity curtain is required. Existing upland vegetation is not to be disturbed. (30.367948°/ -87.185534°).

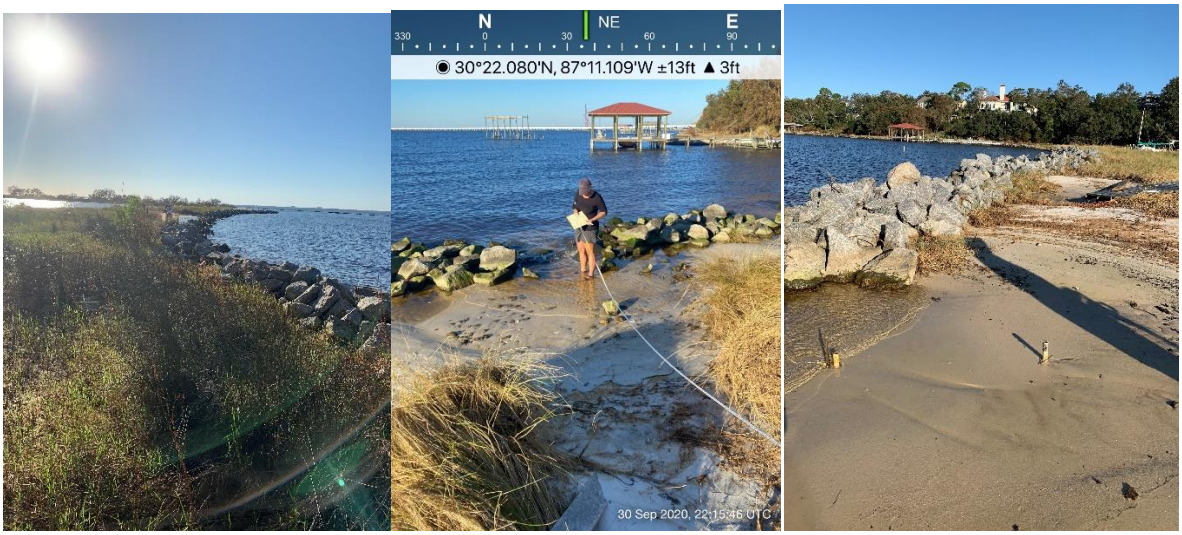

Figure 7: Isthmus project -Left: The ~800FT project is mostly undisturbed by Hurricane Sally. Middle: 100 FT of Riprap was impacted and scarped and eroded the vegetation and protective berm. Right: Horizontal scarping reduced the elevation and exposed the original 2017 pre-construction sediment markers.

Section B-2017 Sand Transport and Community planting vegetation behind the off-shore breakwater

Introduction

Hurricane Sally brought high winds, rising tides, and massive storm surges that eroded the shoreline located directly behind the breakwater and washed sand over mixed vegetation species (Figure 9). The storm's impact endangered the north point's stability and the 16,000 CY sand transport project constructed in 2017 by displacement of sand on top of adjacent vegetation and the nearby Juncus saltmarsh. The sand washed onto the northern end of juncus saltmarsh and smothered a portion of the wetland. The City of Gulf Breeze has maintained the vegetation over the years and has planted over 160,000 plants of mixed species on the transported sand to maintain the stabilization northern end and protect the unmarked cemetery and other historical resources. The City continuously replaced the vegetation as needed. It is estimated through GPS and mapped polygons that over one hundred thousand plants have been smothered or lost along with over forty-four thousand square feet of marsh. The amount of sand lost between Hurricane Michael and Sally was over twenty-four thousand square feet with an average of three feet elevation or 2,743 cubic yards.

Project Background:

In 2017, 16,000 cubic yards of sand was replaced on Deadman's Island's north end to protect an unmarked cemetery and Juncus saltmarsh. This project resulted in several community plantings each year. Over time, a succession of the shoreline vegetation was established. Eventually, 13 varieties of plants were planted to create a robust root system for stabilization. Each planting method varied due to beach elevation changes.

Hurricane Sally impacted the north end beach causing some erosion but mainly displacing the sand (See Figure 9). Hurricane Zeta repositioned sand lost from Hurricane Sally and caused a minimum washout of sand on onshore. During Hurricane Sally, the north end lost the elevation of sand but mostly maintained the original placement's shape. Vegetation was not uprooted but covered with sand. In the past, when sand is displaced over plants past the height of 2 feet it is less likely these plants will survive unless the wind blows the sand off the smothered vegetation.

Typically, the buried vegetation does not recover unless the wind blows the sand off the vegetation over time. Some areas only have a few inches of sand covering the vegetation and the green of the vegetation's stems is visible for photosynthesis. When this has occurred in previous storm events, there is a higher possibility of recovering. A simple fix is to rake the sand until the plants become visible. Unfortunately, due to COVID-19 precautions, the City could not have a volunteer event this year. Additional maintenance is needed for this project to help the vegetation recover.

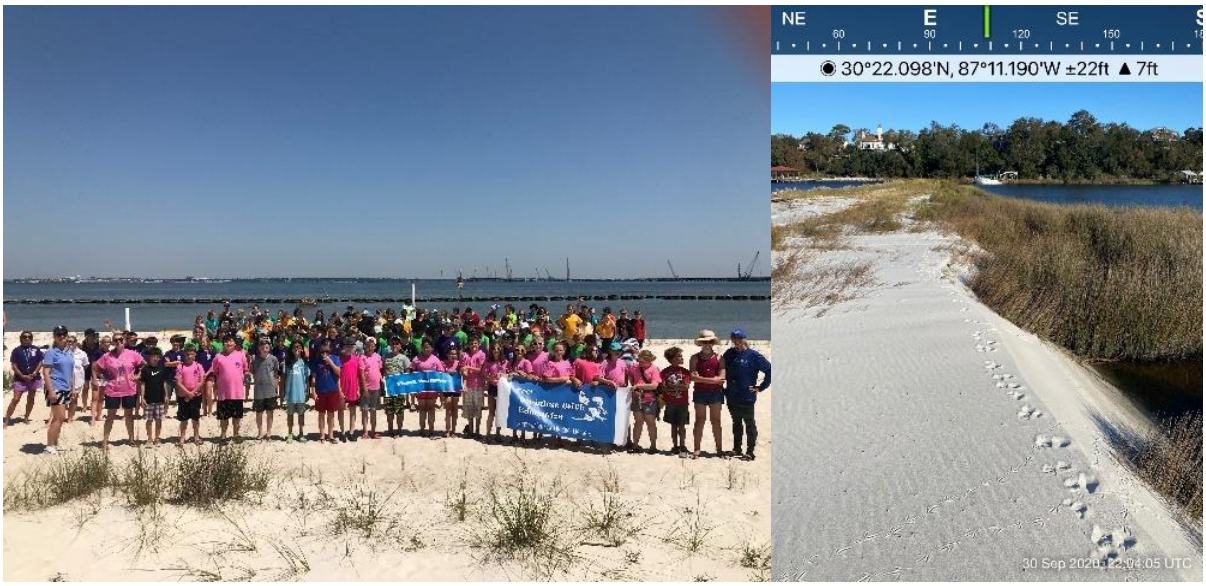

Figure 8: Community outreach volunteer have restored this area over time to the 1976 shoreline. Right: Hurricane Sally displaced and deposited sand in a juncus salt marsh hence smothering the saltmarsh.

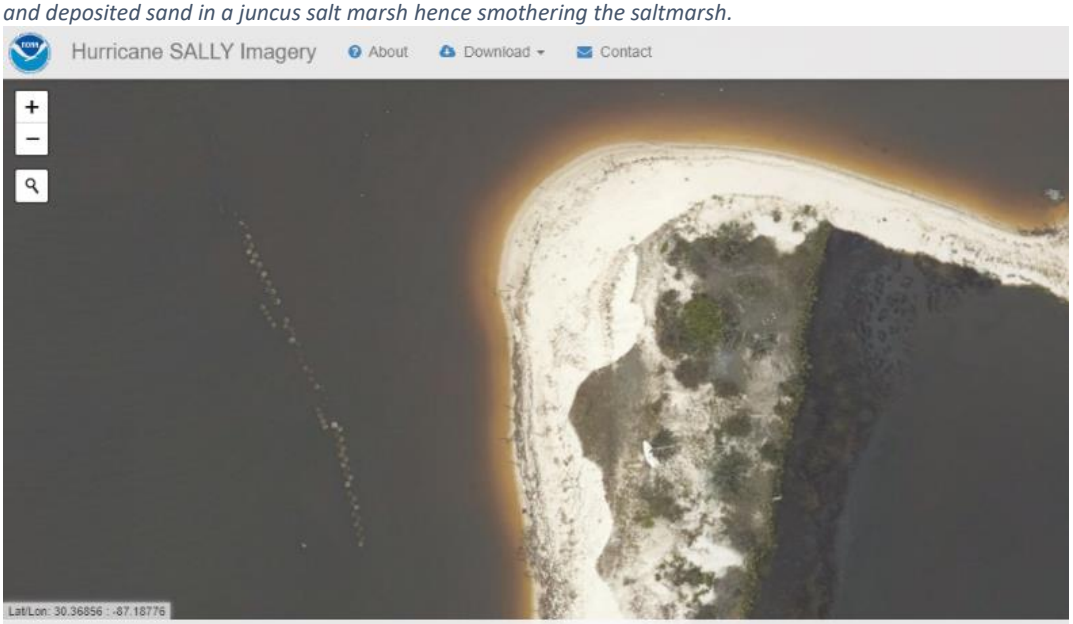

Figure 9: North end (Section B) After hurricane Sally via NOAA Sept 18, 2020

Figure 10: Sand loss between Hurricane Michael and Hurricane Sally

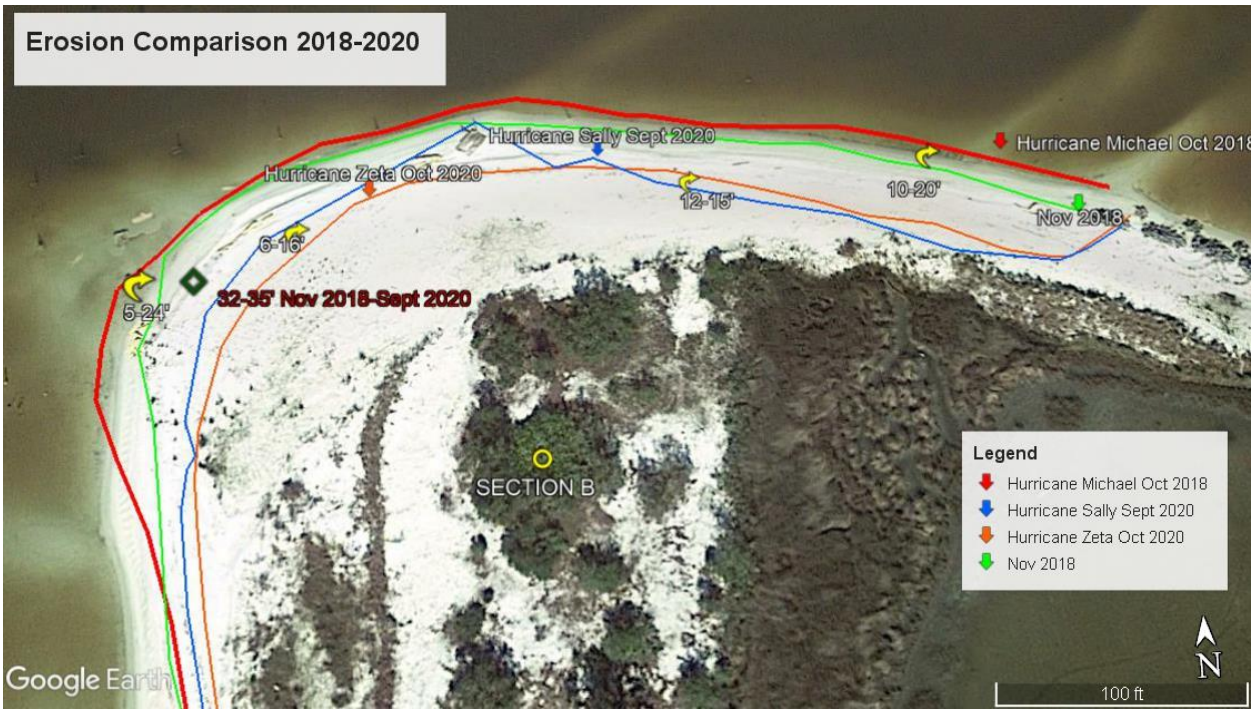

Figure 11:Erosion comparison from 2018-2020

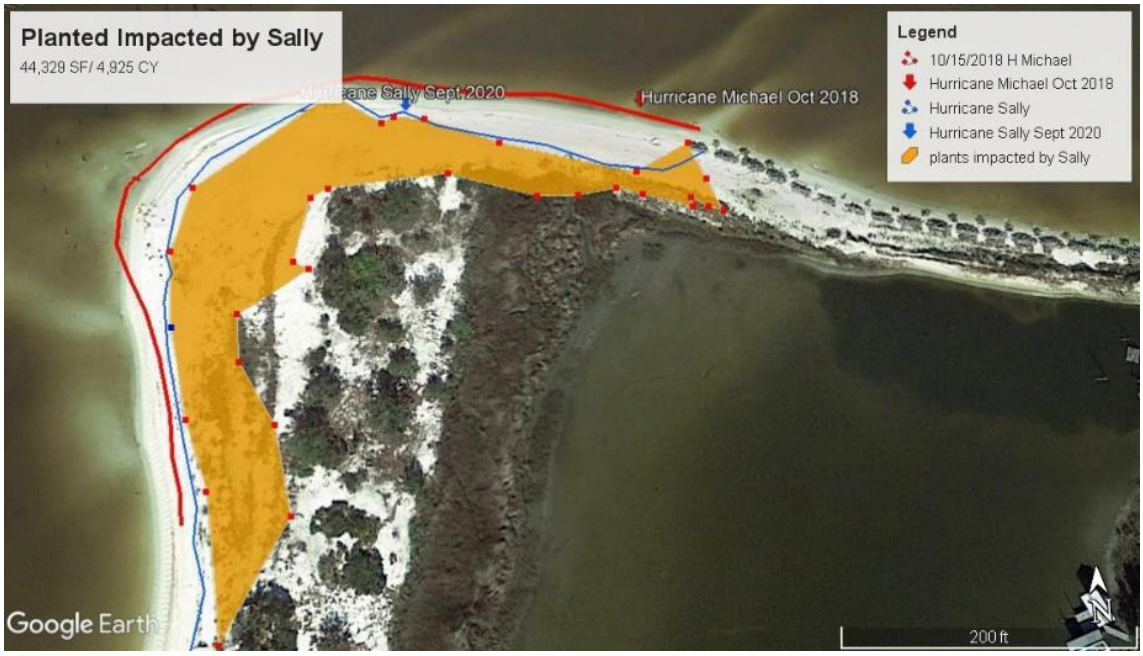

Figure 12:Vegetation impacted by Hurricane Sally

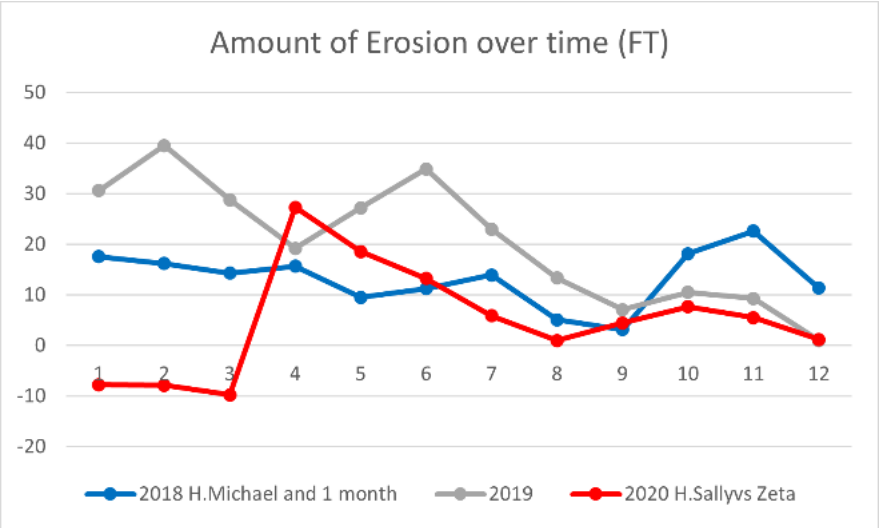

Figure 13: Erosion Comparison 1 month after a Hurricane

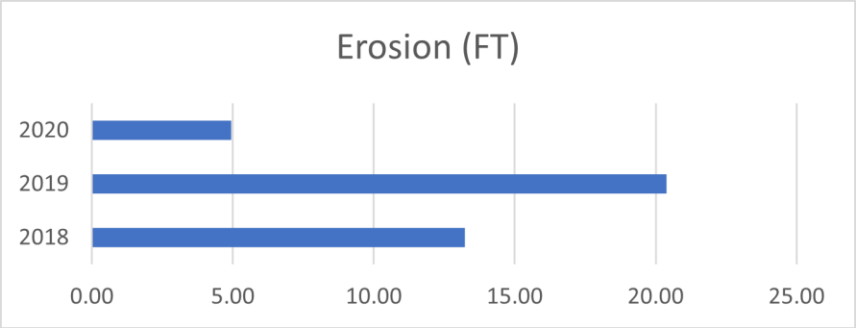

Figure 14: Amount of erosion one month after a hurricane and one month after storm surge.

Methods and Results

A GPS shoreline survey was taken one month after each storm. The rate of erosion was compared to Hurricane Michael and Sally (Figure 10 & 13). Waypoints were also taken one month after each Hurricane (Figure 14). The average rate of erosion of Hurricane Michael and one month after in 2018 was 13.23 ft. The range of erosion measured was from 3.13 feet to 26.16 feet. The erosion rate between Hurricane Sally and Hurricane Zeta in 2020 was 4.95 feet. The range of erosion measured was from 1.2 feet to 27.29 feet. This erosion was measured and compared to hurricanes that previously impacted the site (Figure 12). This observation leaves a question about a large amount of erosion in 2019 when no significant hurricanes impacted the project site. In the 2019 monitoring report, lunar changes and tidal influence may be responsible since there were many higher than normal tide changes caused by super full moons (Reed 2019). These super moons affect the sea level and the earth's distance before the lunar perigee. The closest new moon of the year will cause larger than usual

perigean spring tides. There did not seem to be a correlation specifically to the lunar phases (Figure 15). The two-foot+ tides were over last year's one-foot average (Figure 16).

Figure 16 shows the predicted vs. actual tide where the actual tide was once again higher than predicted but shows the tide level's rise and fall during full moon events and various hurricane events.

2020 Moon Phases Calendar

Jan	2:◐,	10:○,	17:◑,	24:●	
Feb	1:◐,	9:○,	15:◑,	23:●	
Mar	2:◐,	9:○,	16:◑,	24:●	
Apr	1:◐,	7:○,	14:◑,	22:●,	30:◐
May	7:○,	14:◑,	22:●,	29:◐	
Jun	5:○,	13:◑,	21:●,	28:◐	
Jul	4:○,	12:◑,	20:●,	27:◐	
Aug	3:○,	11:◑,	18:●,	25:◐	
Sep	2:○,	10:◑,	17:●,	23:◐	
Oct	1:○,	9:◑,	16:●,	23:◐,	31:○
Nov	8:◑,	14:●,	21:◐,	30:○	
Dec	7:◑,	14:●,	21:◐,	29:○	

Special Moon Events in 2020

- Super Full Moon: Mar 9
- Micro New Moon: Mar 24
- Super Full Moon: Apr 7
- Penumbral Lunar Eclipse visible in Pensacola on Jul 4 – Jul 5
- Black Moon: Aug 18 (third New Moon in a season with four New Moons)
- Micro Full Moon: Oct 1
- Super New Moon: Oct 16
- Blue Moon: Oct 31 (second Full Moon in single calendar month)
- Micro Full Moon: Oct 31
- Super New Moon: Nov 14
- Penumbral Lunar Eclipse visible in Pensacola on Nov 30

Figure 15: 2020 Lunar phases and special moon events

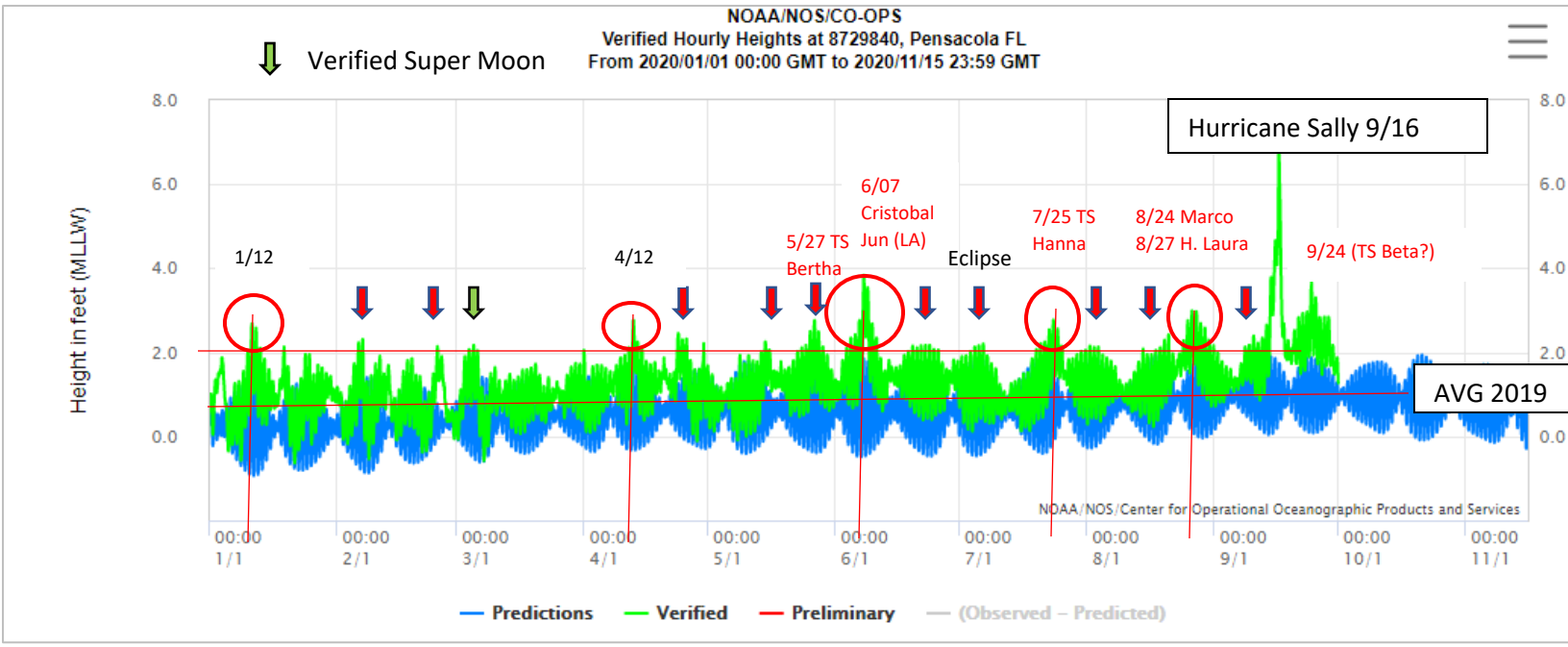

Figure 16: 2020 Tide, lunar and hurricane events

Discussion

In 2020, it was difficult to correlate any increase in water level rise to the lunar cycles as in 2019 (Figure 15). The issue may be due to the incredible hurricane season this year. Observing the graph of the 2020 tides and lunar events vs Hurricanes (Figure 16), it appears there is no correlation to the moon and high tides as were similar last year. However, after reviewing the water level, a trend and correlation to increasing tides due to tropical storms and hurricanes may have been more apparent than initially thought. The surprising fact is that the water level did not rise with just local hurricanes but hurricanes elsewhere that did not impact the area.

The average tidal rise in 2019 was only one foot. This year, the average rise was almost two feet. Reviewing past reports since 2007, we have had more rising sea levels this year than any other year. In fact, with these rising sea levels, as mentioned in previous reports, the upland vegetation and coastal vegetation tends to suffocate under longer than normal exposure times. When vegetation is submerged long periods of time, the root system dies. When this die-off occurs, stabilization of the root system is lost and therefore the land erodes further. If this erosion occurs each year, not only would the adjacent property be affected but properties located downstream that are affected by the littoral drift. Shorelines that were once renourished by the littoral drift and sediment transport are no longer in the pathway of the transport and lose valuable accretion over time.

Hurricanes and tropical storms tend to rise and lower tides as well create surges and erosions (Figure 13, 14, 16). Studies of previous projects do correlate with hurricanes impacting coastal restoration projects (Reed 2019). One observation of the most drastic impacts of water level change that was surprising was Hurricane Irma in September 2017. Hurricane Irma impacted Florida over 500 miles away from Pensacola and Deadman's Island. Although the hurricane was 500 miles away, the water in Pensacola Bay receded drastically, exposing shallow water seagrass under docks. When looking at the water level chart for Hurricane Irma during the timeframe, they were -0.62 inches in Pensacola Bay (Figure 15). The water level receded very quickly in Pensacola Bay and correlated to the tide data and timeframe when Hurricane Irma impacted South Florida (NOAA 2017). The water level quickly receded and gave an eerie impression of a tsunami characteristics, but without a preceding earthquake. The water was pulled from the shallow tidal flats exposing seagrass and fish. It was expected the water would surge and return the water levels quickly causing higher tidal action and impacting at least 15 feet upland. Instead, it took a day for the water levels to slowly return to normal. It was incredible how a powerful storm 500 miles away could remove such a quantity of water from Pensacola Bay.

In the field, high tides and moon phases are often correlated (Figure 15 and 16). Often the projects are planned around the moon phases for safe in-water work. The Irma water level observation has created the chance to observe water levels not only during the moon phases but with *any* Gulf Coast hurricane as well. The Gulf Coast received seven intense hurricanes and several tropical storms in 2020, including tropical storm Bertha on the east side, where it impacted South Carolina. The conclusion made is based on the frequency of the hurricanes with a combination of the tidal pull governed by the moon phases and causing a long-term impact from erosion and land loss over many years without recovery.

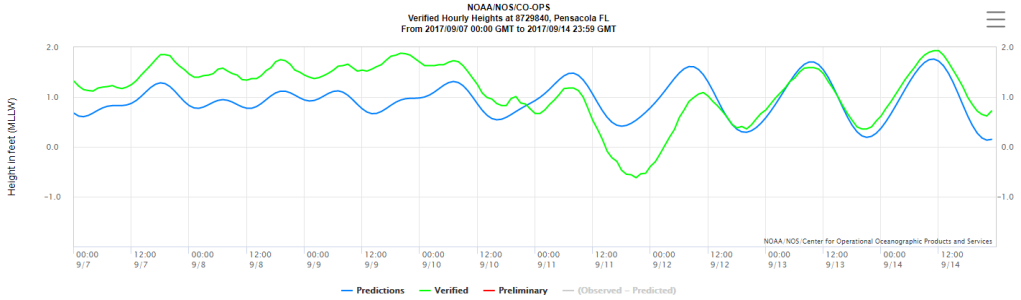

Figure 17: Hurricane Irma impacted south Florida on September 10, 2017. The Hurricane was over 500 miles away and caused a drastic drop(-.062)in the water levels of Pensacola Bay.

Recommendations

Short Term

Short term recommendations for the impact to the plants is to pay for the labor to uncover the buried vegetation using shovels and hand rakes. The vegetation needs some exposure to the sun for photosynthesis to recover. Raking the sand and exposing the plants to sunlight will help in the recovery process.

The second recommendation is to replant any areas that cannot be recovered.

Create wetland bogs developed in 2012 and 2014 to protect the compromised upland.

Long term

Develop a budget and maintenance plan to replant vegetation after a storm. Currently, the City of Gulf Breeze has one to two community planting events per year. These event dates sometimes do not coincide with the storms events.

Section C- Breakwater/wave attenuator project

Introduction

Hurricane Sally brought in high winds, rising tides, and massive storm surges and impacted 35 breakwater units and 140 tiers from these units. **Critical condition** is defined as "very advanced deterioration, overstressing, or breakage has resulted in localized failure(s) of primary structural elements," and typically warrants replacement to be carried out on a high priority basis with strong urgency (ASCE 2015). Deadman's Island is currently at this point. This urgency is due to the shoreline's vulnerability, where a missing portion of the offshore breakwater (Ecosystems) can allow massive wave surge to impact the shoreline and cause erosion. In addition to the breakwater damage, the storm damaged (6) solar lights and caused a large piling with navigational aid signage to break up and wash onshore.

Summary

These reefs are boat access only. An underwater inspection of the reefs showed 35 units out of the 371 were impacted (Figure 18, 19, 20). The 35 units were located mostly on the north end and each have at

least two tiers are completely broken and the pilings are exposed. These units were placed in 2011, and the final section was completed in 2015. These units sustained more damage during Hurricane Sally than Hurricane Michael. Hurricane Michael damaged 32 units but did not break off the individual tiers. Hurricane Michael's repairs were conducted this year by the contractor (ReefMakers). They straightened the leaning pilings and repaired some of the broken units. Except for the piling and the signage, Hurricane Sally's reef damage was not repaired this year. Reef Maker did inspect the site and made minor repairs to some of the leaning pilings. There are still 140 tiers that need to be replaced on 35 pilings.

Recommendation

Replace the reef units damaged by Hurricane Sally. Lessons learned from Hurricane Michael showed that we needed to increase the height of the reef by adding more breakwater units.

Figure 18: Section C- Damaged reef units after Hurricane Sally

Figure 19 : Section C- July 2019 aerial of the northern breakwaters.

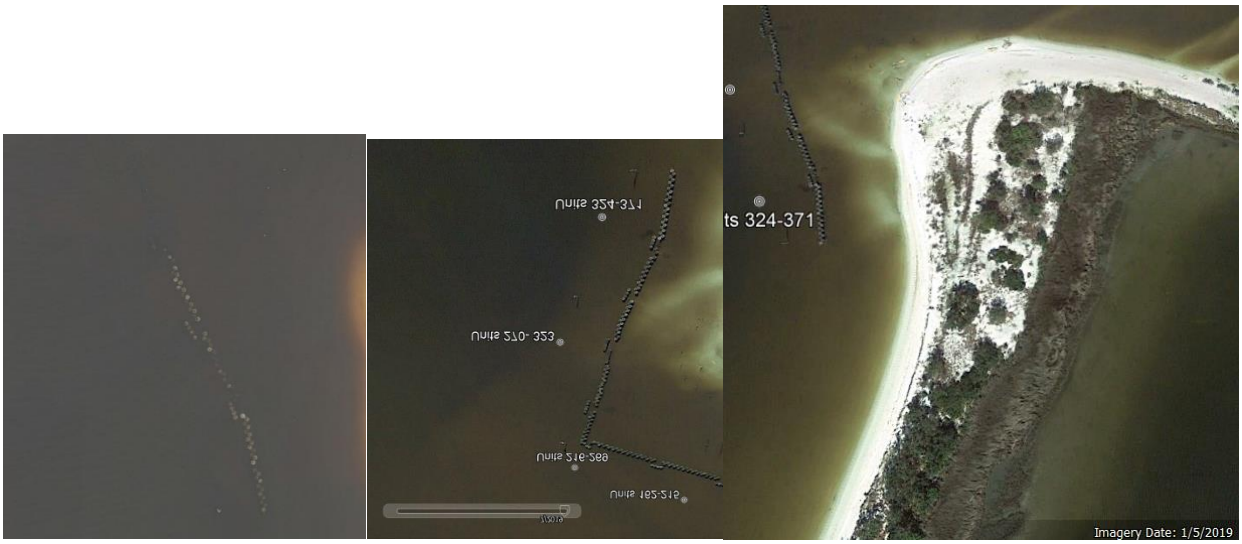

Figure 20: Section C-July 2019 aerial of the eastern breakwaters. The western section of the oyster reef breakwater post Hurricane Sally. Date taken:09/19/2020

Section D- The dunes of Deadman's Island

Introduction

The dunes on Deadman's Island are natural dunes that have been present for hundreds of years. Over time, the general public would use the dunes for recreational purposes, by climbing and sliding down the Dunes and camping on them. This anthropogenic impact has caused grass and sensitive dune vegetation to die-off which leaves the dunes vulnerable to erosion. The National Fish and Wildlife Foundation (NFWF) provided funding for small restoration pilot projects to repair the dunes (Figure 22). The restoration efforts appeared to have been successful. Vegetation was reestablished and the new vegetation continues to grow and stabilize the site.

Summary

During Hurricane Sally, Deadman's Island dunes sustained considerable damage (Figure 21,22,23,24). Unfortunately, despite all the restoration efforts, the dunes were relatively unprotected. During Hurricane Sally, the dunes suffered a maximum of 45 feet inland loss and a four-foot shear from the top of the dunes. The average amount of scarping and erosion measured from the shoreline was 40 feet (Figure 21).

The sand dunes and the Juncus saltmarsh serve as the primary buffer against storms for the Gulf Breeze homes up to 4 miles inland. After Hurricane Sally, the scarping of the dunes was very severe, leaving the root systems of 100-year-old trees and plants exposed (Figure 23 and 24). The following pictures below show the tree trunk's discoloration showing the line where the tree was buried in the ground versus how much of the tree is exposed and currently in the ground (Figure 24). Also, notice how much of the

dune was washed away by comparing the current location of the dune to the grass line that used to be at the base of the dune (Figure 21 and 22).

Figure 21: Section D- Aerials of Section D September 19, 2020 – the Red polygon represent the loss of dunes. The orange dots are the GPS points taken along the shoreline and to the new edge of the dunes.

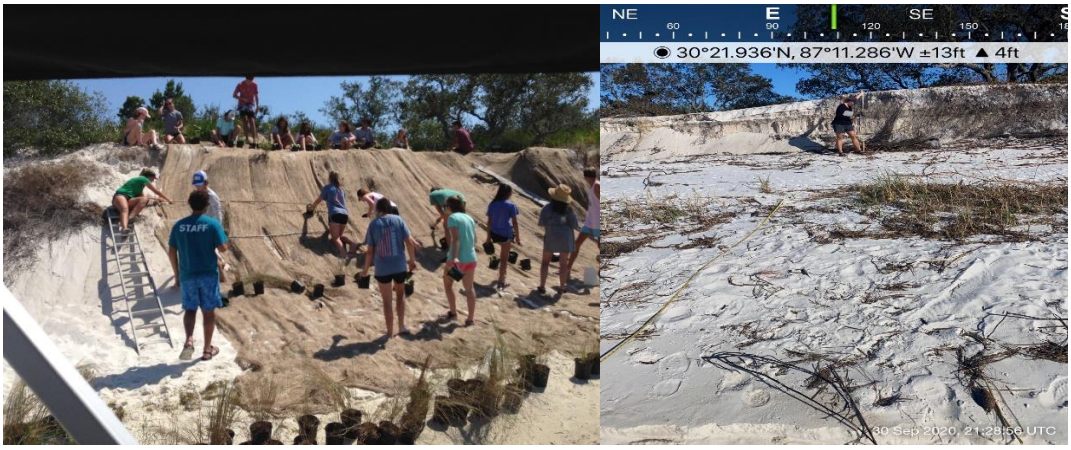

Figure 22: (Left) A section of the dunes being restored before Hurricane Sally, (Right) The same dunes impacted by Sally note where the grass is that was originally at the foot of the dune.

Figure 23: Another section of the dunes before Hurricane Sally that the City maintains. (Right) After Hurricane Sally. Note where the trees are no longer 25 ft behind the dunes.

Figure 24: Damage to the dunes and vegetation. Note the shading of the where the tree was once rooted underground.

Recommendation

The recommendation is to rebuild the dune using local dredged material in a tiered system using several vegetation types over five- years. The ECS tiered system would involve using wood posts with a step system for building up the dunes.

Section E-The dredged material disposal site and shoreline along Gilmore Bayou

Introduction

The dredged material disposal site was built in the 1950s to hold the dredged material when the channel was created in Gilmore Bayou. In 2017, the beneficial use of dredged material project was implemented and transported sand by pumping it from this disposal site through a pipe to rebuild the north end of Deadman's Island. Once completed, the disposal site was reshaped with heavy equipment, and vegetation was planted by volunteers inside and outside the dredged material disposal site. A living shoreline project was implemented adjacent to the site to prevent sand from blowing in the water and filling the channel (Figure 25).

Summary

The living shoreline vegetation on the backside of Gilmore Bayou appears to be untouched and stable. The dredged material disposal site is also stabilized with vegetation along with a few pine trees and did not experience any erosion during the last hurricane. Unfortunately, the local canal has filled in with sand. This filling of the canal is most likely due to sand from the adjacent property that has blown and washed out into the bay and canal. The sand is typically placed in the designated dredged material disposal site on Deadman's Island for later use in restoration projectss. The dredged material disposal site has the capacity to store more sandy dredged material at this time.

Figure 25: Upper left is the re-shaped dredged material disposal site after the 2017 Beneficial use project. The upper right shows the project after Hurricane Sally. The lower left is the shoreline reshaped from the 2017 Construction. The lower right is the project after H. Sally.

Storm Debris

Prior to Hurricane Sally, there was no debris on Deadman's Island. The City and volunteers maintain the small debris cleanup of the island throughout the year. After hurricane Sally, large, bulky debris washed up on Deadman's Island and the surrounding waters. The estimated weight of the debris is 1.5 tons. Additional debris is suspected to be in the water and around the reefs. This underwater debris is a navigation hazard to the general public and boaters' health and safety. Due to the shallow water, boaters can easily collide with the debris near Deadman's Island and severely damage or possibly sink their boat. Additionally, if left too long, the debris has a high probability of being buried in the sand or

washed back onto the shoreline during the next storm. This debris needs to be removed as soon as possible especially before the summer recreation season.

Methods

GPS waypoints were taken of each large pile of heavy debris. Large amounts of wood planks, pilings, and even a cleaning station sink washed onshore, along with plastic and other debris. If washed back into the water, this debris can be hazardous to the general public and our navigable waterways.

Recommendations

Removal consists of contract labor and a small barge for transport and (2) 30 cubic yard dumpsters to be hauled to the City's transfer station and/or nearest landfill. If Hazard materials are found during the cleanup, these materials will be disposed of according the RCRA law.

Remove the debris and haul to landfill. This site is boat access only. Barges will need to be deployed to access the site. Paid labor will be used load the barge. The City can place a trailer or dumpsters at City right of way off of Montrose Dr. The debris will be unloaded from the barge into the trailer or dumpster and the City will haul to the transfer station or nearest permitted landfill. If Hazard materials are within this project, these materials will be disposed of in accordance with local, state and federal laws. Table 1 below has the GPS locations of the debris that requires removal on Deadman's Island.

Table 1:Large Debris Coordinates

Debris Locations on Deadman's Island		
30°21.907	-87°11.304	Debris
30°21.946	-87°11.283	Debris
30°21.936	-87°11.286	Debris
30°21.959	-87°11.273	Debris
30°21.973	-87°11.264	Debris
30°21.983	-87°11.265	Debris
30°21.984	-87°11.258	Debris
30°21.991	-87°11.262	Debris
30°21.999	-87°11.259	Debris
30°22.009	-87°11.247	Debris
30°22.015	-87°11.244	Debris
30°22.017	-87°11.236	Debris
30°22.020	-87°11.242	Debris
30°22.020	-87°11.243	Debris
30°22.022	-87°11.244	Debris
30°22.036	-87°11.219	Debris
30°22.071	-87°11.230	Debris
30°22.106	-87°11.246	Debris
30°22.098	-87°11.190	Debris
30°22.081	-87°11.106	Debris
30°22.080	-87°11.106	Debris
30°22.082	-87°11.109	Debris
30°22.080	-87°11.109	Debris
30°22.079	-87°11.111	Debris
30°22.079	-87°11.106	Debris
30°22.883	-87°11.333	Debris
30°22.907	-87°11.305	Debris
30°21.922	-87°11.295	Debris
30°21.932	-87°11.287	Debris
30°21.945	-87°11.283	Debris
30°21.963	-87°11.267	Debris
30°21.974	-87°11.268	Debris

4.0 Final conclusion

2020 Project Discussion

Sea Level Rise – A different twist and recommendation

As mentioned in previous reports, sea-level rise has had a significant impact on Deadman's Island. It is even more important to address this year. Sea-level rise is apparent along the entire Gulf Coast. There have been many predictions on how sea-level rise will affect the United States. It has even been challenging to find the supporting datum. This project has provided the data and monitoring to help understand the importance of restoration and help reduce the impacts of sea-level rise since 2008.

Through observations over the years, as the high tide comes in and inundates the land it drowns the vegetation and washes away the sand. As the moon gets closer to the earth and our tides increase, the same effect occurs each year. It is the smothering of the newly established or stressed vegetation.

As the hurricanes increase and create more erosion, the land decreases more and more. Throw in an unexpected oil spill that smothers the marshes, kills coastal vegetation and causes many acres to wash away, only worsens the problem.

What can be done to counteract the loss of shoreline? Do we keep planting and hope the vegetation holds and survives when submerged underwater during the summer tides?

These plants are not meant to be underwater for any significant period of time only roots and ½ and at most ¾ coverage of the stems. As mentioned in previous reports, the upland vegetation is more threatened if the shoreline vegetation washes out.

In past years, previous reports discussed the importance of a bog area behind the upland vegetation. This bog area would be at a lower elevation but act as a reinforcement for the upland vegetation since the root system has time to strengthen and stabilize the site. The bog project on Deadman's Island survived two years before a hurricane moved the upland sand, displaced it over a well-established marsh and suffocated a section of the historic marsh.

In the future, we may want to consider constructing more man-made bogs in areas experiencing moderate erosion. This will help us to better understand water collection and supply to man-made bogs and how long it will take for a root system to become established and more resilient to coastal erosion forces.

Man-made bogs may be the next restoration method to help in the battle of coastal erosion and sea-level rise.

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