2019 MONITORING REPORT

of

CITY OF GULF BREEZE DEADMAN'S ISLAND RESTORATION PROJECT

For the

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.

2019

Contents

Special recognition and thanks to Ashlie Johnson, Julie Peterson, Katie Condron, Katherina Smith, and Dr. Robert Menzer for their valuable contribution to this report.

1.0 Executive Summary

The purpose of the monitoring report is to identify the effectiveness of the environmental and structural stability of the final breakwater design, the colonization and development of an oyster reef ecosystem over time, and the overall function of the reef to the sustainability of Deadman's Island in Gulf Breeze, Florida. In addition to the resident eight species of reef fish, there were twenty-one species of non-reef species of fish that travel throughout the entire reef. A review of previous years' data showed that the reefs had the most oyster drills in the year 2019. The summer of 2019 was dry and hot, for the most part. Rainfall was average for the year except for the summer months. Salinity was moderate, but data collection was limited. There were no named storms or hurricanes that passed through the vicinity of the project. Sea level rise was still consistently higher than predicted charts for the year. This level of rising was probably due to the number of different moon phases in 2019, which can affect the tides such as super moons, black moons, and other unusual moon phases. These moon phases close to the earth typically cause higher tides. There were no maintenance plantings on the north end project site in 2019. Shoreline erosion continued in the areas of the damaged reefs impacted by hurricane Michael from 2018. Erosion continues in the northern portion of the project site due to the broken and missing reef units damaged by Hurricane Michael.

The major project that repaired the isthmus a few years ago is stabilizing well. Hurricane Michael moved some of the rocks, creating scour points that have increased the vulnerability of the isthmus. Also, several species of plants on the shaped dune behind the rocks have helped stabilize the isthmus. There was no funding for repairs from hurricane Michael for this or last year. There were minimal volunteer efforts at the project site this year except for one dune restoration pilot project funded by the National Fish and Wildlife Foundation.

1.1 Project History

Deadman's Island has been a victim of erosion since the beginning of hardening the shoreline through seawalls and the construction of the three-mile bridge in the 1940s. The bridge interrupts the littoral bridge 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 Army Corps of Engineers (ACOE) monitoring reports and presentations (Reed 2013, 2015).

In 2005, Hurricane Dennis exposed several coffins, and human remains. The State Historic Preservation Office informed the City of Gulf Breeze that they need to start preventing erosion, which is causing unearthing of historic structures and human remains. In an effort to stop the erosion and prevent 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 structure fell apart.

Through comparing 2009 pre-oil spill monitoring data and 2011 monitoring data, the oyster coverage went from 95% to 1% coverage. The 2010 Deep Water Horizon oil spill caused delays in the construction of the previously planned additional breakwater. This was due to the project site being blocked and surrounded by oil booms. The delays resulted in further erosion of the project area and other areas in the vicinity of Deadman's Island. In 2011 and 2012, a new breakwater called "Ecosystems" made by Reefmakers was deployed. This footprint now includes outside breakers. Including the outside breakers, 530 feet of the 1450 ft 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, of 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 began to lose 90% of the shells in the bags during 2012 from tumbling by wave actions and falling through the mesh containing the oysters. 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. This caused the sand to displace and wash away from the inside 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, 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 due to the Reefblk breakwater losing function in 2012. In addition to the breakwater project, an osprey nest was relocated on the signage reef pilings at Deadman's Island. This project was not funded by the ACOE.

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 land mass 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. Deadman's Island is listed as John H. Chafee Coastal Barrier Resources System (CBRS) in the state of Florida. As a recognized conservation CBRS site, FEMA funding was unavailable for repairs from the storms.

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 large riprap, but overall the vegetated berm that was placed behind the rock held up well with only a few intense water blowouts of the established root systems.

This year, 2019, 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.

1.2 Project Purpose

The purpose of this project is 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 is to provide protection to numerous cultural resources and artifacts identified at the site. The loss of salt marsh in this area is the result of increased erosion due to wave energy. The project would create approximately 1.04 acres of an emergent salt marsh for shoreline protection and an additional 0.046 acres of a coastal dune. The structures protect the area by reducing the amount of wave energy that reaches the shoreline. Approximately 16,000 cubic yards of sandy material and vegetation will protect and cover historic resources and create a small peninsula that adjoins the land, separated by small dunes. In summary, the project increases the productivity and diversity of flora and fauna indigenous to the Florida areas, as well as protect and stabilize the existing shoreline.

1.3 Project Goals 2011-2019

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 (2 of requested four receivers are installed)
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 ongoing-funding dependent)
10. Control erosion and stabilize the shoreline by planting emergent vegetation

11. Monitor, maintain and study the site for five years once all construction is complete (ongoing)
12. Replace broken tier units from Hurricane Michael

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

According to GPS surveys, the 2015 breakwater structures, which replaced the ReefBLK damaged during the time period of the 2010 oil spill, appears to have stabilized the shoreline on the north and south-west side, directly behind the breakwater.

In 2017, the tides continued to rise higher than the tide charts predicted. 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 vulnerability of the shoreline 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 Ecosystems 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 allowed more shifting of the 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, to provide better wave attenuation during higher tides. As of October 2017, the shoreline GPS has not changed, and the vegetation has stabilized.

In comparison to the 2013-2019 tides and monitoring reports, the tide charts are showing 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 problems for daily field planning, especially for boat launching, since Deadman's Island is boat access only.

In 2018, Hurricane Michael caused strong winds from the north for a long duration of time and caused damage to the structures, the vegetation, and the shorelines. The 2019 monitoring event in the summer provided closer observation of the damaged units, vegetation, and shoreline.

2.0 2019 Summary of monitoring results

2.1 Description of Field Work Summary and Results

Underwater monitoring of the existing breakwaters occurred from March 2019 for pre-monitoring to July 25, 2019. All 371 units were monitored. In order to compare previous years' data with the same number of units, one hundred and two units of the breakwater reefs were randomly selected for monitoring. The visibility of the water was 1-5 feet, predominantly 1-3 feet. Two hundred and fifty of the new reefs were mapped according to species presence.

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

Spat settlement was abundant on the reef, but less than 20% live coverage of spat. The oysters present on the reef size range from 1 to 5 inches. There was a 26% increase in predator abundance.

2.1.2 Shoreline vegetation monitoring

There was a 25% loss of shoreline and vegetation at the northern point. The northern isthmus vegetation was covered with sand, but the vegetation was beginning to emerge in some areas. The shoreline of the isthmus remained stable.

2.2 Finfish surveys

In comparison to 2018, there was a 30% decrease in overall fish abundance.

2.2.1 Wetland creation

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

2.2.2 Reef Structural Integrity

Overall the structural integrity of the reef has been ideal for an offshore oyster reef/fish habitat. Hurricane Michael impacted 32 out of 371 units. Out of the 8% of damaged units, the first two tiers of the units were damaged from the storm.

3.0 Monitoring plan and results description

The entire breakwater encompasses North, South, East, and West sections (Figure 1). Each breakwater unit is monitored in sections according to orientation to the land, the landside (LS), the northern direction (ND), the eastern direction (ED), and the western direction (WD). The landside exposure on each breakwater is protected. The opposite side is exposed to the open water and fetch wave impact. The other two sections have little exposure to land or direct wave action and may provide a more protected habitat by being adjacent to the next unit. The east side breakwater is closer to residential property, is exposed to the twelve-mile fetch, and is in the path of littoral transport of sand from the northeast. The east breakwater has more exposure to morning sunlight and afternoon sunlight and is subjected to fierce northern winds.

The west breakwater is exposed to a 3-6-mile fetch and is protected from the strong current from the northeast. The west end is the closest to the shoreline of Deadman’s Island.

Figure 1: The completed breakwater at Deadman's Island

3.1.1 Oyster growth rate, spat settlement, recruitment, predation, and health

3.1.2 Oyster Growth

Success Criteria: The success criteria were not met.

Since the entire reef are the Ecosystem units, comparing the species on the reef was more effective — the small number of living oysters present on the reef size range from 1 to 5 inches. The oysters in the deeper water (5-6 feet) seem to show the most significant size (4-5 inches) as compared to the oysters in the shallow locations.

3.1.3 Oyster Spat Settlement/recruitment

Spat settlement was abundant on the reef, but the live spat coverage was less than 20%. From the coloration of the spat, it looked relatively new. According to the water temperature chart, oyster spawning probably occurs around April or May, which would have given the predators plenty of time to consume the majority of spat.

3.1.4 Oyster Predation

Evaluation is done throughout random stations- using the point count method of the quantitative underwater ecological surveying techniques. Drills are counted individually.

There are many predators of oysters on the reefs; the most abundant threat to the oysters, are oyster drills, *Stramonita haemastoma*. Oyster eating species on the lower tiers include Sheepshead Fish (*Archosargus probatocephalus*), Stone Crabs (*Menippe mercenaria*), Hermit Crabs (*Pagurus longicarpus*), Blue Crabs (*Callinectes sapidus*). Most of these species can only eat the smaller younger oysters at the top tiers due to the size of the oyster's shells. Sheepshead fish can pick off spat growing on the lower tiers while the other crab species can access all the tiers. The oyster drill is the most prominent predator of the oyster on the Deadman's Island System. They do well in Pensacola Bay's waters due to the salinity hovering around 18 ppt for the entirety of the summer months. Salinity is affected by freshwater input in the form of rainfall and river output. Oyster drills can thrive in 15 ppt (Reed, 2018) while they can handle a range of salinity. Oyster drills use their radula to carve out a whole to insert themselves into the oyster to dissolve its tissues and consume the oyster (Massie, 1998). The same predators that prey on oysters will also eat Oyster Drills. Larger stone crabs observed on the lower tiers may be giving the larger oysters a chance to grow, as they eat Oyster Drills on the lower tiers. Sheepshead also prey upon oyster drills, picking them off the reefs.

Oyster drills prefer salinity above 15ppt but can survive in 8ppt. Since oyster drills are the most substantial threat to the reef, it is essential to understand any correlation to drills and drill predators. Oyster drills were counted individually and by hand. Counting by hand is the only way to determine whether the oyster drill shell was a hermit crab, which adopted the mollusk's shell or an oyster drill. During the summer months, the salinity is usually the highest. In the previous years, the oyster drill populations appear to fluctuate on the entire reef. This included both the Reefblk and the Ecosystems. The oyster drill population from 2013-2015 increased 4.7 times. By 2015, there was a 65% decrease in numbers. However, the egg casings increased over 2000 times (Figure 2. Table 1). As with the 2014 floods, the salinity in the year 2017 was extremely low. This low salinity caused the lowest number of drills of all the years. This decrease coincided with the same drop in numbers as with 2014. This year doesn't seem to coincide with the previous observation.
Salinity was measured only during the months of monitoring. Unfortunately, databases such as EPA STORET to cross-reference salinity from this area, and other water quality parameters were decommissioned on June 29, 2018 (www.EPA.gov, 2018). The State of Florida FDEP STORET has not continued its water quality monitoring program either. The Florida Wildlife Commission (FWC) has a buoy close to Deadman's, but the database was unable to be located. The summer salinities ranged from 10 ppt to 22.5 ppt. This temperature was ideal for oyster drill growth. The year 2019 showed the highest amount of oyster drills. Surprisingly, 2018 did not show the highest amount of egg casings as previous years (296% increase), yet 2019 showed the highest amount of oyster drills (Figure 2).

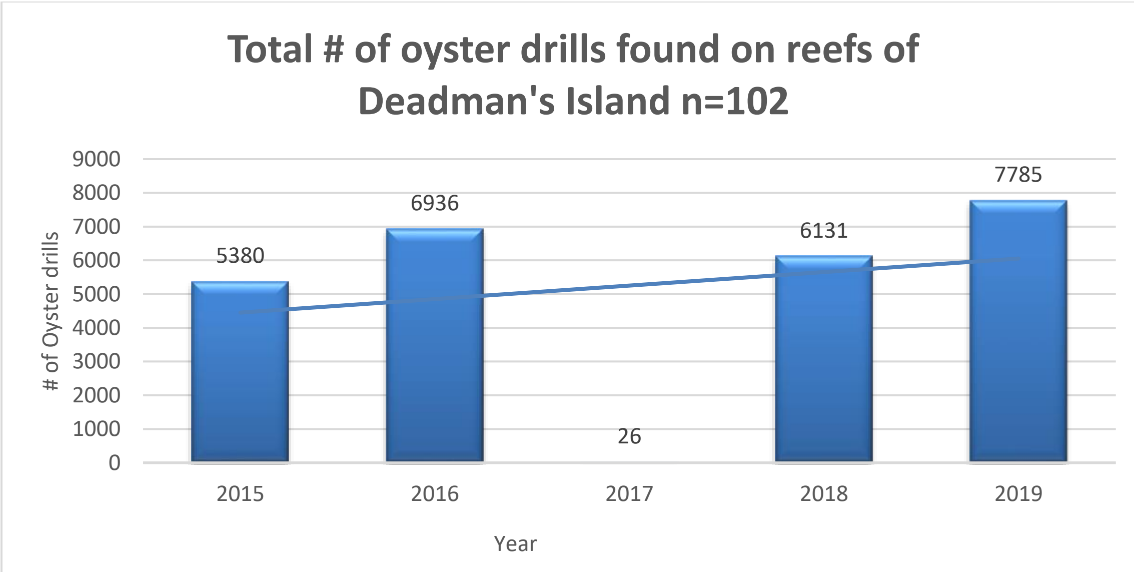


Figure 2: Total count of oyster drills over time.

3.2 Oyster Health

Evaluation of oyster health was performed throughout random stations. Visual inspections on the outside shell and inside tissue and mantle of the oyster were performed instead of tissue laboratory testing from previous years. The oyster was considered healthy if it had no hollow or convexed shells nor any sign of fungus.

3.3 Percent coverage on the tiers- species abundance

Each breakwater has 4-6 tiers depending on the depth and whether the intention of the breakwater is to accrete sand or maintain the existing depth.

The reef is numbered and explained in previous reports. Each section has its own physical characteristics. Units 1-54 are located on the farthest eastern section of the reef. Units 55-108 is the mid-east section meaning the long row of breakwaters is the middle but on the east side and is usually a more shallow depth. Units 109-161 are the midsection, which is the most shallow depth (3 feet). Units 162-215 are the mid-west section, in the middle but on the western side and gradually get deeper. The reef gradually gets deeper from the middle to the northwestern section. Units 216-269 are called North West Section, the deepest sections, ranging from (5-6.5 feet) and usually the colder sections of the reef. The largest of the oysters are found here. The west units are 270-323 and have the round and square prototypes of the reefs. The Southwest units are 324-371, and this area contains ballast rock and sometimes tropical species of the fish. The southwest is also closest to the land and has the warmest water and subtidal bottom temperature.

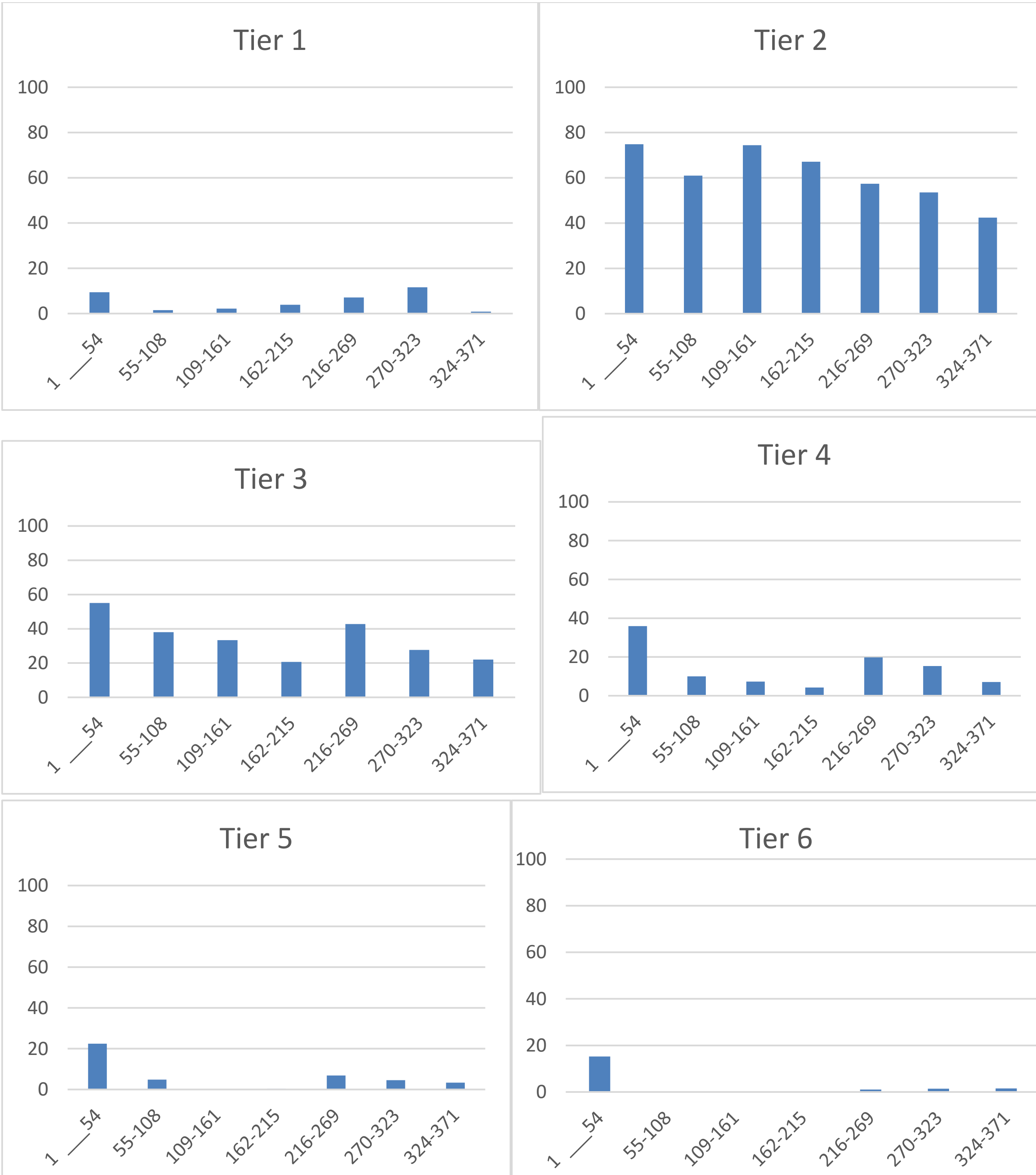


Figure 3: Abundance of organisms on the reef per tier

The units are concrete structures that either have four, five, or six tiers on the unit. Tier 1 is sometimes exposed out of the water. There is some coverage on tier 1, which shows the units are submerged at times. Tier 2 and 3 show the most coverage, as well as Tier 4, but the bottom two tiers, Tier 5 and 6, show a decline in percent coverage.

In 2019, tier 6 shows larger live oysters in some parts of the reefs and zero percent coverage in other areas of the reef (Figure 3). Tier six was noticed to have the largest oysters. These oysters were more substantial than the uppermost tiers, though there were fewer observed on the lowest tier. It is unsure if the deeper tiers support more area for growth due to less space competition, fewer predators at the deeper tiers, or have better access to the currents which carry food to the oysters, leading to less resource competition.

The deepest part of the Deadman's Island breakwater is around six feet deep; this spot is located at the western corner of the breakwater. The shallow areas are situated in the leading eastern edge, the northern side facing the open bay and the trailing west end. All these areas have water depths of five feet and under with three feet being the average shallow depth.

3.3.1 Live oysters

The eastern section of the breakwater was observed to show the most live oysters out of all the sections. Units 1-54 begin the east side of the reef (Figure 4). These are the most sheltered of the units with the geography of the greater Gulf Breeze Island and the Pensacola Bay Bridge acting as a buffer from wave action and water currents (CO-OPS Map, 2019). These units were recorded as having the most live oyster coverage on the upper tiers as well as overall oyster coverage. The last tiers, either the fifth or sixth tier, were observed to have large growing single or clumped in twos or threes oysters attached to the concrete. Reasons for the larger oysters in this area could be due to the currents in the bay transporting a food source, variable salinity, or perhaps more oxygen with the fast-moving currents.

Currents in the Pensacola Bay area are variable (NOAA, Tides & Currents). Freshwater input comes from the Escambia River, the Blackwater River, plus many other freshwater inputs. These freshwater systems do change the salinity levels within the Bay systems, as do rain events and the incoming tide from the Gulf of Mexico (AccuWeather, 2019). Although not tested, the oysters at the deeper tiers may have more stable salinity levels due to denser saltwater sitting below freshwater input.

More wave action at the first three tiers can lead to a more oxygenated habitat at the surface of the water and just below the surface (NOAA, 2004). The first three units also are the area that takes on most of the wave action. The Breakwater slows wave energy on the north or bay side of the units. The northern middle area was observed to have the least amount of oyster coverage on the side, facing the most wave action (Figure 5).

Oysters at the bottom tier are sheltered from the intense wave action at the surface. The lack of high wave action may be one of the reasons oysters have a tendency to grow larger in this section of the reef. The oysters were found on the bottom tiers, and even on the underside of the bottom tiers. This shows the current transporting and moving the oyster spat isn't only surface and subsurface.

The current moves in various directions which allow the oyster spat to settle all over the entire reef. These same currents can be a food source oysters can filter. Currents flowing lower in the water column tend to carry sand and deposit it over the lower tiers. This action may play a role in spat settling and spat growth. Too much sand in the water column can sandblast spat and cause less spat to settle and to grow to maturity (Sediment Transport and Deposition, 2014).

The observed trend of the larger oysters on the lower tiers was seen across most of the other species observed on the units. The uppermost tiers act as a nursery for juvenile organisms such as stone crabs, sheepshead fish, mangrove snappers, blennies, and gobies. Deeper water may lead to only a few large organisms to thrive. Less space competition between the oyster shells coupled with the sparseness of the lower tiers leads to fewer places for small animals to hide, allowing larger animals space to move and hunt.

All of these observations it is only speculated on what may be causing the oysters to grow to their larger size at the bottom tier. Another possibility may be temperature. Perhaps the cooler temperature at the six-foot depth and lack of predators allows the oysters to grow to a larger size at this depth. During the spring, the months are colder, and there are fewer predators throughout the reef. The summer is when we see the most predators, such as oyster drills. This summer, there was lower than average rainfall and higher than normal temperatures (Figures 6 and 7). During the month of June 2019, we had 3.6 inches of precipitation for only one day, and the temperature was about average for the month (Figure 6). July showed the highest temperature and rainfall of only 1.92 inches (Figure 7).

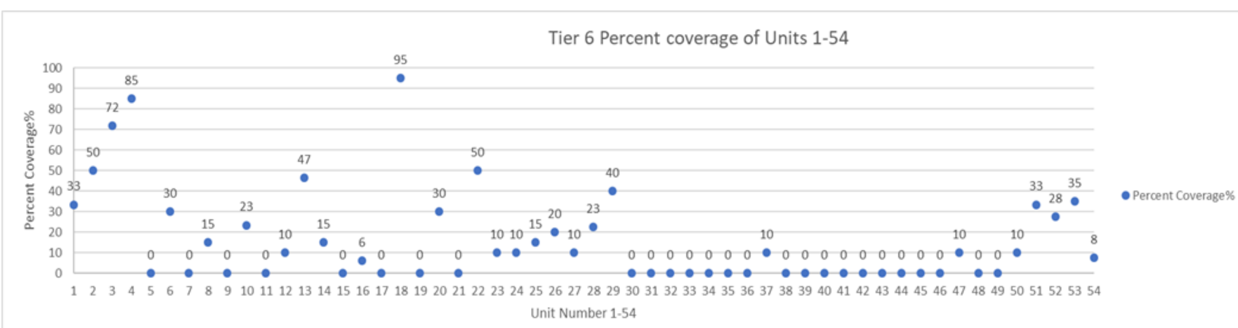


Figure 4: Units 1-54 of the Eastern Portion of the Reef Breakwater Percent Coverage of Tier Six. Graph author Katherina Smith.

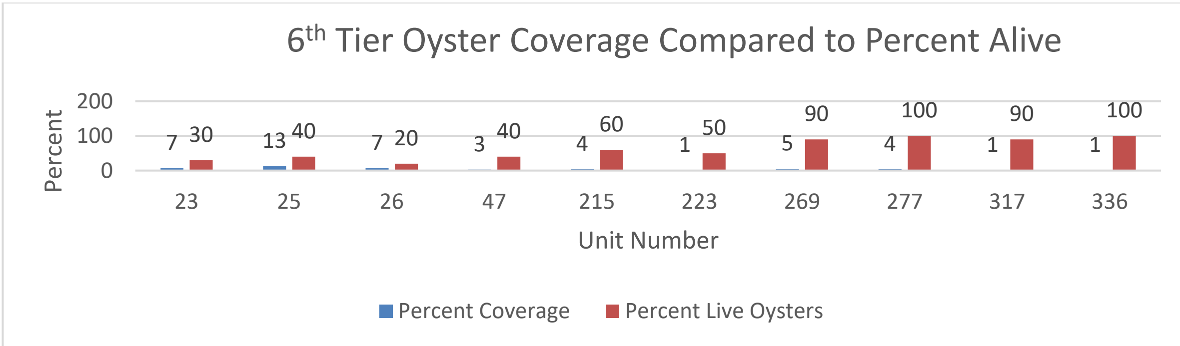


Figure 5: A Sample of Reef Units with a Percent Coverage Less Than 20% and Percent Alive Greater Than 10% for Reef Units with Six tiers. Graph author Katherina Smith

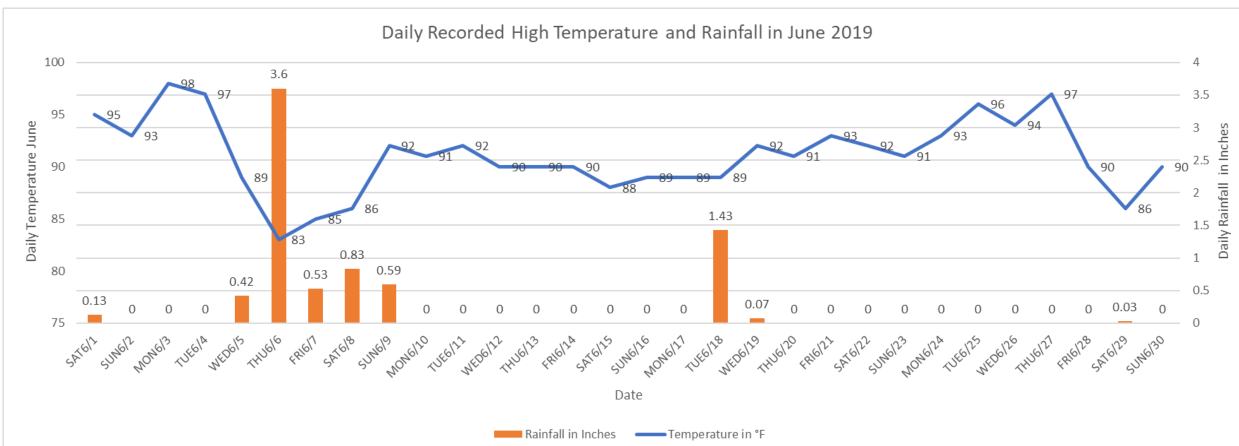


Figure 6: The High Temperature in °F for Pensacola Fl, Compared to Daily Rainfall for June 2019. Graph author Katherina Smith

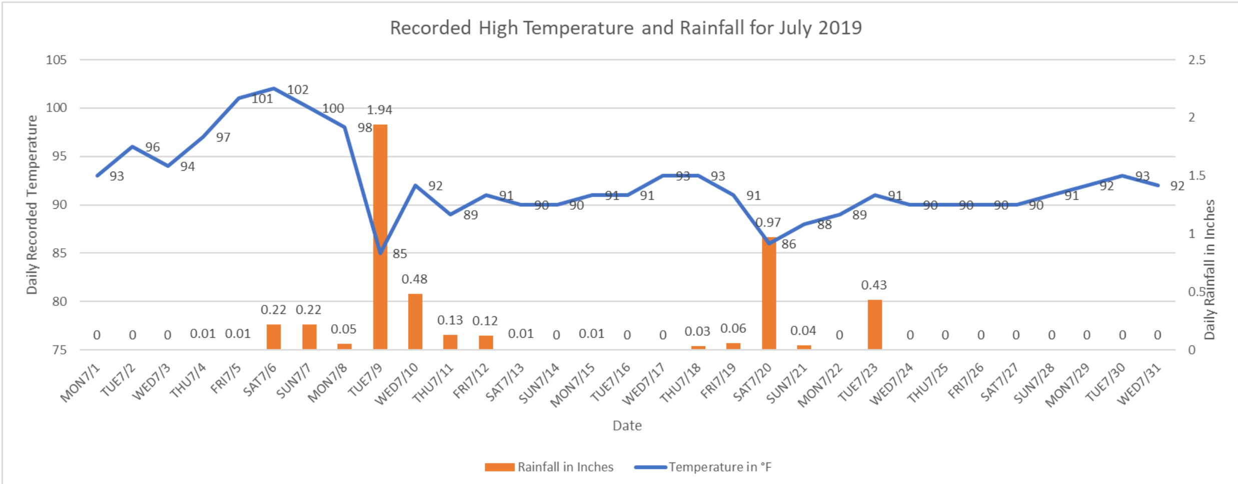
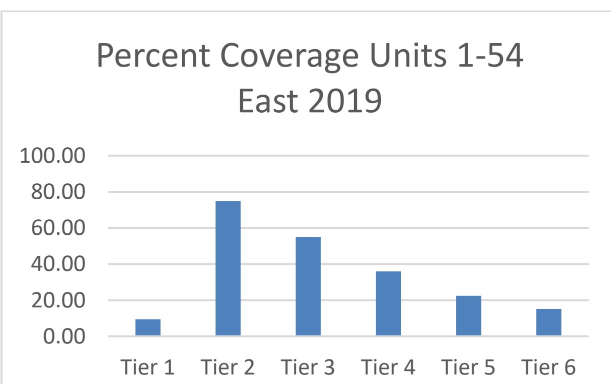


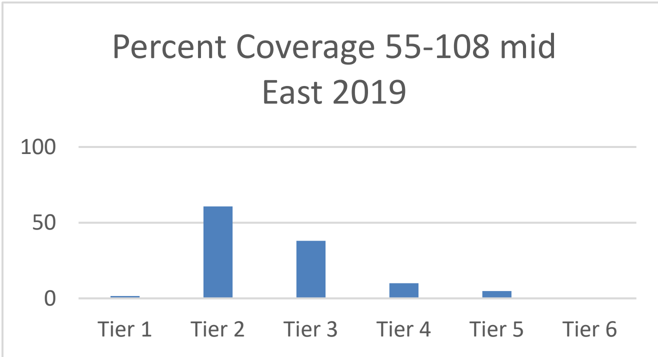
Figure 7:The High Temperature in °F for Pensacola Fl, Compared to Daily Rainfall for July 2019. Graph author Katherina Smith.

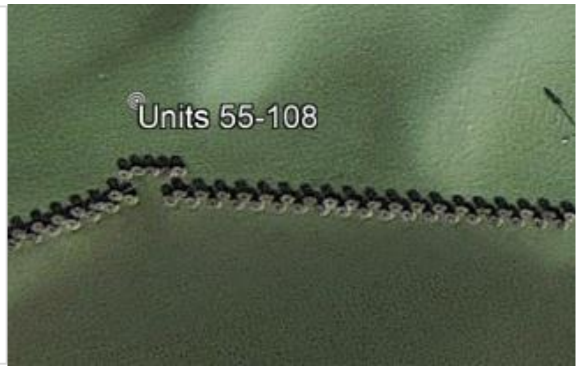
3.4 Percent Coverage of each reef section

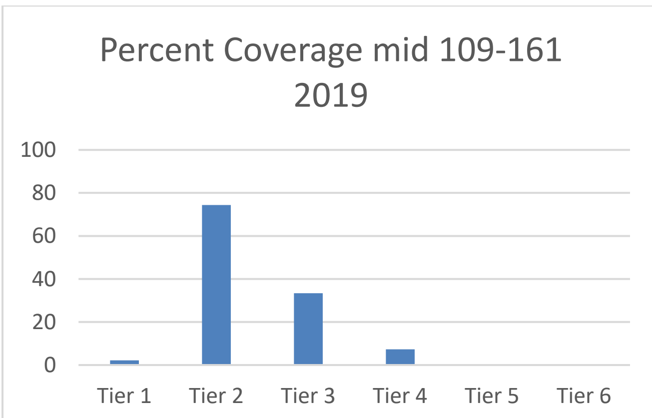
Percent coverage measures anything competing for space on the surface of the breakwaters, which are usually sessile organisms. Percent coverage is a mixture of oyster shells, barnacles, hooked mussels, sponges, etc.

All sections showed habitat of some sort to various species, but the eastern side of the reef continues to show the most coverage on all tiers 1-6. The shallow areas have fewer tiers according to the height, which is why zero species show in the graphs for tier 6. (Figure 9 units 1-54).

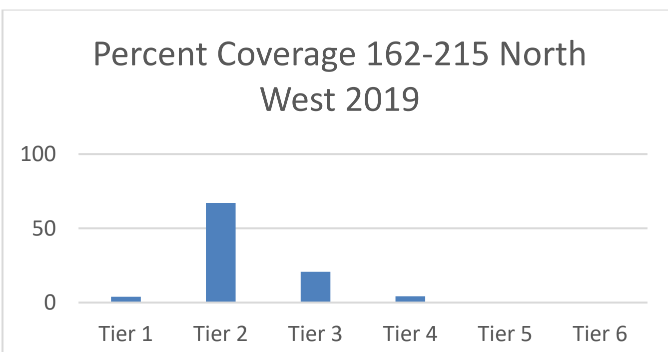


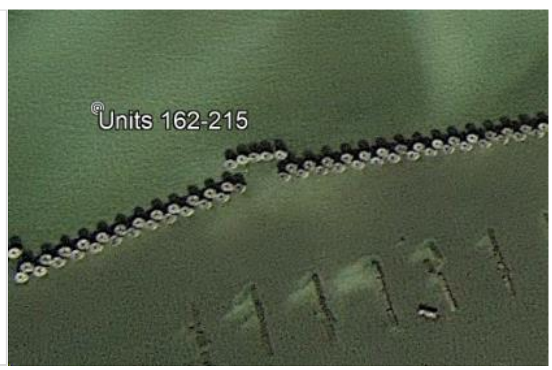

Percent Coverage 55-108 mid East 2019
100
50
0
Tier 1
Tier 2
Tier 3
Tier 4
Tier 5
Tier 6

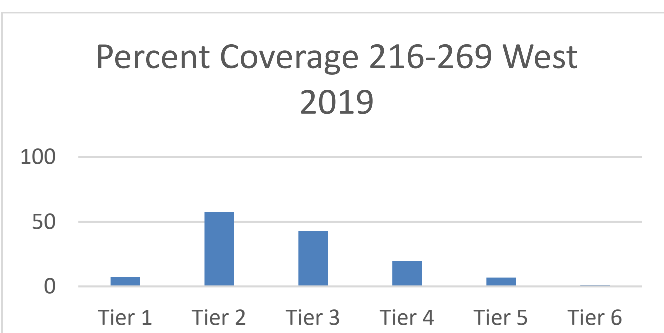

Units 55-108


Percent Coverage mid 109-161 2019
100
80
60
40
20
0
Tier 1
Tier 2
Tier 3
Tier 4
Tier 5
Tier 6

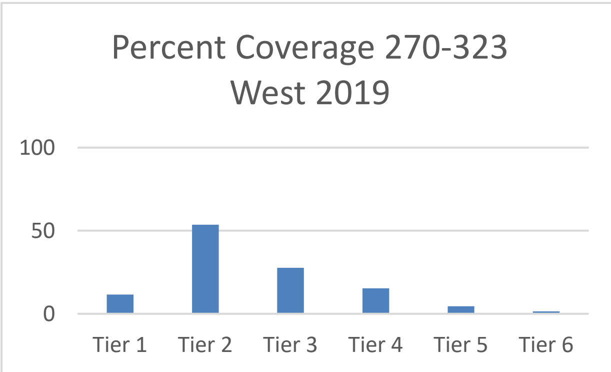

Units 109- 161


Percent Coverage 162-215 North West 2019
100
50
0
Tier 1
Tier 2
Tier 3
Tier 4
Tier 5
Tier 6


Units 162-215


Percent Coverage 216-269 West 2019
100
50
0
Tier 1
Tier 2
Tier 3
Tier 4
Tier 5
Tier 6


Units 216-269



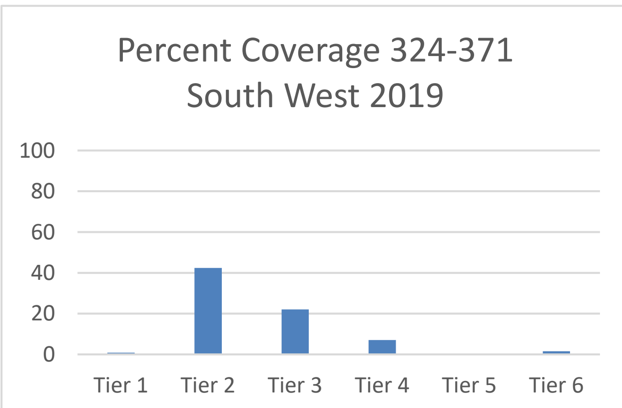


Figure 8: Percent coverage per tier on each reef section

4.0 Community Structure

4.1 Species abundance and Individuals present:

During the early years of 2012 and 2013, the species abundance coincided with community structure. Last year's data showed there was a steady yearly increase of species abundance from 2012 through 2015 Since 2015 is the year the entire reef was completed, the 2019 data was compared with 2015, 2016, 2017, 2018 (Table 1). Typically, a stable ecosystem is observed to have a constant change in species abundance numbers. Certain species numbers increased significantly on various sides facing the reef. However, the main point to understand for reef orientation is that the Landside is more protected from wave action from the open bay. The East and West sides of the breakwater would appear to have similar exposure to the wave action. However, the East side of the breakwater is more exposed to the morning sun than the west side.

In 2015, the hooked mussel, *Ischadium recurvum,* occupied the reef and was added to the spreadsheet for the first time. Hooked mussels prefer the low salinity ranges. In 2017, the highest number of hooked mussels was observed, and in 2019 a meager number of hooked mussels were present. Although hooked mussels are symbionts on the reef, there is still a competition for space with the oysters. The main predator of hooked mussels is blue crabs. Very few blue crabs were found on the reef in 2019. A few sergeant majors were the only tropical species found on the reef this year.

5.0 Fish Surveys

Fish surveys were performed when visibility was at least 1.5 feet to 6 feet, tide dependent, and using an underwater flashlight. Monitoring was conducted by using shallow reef hookah rigs with supplied air and regulator and flashlights. At times, silhouettes of the fish could be identified. It was usually a snapper but we could not identify the type of snapper. In most cases, the fish were identified as snapper species. The depth of the water was 3 to 6 feet. The species were also mapped using Arcmap and ArcPro GIS on the first 215 units. Funding was not available for the additional time to complete the mapping for the entire reef. The mapping gave an excellent visual of the habitat of several species.

The chart shows the number of fish found throughout 371 reef units (Figure 9). Blennies, pinfish, and gobies were the most abundant. Followed by the sheepshead and snapper. There were only 22 toadfish and 39 spadefish, throughout the reef.

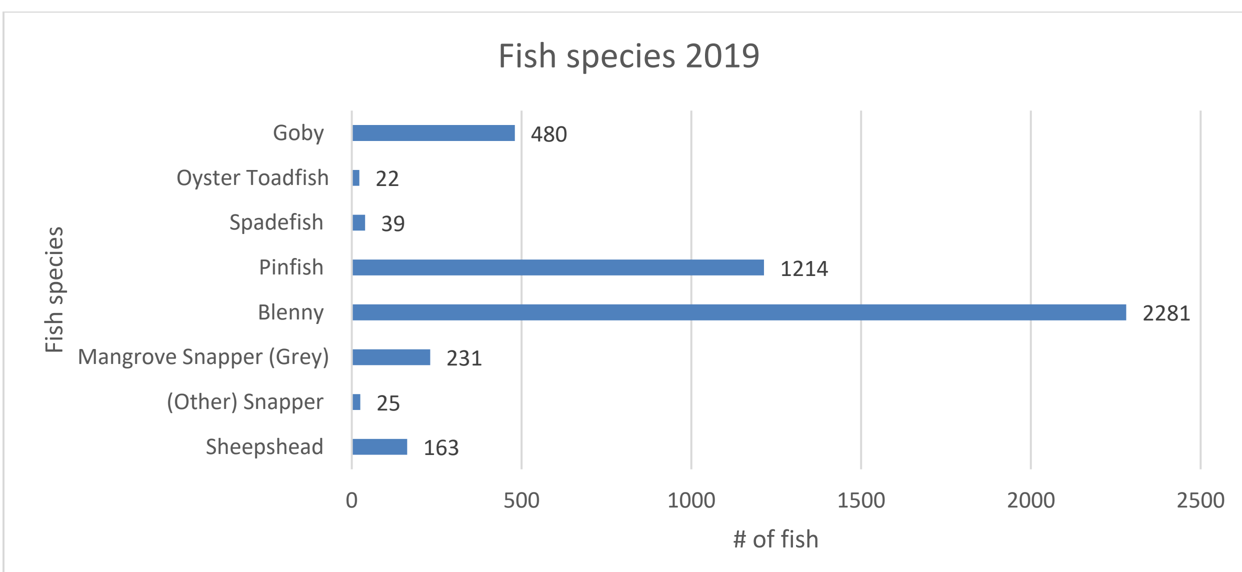


Figure 9: The abundance of fish species on the reef of Deadman's Island

Table 1: marine species found on the reef of Deadman's Island n=102

Species name	Common name	2015	2016	2017	2018	2019
Urosalpinx cinerea	Oyster Drills (OD)	5380	6936	248	6131	7785
Urosalpinx cinerea	OD Egg Casing (EC)	74380	74900	1784	6060	24035
Crassostrea virginica	Live Oyster (LO) %	63	46	2	UD	23
Barnacles sp.	Barnacles sp %	8	37	11	UD	25
Archosargus probatocephalus	Sheepshead	1	69	24	111	40
Lutjanus campechanus	Snapper sp.	123	35	61	7	3
Lutjanus griseus	Mangrove Snapper	23	24	105	22	61
Zooanthis sp.	Zooanthids	4575	15	6	0	0
Hypsoblennius hentzi	Blenny (Feather)	4575	5428	435	1412	568
Cerianthus spp.	Tunicates	0	11	1	0	0
Menippe mercenaria	Stone crab	12290	6296	1813	607	200
Pagurus longicarpus	Hermit Crab	1387	734	2692	484	391
Lagodon rhomboides	Pinfish	1336	569	1813	266	327
Chaetodipterus faber	Atlantic Spadefish	2	0	1	4	9
Astrangia danae	Coral	3	0	0	1	0
Opsanus beta	Toadfish	48	40	24	5	6
Brevoortia patronus	Menhaden juv*	2	0	0	0	
Sabellidae spp	Feather duster worm	3	543	47	0	0
Cerianthus spp	Anemone	1755	39	0	0	0
Micropogonias undulatus	croaker	99	39	4	0	0
Ischadium recurvum	Hooked mussels	20979	5167	26679	1555	160
Callinectes sapidus	Blue crab	188	13	1	28	9
Gobiosoma bosc	Naked Goby	1955	1947	1025	228	123
Littorina littorea	Periwinkles	5182	8004	3210	2146	3952
Total fish		5147	8151	3492	2055	1137
Total oysters %		63	46	2	3	4
Total crabs		12478	6309	4506	1119	600
Total #species		59906	35909	38189	13007	13634

6.0 Observations

During the monitoring events, several observations were made that would require additional monitoring techniques to quantify, but observations also validate some of the data found.

Table 2: marine species found in the vicinity of the reef at Deadman's Island

Other Fish randomly seen around the reef	
Gobiesox strumosus	skilletfish
Lobotes surinamensis	Triple Tail
Sciaenops occelatus	Red drum
Anchoa mitcheli	Bay anchovy
Pogonias cromis	Black drum
Bairdiella chrysoura	Silver perch
Dascylus albeisela	Sergeant major, damsel
Gobiesox strumosus	Skilletfish
Menticirrhus americanus	Southern kingfish
Cynoscion nebulosus	Spotted seatrout
Mugil cephalus	Striped mullet
Elops saurus	Ladyfish
Syngnathus spp	Pipefish
Brevoortia patronus	Gulf menhaden
Menidia beryllina	Inland silverside
Leiostomus xanthurus	Spot
Prionotus rubio	Blackwing searobin
Sphoeroides parvus	Least puffer
Synodus foetens	Inshore lizardfish
T. carolinus	Pompano
Halichoeres bivittatus	Wrasse

6.1 Species Mapping

Using ArcMap, the species were mapped according to what unit they were found on. Mapping techniques are still being improved, and due to time and funding, the entire reef of 371 units could not be mapped. The idea is to create the layers to give a snapshot of the species without the presence of the more abundant species. In the future, the mapping will give a better idea, and a pivot chart of which tier and location of the reef the species are found can cross-reference individual or multiple species for competition, predation, interaction in the same habitat (Figure 10). Some of the problems with the visual snapshot of the date are the chart can be too noisy and dominate the entire reef. For example, blennies and gobies were found on almost every tier of each unit and can appear noisy if cross-referencing the two fish with pinfish and stone crab. (Figure 11,12,13 and14). However, the mapping is a perfect tool for locating species that aren't abundant on the reef such as, blue crabs and the crown conch whelk that are found at different heights in the water column (Figure 13). Perhaps the Crown conch only prefers tier 4, and blue crabs only prefer tier two. The mangrove snapper was one of the most abundant fish where the toadfish was the least abundant present on the reef (Figure 14). The mapping program will allow a cross-reference, according to tiers.

Another thing the mapping program can do is take the reef with abundant fish such as sheepshead and break the habitat down to individual units (Figure 15 and Figure 16). Perhaps there are larger oysters or more drills on specific units. The mapping program can easily break down the species location to individual units.

In addition to mapping the organisms on the reef, the location of fish that frequent the reef but do not use the reef for habitat can be shown. For example, some of the snappers were not present inside the reef but around the reef as with the spadefish (Figure 17). There are many other species that frequent the reef that does not live on the reef (Table 2).

Figure 10:The interaction of species found on each unit (left). Individual species such as the hermit crab were found on all reefs (right).

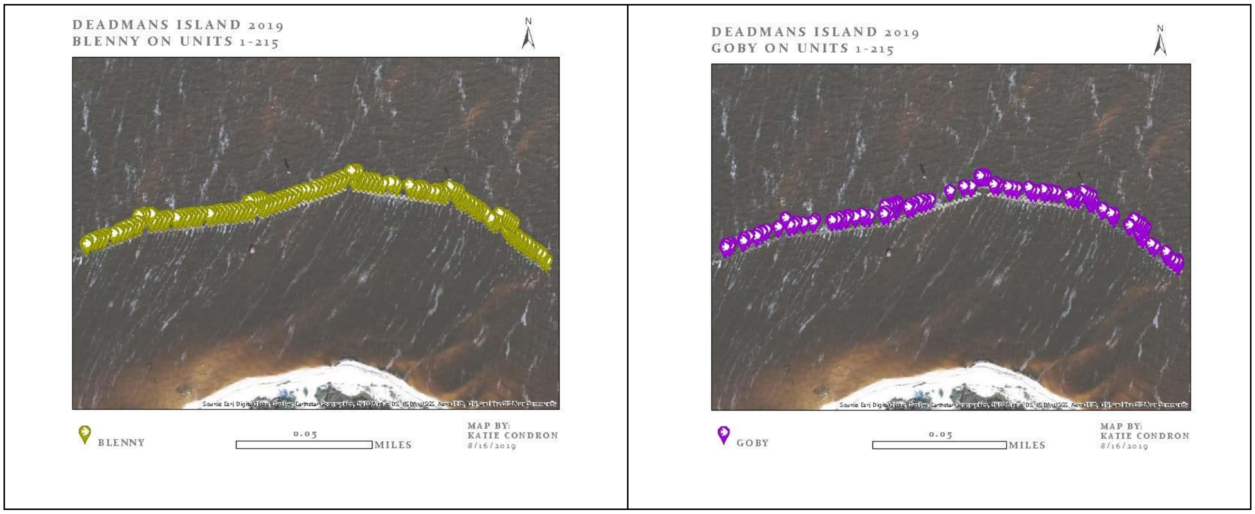


Figure 11: Blennies on the reef units 1-215 (left). Gobies present on reefs 1-215.

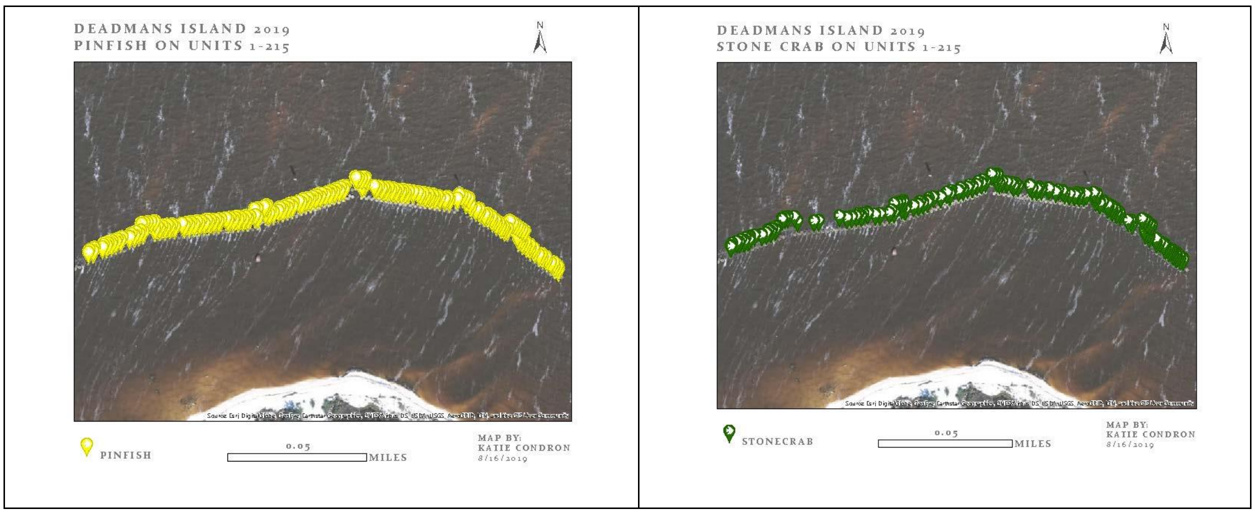


Figure 12: Pinfish on reef units 1-215 (left) Stone crab on reef units 1-215 (right)

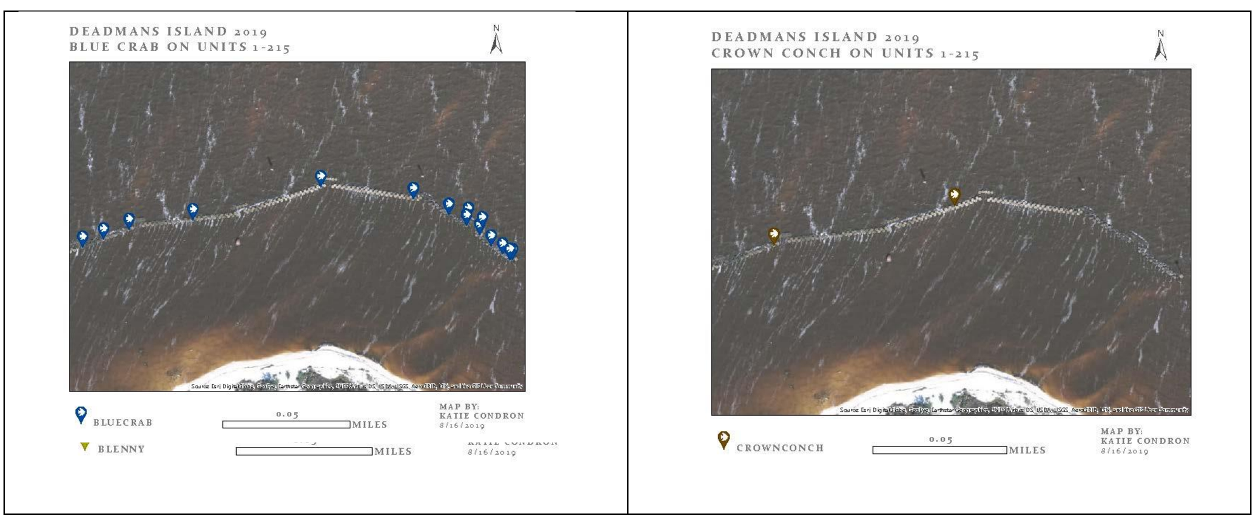


Figure 13: Blue crabs scattered among reef 1-215 (left) Crown Conch whelk located among the reef (right)

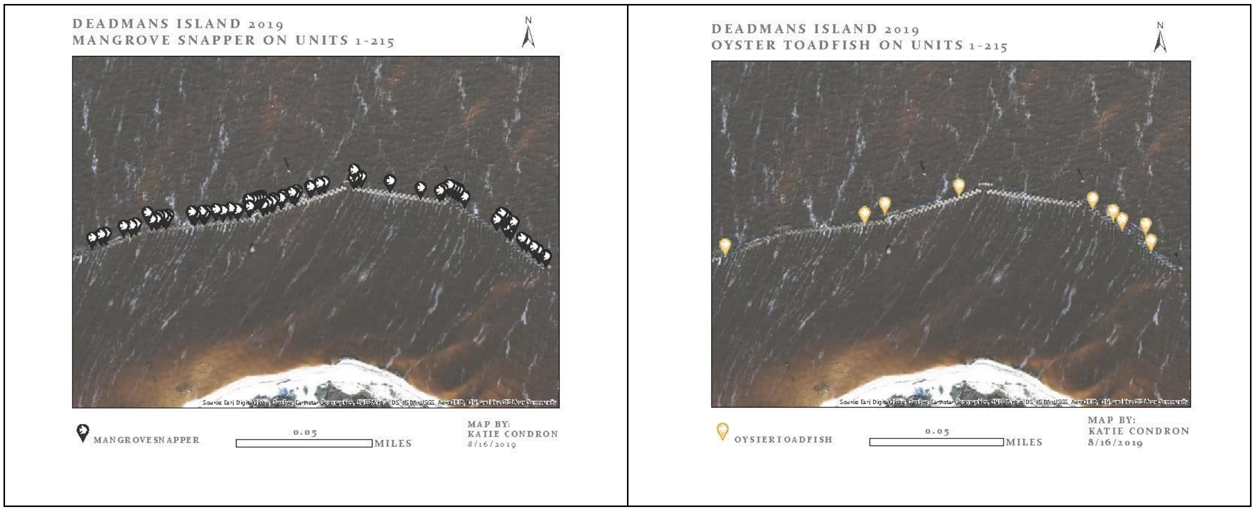


Figure 14: Mangrove Snapper scattered among units 1-215 (left) Oyster toadfish scattered among units 1-215 (right).

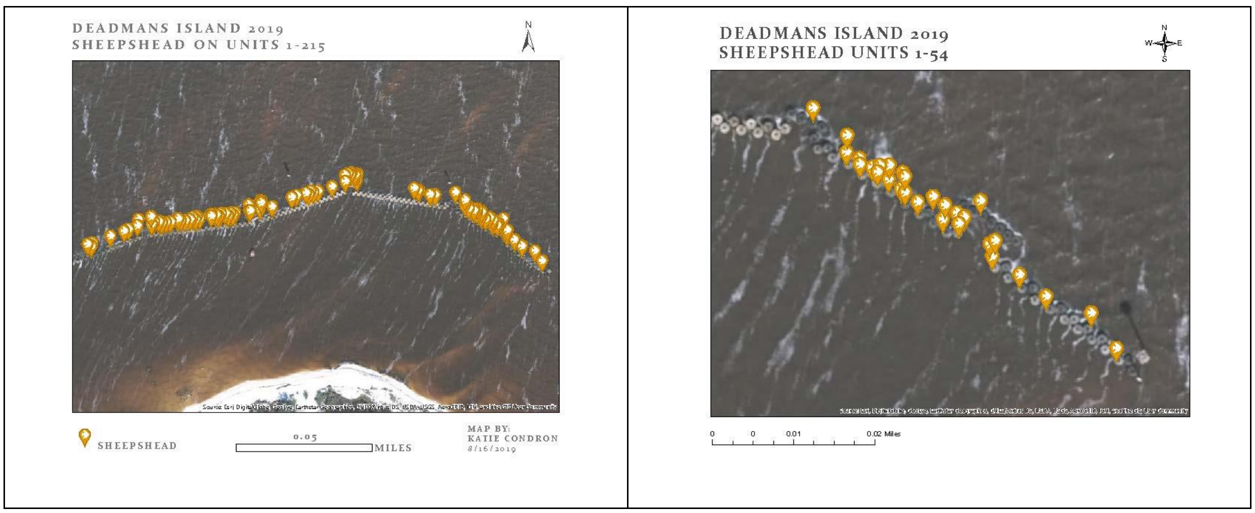


Figure 15: Sheepshead present on reef 1-215 (left) Sheepshead located on units 1-54 (right)

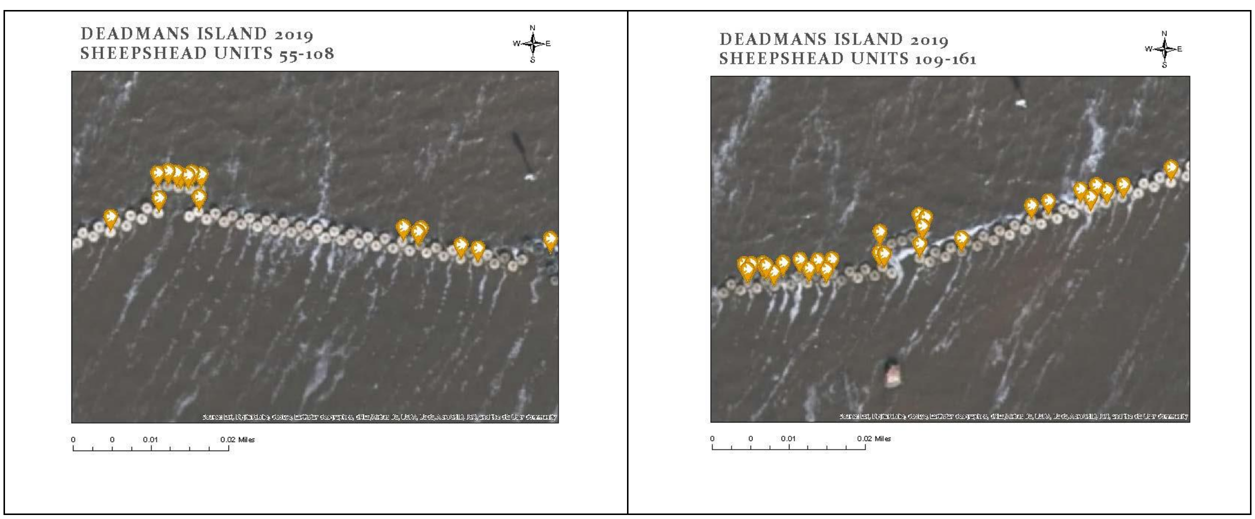


Figure 16: Sheepshead present on reef 55-108(left) Sheepshead located on units 109-161 (right).

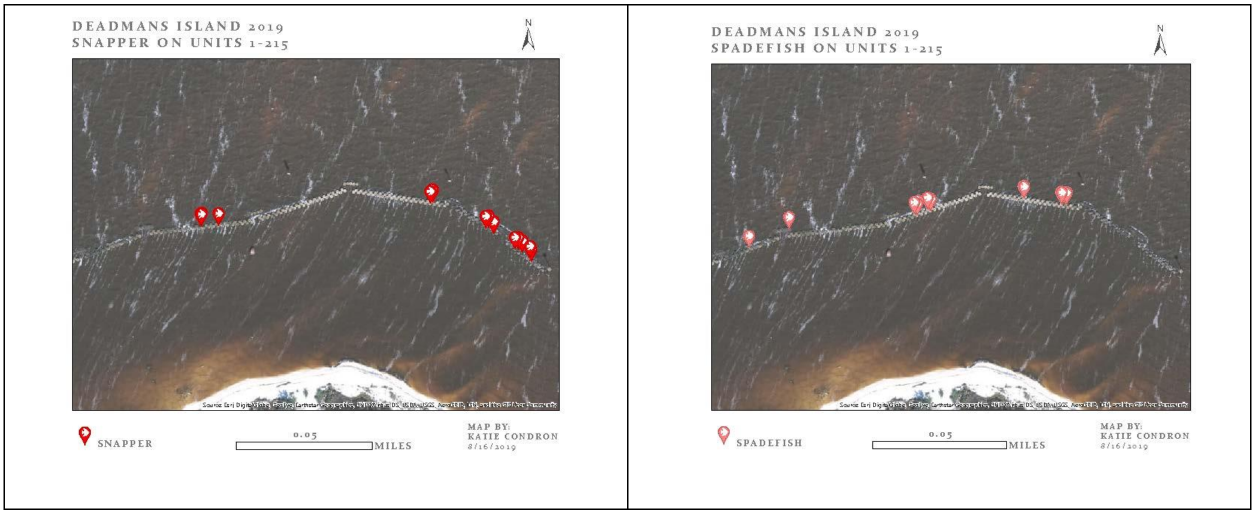


Figure 17: Snapper sp. located around the reefs of Deadman's Island(left) Spadefish scattered around reef units 1-215 (right).

7.0 Abiotic Factors affecting the reef

7.1 Storm Events

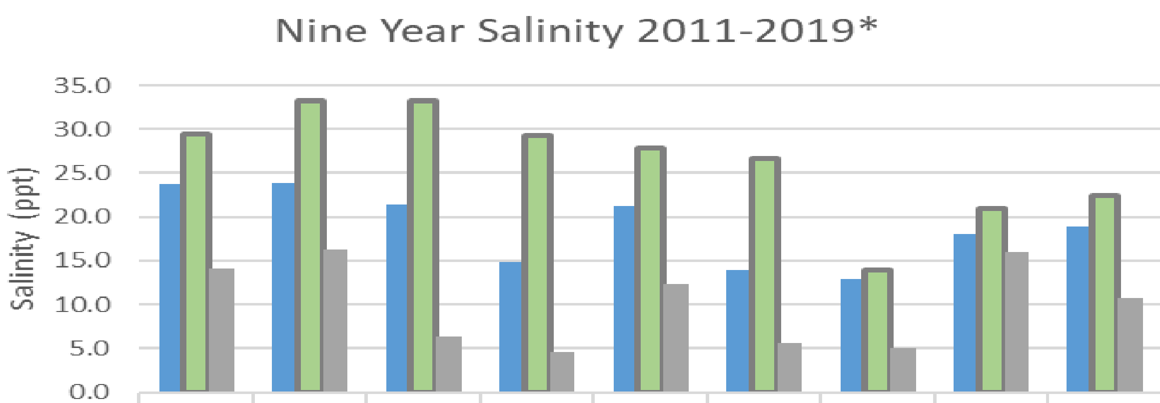
7.1.1 Number of high water events/ significant storms 2019

Aside from the higher than normal tides in the summer, this year did not receive any hurricanes or high windstorms. Rainfall was lower than normal this year in the summer months (Figure 26).

7.2 Salinity

Salinity is the most important physical factor to trend. Salinity levels help understand whether the oysters will have a good year or predict a possible change in growth. Salinity influences the health of the oyster and its predators. Higher salinity accommodates most of the predators of the oysters (Savarese 2005). Oysters can grow and spawn in intermediate salinity, such as 5-25 parts per thousand (Bartol et al., 1999). Historically, in 2013, the salinity reached its highest in the bay at 32ppt, and every year went above the maximum limit, only briefly, the lowest in 2015 at 4.57 ppt. In 2018, salinity ranged from 16-21 ppt from July to September. As observed in the previous years, the increase in salinity correlated with the increase in oyster drills, which are most abundant when the salinity is high (Figure 2 and Figure 19).

It was surprising for 2019 to see the salinity levels were low in June, July, and August, even though we had very little rainfall and high water temperatures. Commonly, it has been observed when there are very little rainfall and high temperatures, the salinity increases. However, the salinity data does not represent the entire year as the temperature and rainfall data does.



	2011 AVG	2012 AVG	2013 AVG	2014 AVG	2015 AVG	2016 AVG	2017 AVG	2018 AVG	2019 AVG
Avg	23.8	23.8	21.4	14.8	21.3	14.0	13	18.0	18.9
Max	29.4	33.26	33.26	29.3	27.9	26.7	14	21	22.5
Min	14.16	16.23	6.32	4.57	12.4	5.7	5	16	10.7

Figure 18: Salinity chart for 2011-2019.

Salinity levels represent March, June, July, August, and September of 2019. The year 2019 shows an average range of 19 (ppt) and min and max range 10.7-22.5 (ppt) during the summer months — data source FDEP STORET and Deadman's Island project monitoring data.

7.3 Water Temperature

There were several temperature fluctuations throughout the year, which could have induced oyster spawning. The temperature chart shows the large temp fluctuation in April, May, and June and remained steady for the rest of the year (Figure 20). Precipitation begins to lower the salinity levels in March (Figure 21). Oyster spawning most likely occurred in May due to the drastic 10 degrees temperature change. The spat settlement looked relatively new at the beginning of the June monitoring.

Salinity is generally affected by rainfall and water temperature. As the temperature rises, the salinity increases in the bay (Figure 19 and Figure 20)). The exception would be due to freshwater influx, as observed with the floods of 2014 (Reed 2017) and multiple heavy precipitation events in 2017 (Reed, 2017). The salinity was much lower in the bay despite the temperature. Observations of nearshore shallow water oysters indicate they are more susceptible to disease from stress and baking in the sun from hotter temperatures when exposed. The offshore distance of the breakwater keeps the temperature and dissolved oxygen ideal for the oysters because of continual underwater exposure. Monitoring shows some oyster growth out of the water, but this exposure usually is tidally influenced and not for long periods nor sitting on the warm sandy shallow bottom.

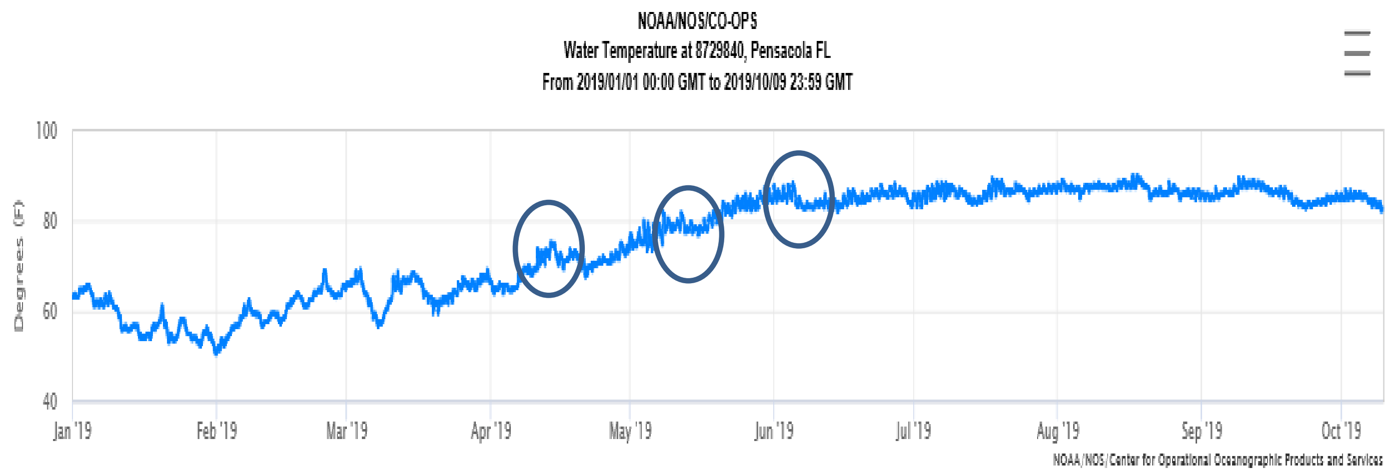


Figure 19: 2019 Water temperature. This chart was used to determine possible random spawning by determining temperature fluctuations. The circle represents the spikes in temperature, possibly causing the spawning. NOAA Air Temperature, Pensacola FL.

Figure 20: 2019 Water temperature. This chart was used to determine possible random spawning by determining temperature fluctuations. The circle represents the spikes in temperature, possibly causing the spawning. NOAA Air Temperature, Pensacola FL. January to October 2019.

7.3.1 Rainfall

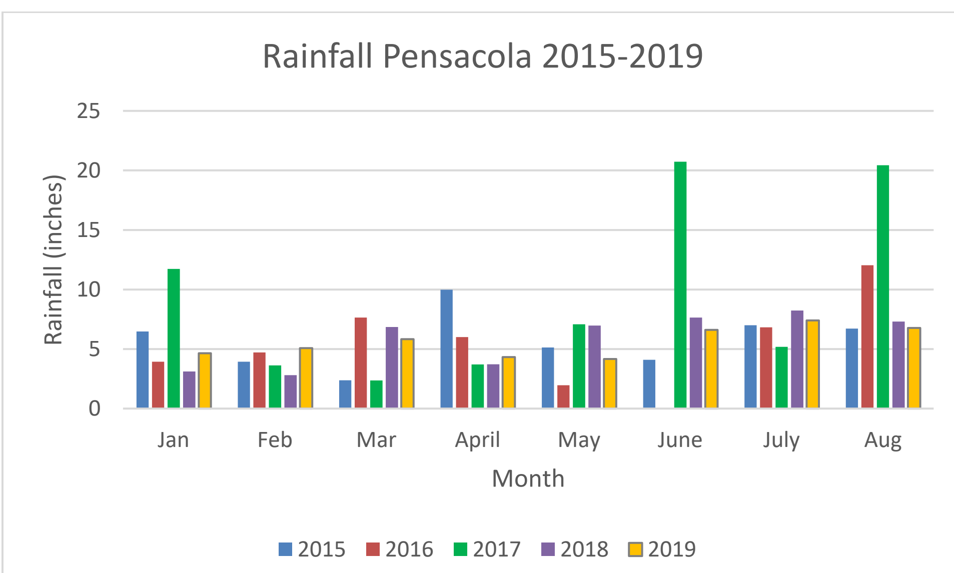


Figure 21: Yearly rainfall near Deadman's Island.

7.4 Hurricanes and Tropical Storms affecting the project

Tropical storms and hurricanes have had a significant effect on the project over the past several years. Fortunately, there were not any named storms that directly affected the reef project this year. However, this year's monitoring did show the effects of Hurricane Michael that impacted the site last year. Hurricane Michael's impacts are listed in the 2018 monitoring report.

Although there were no named storms that directly affected the project, the project did endure high gusts of wind and caused considerable wave erosion to the shoreline. About ten high wind gust events occurred throughout the year. The most damaging winds are from the north. Even though the wind duration was not as long term as with Hurricane Michael, there was a considerable amount of wind from various directions, as indicated in Figure 22.

7.4.1 Wind direction and speed

Wind direction is measured in degrees clockwise from due north. Consequently, a wind blowing from the north has a wind direction of 0°; a wind blowing from the east has a wind direction of 90°; a wind blowing from the south has a wind direction of 180°, and a wind blowing from the west has a wind direction of 270°.

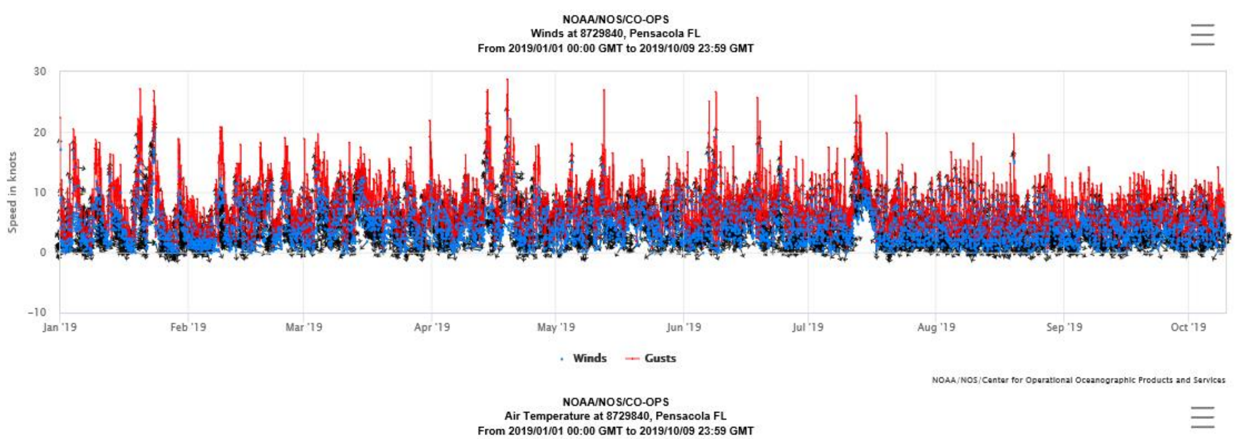


Figure 22: Wind direction and speed. The arrows show the direction, and the colors show the wind (blue) and gust speeds (red).

7.5 Sea Level Rise

As mentioned in the previous year's report, the sea-level rise seems to be measurable on a local scale now. Historically, the NOAA tides charts depicting actual tides are above the predicted tides and appears to remain the same trend as the previous years (Figure 23).

The predicted tides are from models based on the last 100 years. In most cases, not only was the high tide greater than average but the low tide, for some months, represented more of a high tide and remained one foot above normal. In other words, the verified data in the charts, which is the green line, shows the low tide was absent at a time when salt-tolerant plants needed to recover from the lengthy duration of high tides.

Understanding when the tides will be the most destructive to the shoreline can help with the planning of the daily field monitoring and planting events. Since the moon's gravitational pull influences tides, it is essential to check the moon phases (Figure 25) to determine if a phase or a particular phase of events may have created a more considerable influence on the tides. There seemed to be more special moon events this year than last year; however, Figure 24 shows a consistent increase in the actual versus the predicted tides. The special moon events may cause higher than normal tides and do coincide with special moon events, but the ongoing high tide events appear to be the new normal and coincide with NOAA 100 year sea-level rise trend (Figure 23). When the moon phase data from NASA and the NOAA tide data are cross-referenced, there appears to be a correlation with sea-level rise events. Daily field monitoring deployments observe the chart (as well as weather forecasts) were always inconsistent with what was predicted in the daily charts. This inaccuracy would validate NOAA's one-hundred-year average trend if the special moon events, supermoon, super new moon, lunar eclipse, Black moon, etc., as an increase the gravitational pull of the scheduled full and new moons. For example, according to NASA, the supernew moons of 2019 show the moon will be at its closest orbit to the earth at a distance of 224,074 miles (NASA 2019). On November 14, 2016, the distance between the centers of the moon and Earth showed the smallest distance for the year of 221,524 miles. Further evaluation of the historical/special moon events versus tidal change will be discussed in the 2020 monitoring report.

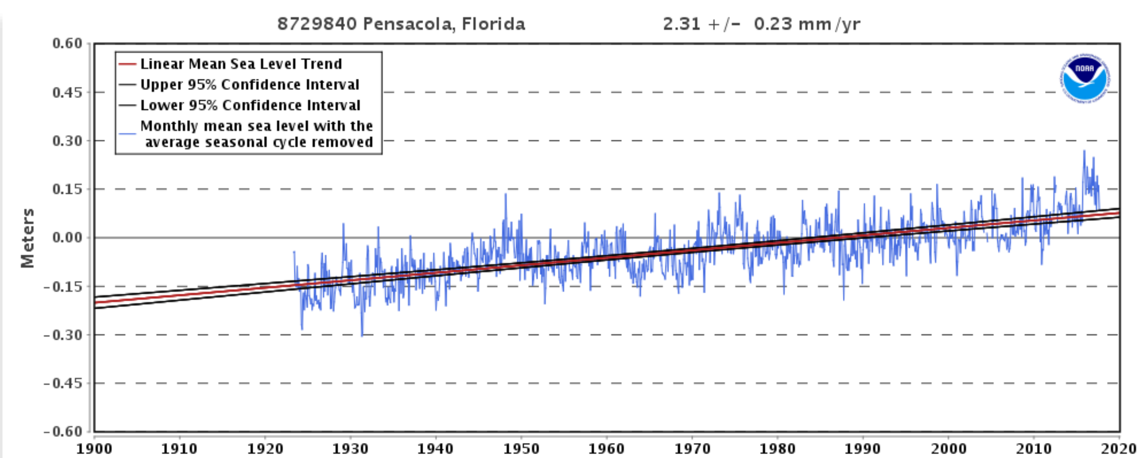


Figure 23: One Hundred year average trend of sea-level rise of Pensacola, Florida.

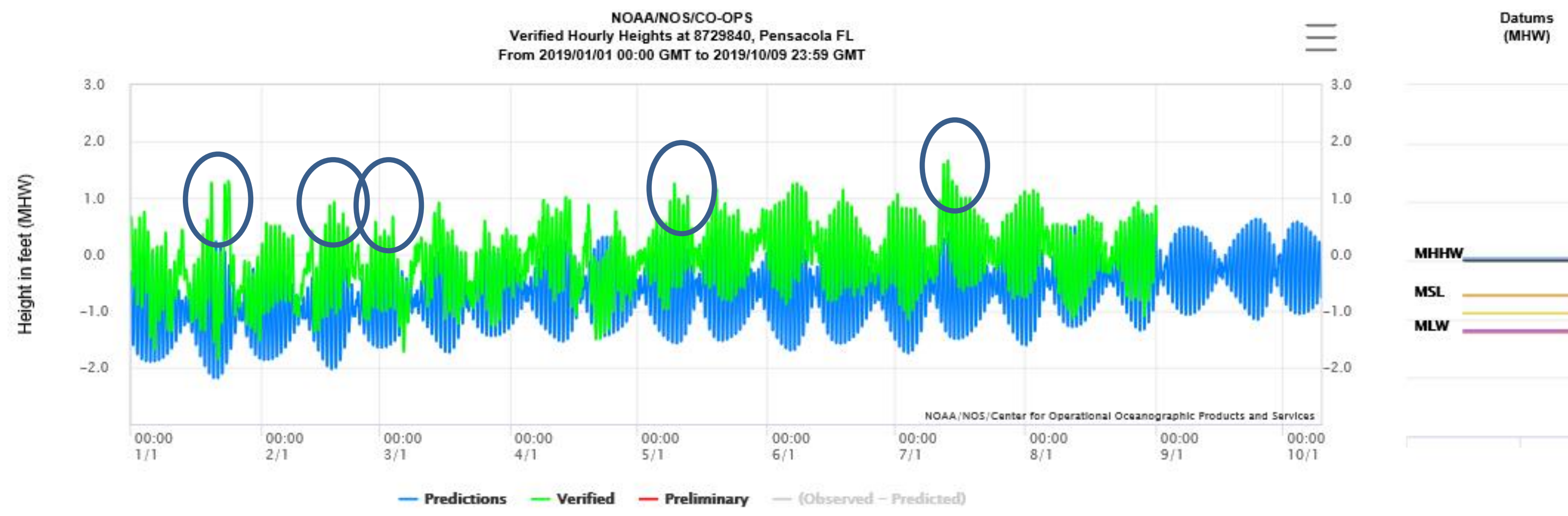


Figure 24: The actual(blue) and predicted(green) tides levels of 2019. The blue lines are the predicted tides given, and the green lines are the verified tides, which were the actual tides. Historic Tides data from Station # 8729840. The circles are the moon events.

2019 Moon Phases Calendar

Jan	5:●, 14:◐, 20:○, 27:◑
Feb	4:●, 12:◐, 19:○, 26:◑
Mar	6:●, 14:◐, 20:○, 27:◑
Apr	5:●, 12:◐, 19:○, 26:◑
May	4:●, 11:◐, 18:○, 26:◑
Jun	3:●, 10:◐, 17:○, 25:◑
Jul	2:●, 9:◐, 16:○, 24:◑, 31:●
Aug	7:◐, 15:○, 23:◑, 30:●
Sep	5:◐, 13:○, 21:◑, 28:●
Oct	5:◐, 13:○, 21:◑, 27:●
Nov	4:◐, 12:○, 19:◑, 26:●
Dec	4:◐, 11:○, 18:◑, 25:●

Special Moon Events in 2019

- Super Full Moon: Jan 20
- Total Lunar Eclipse visible in Pensacola on Jan 20 – Jan 21
- Micro New Moon: Feb 4
- Super Full Moon: Feb 19
- Blue Moon: May 18 (third Full Moon in a season with four Full Moons)
- Black Moon: Jul 31 (second New Moon in single calendar month)
- Super New Moon: Aug 30
- Micro Full Moon: Sep 13
- Super New Moon: Sep 28

Figure 25: 2019 Moon phases- 2019 shows nine special moons events that can enhance the tide levels

8.0 Measurements: Shoreline Vegetation Survival, Mortality and

8.1 Shoreline Vegetation survival:

In 2018, Hurricane Michael placed almost a foot of sand on the shore and smothered the shoreline vegetation. In 2019, 60% of the shoreline vegetation that smothered, was slowly emerging through the sand.

8.1.1 Planting

There were no maintenance plantings in 2019.

8.1.2 Shoreline Erosion Conclusion

The shoreline on the northern point suffered the most erosion and continues to erode. The shoreline from the east and west sections remain the same.

9.0 Shoreline Erosion/Change

A bathymetric survey was not performed this year due to a lack of funding. Shoreline erosion was measured with GPS surveys, and a map was created to show the change in the shoreline.

Figure 26: Clearance gaps (inches) between the floor and bottom of the unit.

With the damage to the reefs from hurricane Michael causing gaps in the breakwater and the tides levels almost always covering the reef, the point of Deadman's Island suffered much erosion. Since the northern point is mostly beach, the *spartina alternaflora* could not become established. We planted wetland Sporrey bogs in 2018 with spartina alternaflora behind the shoreline anticipating the root system would become established even with an established bog; the storms and wind would transport sand and smother the planted Sporrey bogs. Therefore, when the wave action scoured the area, there was no re-enforcement of a spartina root system, and severe erosion occurred.

Underwater gaps in the reef caused the current to create eddies along the shoreline.
The chart represents the entire reef, and each reef unit is numbered (Figure 26). The chart shows dark blue spaces representing the number of inches of space between the subtidal floor and the bottom of the unit. The dark blue spaces are the gaps under the reefs.

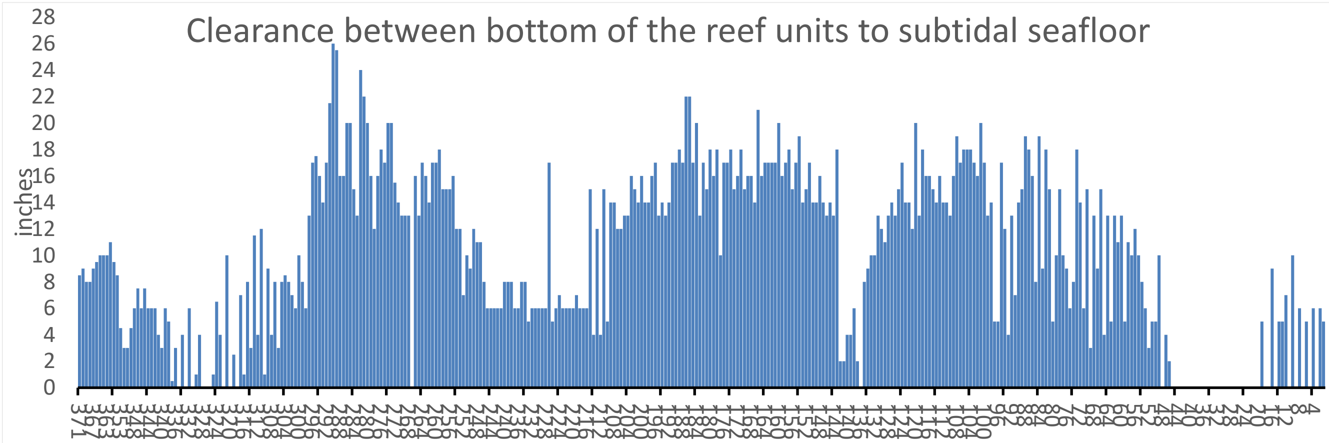


Figure 26: The blue areas show the reef units were there are gaps from the sediment surface to the underside of the bottom unit of the breakwater.

Since the reefs were offshore, it is ideal to have the reef at least 1-2 feet above the water, but as determined by the FDEP permit and rules, this was not allowed. It is hopeful in time; projects such as the Deadman's Island reef will show better science to help change the regulations and statutes for more effective offshore wave attenuators and better use of grant funding.

Figure 27: The red areas show the reef units were there are gaps in the breakwater and allow the wave action to impact the shoreline.

Figure 28: A map of units that have a clearance gap underneath the breakwater 10 inches or more.

Figure 29: A map of units that have a clearance gap underneath the breakwater 20 inches or more.

Figure 30: A map of units that have a clearance gap underneath the breakwater15 inches or more.

9.1.1 Isthmus

The isthmus repair performed in 2017 has performed very well. As predicted, the rocks that were once on the shoreline are now underwater. This erosion is due to the new bridge construction project trapping sand at the bridge and not allowing a sediment bypass. Therefore, no sand gets to Deadman's Island to renourish the shoreline. The breakwaters allowed shoreline accretion to the shoreline directly behind the breakwater.

The isthmus survived Hurricane Michael, but the strong winds and waves moved the rocks off the breakwater in some areas and reduced the height and some structural function of the breakwater. This loss caused the wave attenuation at the openings in between the breakwater to be reduced. In addition, it was shown in previous projects, when large, heavy materials such as Class 2 and 3 riprap is placed onto sandy substrate, even with an under-laying of geofabric, the heavier materials still subside over time. The geofabric has shown over the years that it prevents subsidence; this geofabric is especially helpful only if the materials deployed are lightweight. It was suggested to place Class 3 riprap by an engineer. As expected, the Class 3 riprap, along with the thick fabric, is sinking. The section that only has Class 1 and Class 2 riprap is not subsiding. This concern was demonstrated in the previous Reefblk systems in 2011, where five sections of the reef were double the size and weight of the smaller reefs. These reefs sections and the geofabric were sinking at a slower rate and could be measured. From this project, it was learned Geofabric does not prevent sinking of the rocks in shallow sandy areas. However, without geofabric, the rocks would have subsided at an accelerated rate. This project used geofabric and bagged oyster shell was placed over the geofabric to help displace the rip rap where several sizes of riprap could interlock. Class 3 riprap was not ideal and caused more issues in this project. The larger the structure, the more probability of the structure subsiding in sand.

What can help determine the rate of subsidence is understanding where the hard-pan depth is under the sand (it is usually about five feet in this area). The take-home lesson is to determine a weight balance to maintain the height and where the hard-pan sediment depth place less weight on geofabric when planning wave attenuation projects. Overall, the project is still sustainable after the strong north winds brought indirectly by Hurricane Michael. It is anticipated when a direct hurricane occurs; such as the previous years' storms, Hurricane Ivan and Dennis, the water level will rise over the coastal structures and sand. The coastal structures may not be damaged, but there may be a loss or shifting of sand if submerged underwater too long. This can cause the loss of vegetation if the root system is submerged too long.

Nature is constantly evolving this project. Monitoring these changes can provide scientists more opportunities to improve on coastal protection, sea-level rise, and help managers worldwide determine the transferability of methods to their site-specific coastal projects.

Figure 31: 2019 results from the 2017 Isthmus repair

10.0 References

Biological Assessment for Section 206: Aquatic Ecosystem Restoration Project. 2004.

Gorzelany, J., 1986. Oyster associated fauna: a data collection program for selected coastal estuaries in Hernando, Citrus, and Levy counties, Florida. Vol. 5. Report prepared by Mote Marine Laboratory for the Southwest Florida Water Management District. Miller, D.L. Thetford, and L. yager. 2002.Evaluation of sand fence and vegetation for dune building following overwash by Hurricane Opal on Santa Rosa Island, Florida.J. Coastal Res. 17:936-948

Houser, Chris 2007 Historical Shoreline Erosion: Deadman's Island Dr. Chris Houser, Department of Geography, Texas A&M University updated and sent 8/20/2007 (3pg)

Identification and Evaluation of Submerged Magnetic Anomalies Deadman's Island Santa Rosa County, Florida - Technical Report #DACW01-03-T-0048 , From Tidewater Atlantic Research (TAR), Inc. Washington, North Carolina was submitted to the ACEO, Mobile District 10/2003

Moran, Kilgen, Dugas. 1989. The Ecology of oyster reefs of the Northern Gulf of Mexico and open file report. U.S. Fish and Wildlife Report, Dept. of Interior.

Northwest Florida Water Management District. 1997. Pensacola Bay System Surface Water Improvement and Management Plan: A Comprehensive Plan for the Restoration and Preservation of the Pensacola Bay System. Program Development Series 97-2. Developed by the Northwest Florida Water Management District in cooperation with the Florida Department of Environmental Protection. October 1997.

Morgan, James. 1993. Erosional changes between 1940 and 1992 and the resulting impact on Deadman's Island, Gulf Breeze Peninsula, Florida.

Reed H. 2011, Monitoring and Detection of Gulf Sturgeon During a Bridge Deconstruction Project in Pensacola Bay, Gulf Breeze, Florida. A Technical report for Tetra-tech and the City of Gulf Breeze.

Reed, Heather. 2018. The 2018 Monitoring report of the city of Gulf Breeze Deadman's Island restoration project, Gulf Breeze, Santa Rosa County, Florida, for the US Army Corps of Engineers, Estuary Habitat restoration program. Ecological Consulting Services, Inc. 40 pp.

Savarese, Michael, 2005. Influence of salinity on the habitat use of oyster reefs in three Southwest Florida estuaries. Journal of Shellfish Research

Internet references last accessed October 1, 2019

CO-OPS Map - NOAA Tides & Currents, NOAA, 2019, tidesandcurrents.noaa.gov/map/index.html?id=8729840.

Couranz, Kim, and Blue Water Media, Inc. “Oysters - Fish Facts.” *Environmental Education - Wetlands- Fisheries - NOAA Chesapeake Bay*, 2019, chesapeakebay.noaa.gov/fish-facts/oysters.

Hodges , Michael. “SCORE.” *Oyster Biology & Ecology*, 2019, score.dnr.sc.gov/deep.php?subject=2&topic=15.

Massie, Frederick. “The Uncommon Guide to Common Life on Narragansett Bay.” *Oyster Drills*, 1998, www.edc.uri.edu/restoration/html/gallery/invert/drill.htm.

Noaa. “Oyster Reef Habitat.” *NOAA Fisheries*, U.S. DEPARTMENT OF COMMERCE, 11 Mar. 2019, www.fisheries.noaa.gov/national/habitat-conservation/oyster-reef-habitat.

NASA.gov https://solarsystem.nasa.gov

NASA.gov https://eclipse.gsfc.nasa.gov- Eclipse Predictions by Fred Espenak, NASA/GSFC Emeritus"

“Pensacola, FL.” *AccuWeather*, 2019, www.accuweather.com/en/us/pensacola-fl/32501/july-weather/328165?monyr=7%2F1%2F2019&view=table.

“Pensacola, FL.” *AccuWeather*, 2019, www.accuweather.com/en/us/pensacola-fl/32501/june-weather/328165?monyr=6%2F1%2F2019&view=table.

“Sediment Transport and Deposition.” *Environmental Measurement Systems*, 2014, www.fondriest.com/environmental-measurements/parameters/hydrology/sediment-transport-deposition/.

Tolley, S Gregory, and Aswani K Volety. “The Role Of Oysters In Habitat Use Of Oyster Reefs By Resident Fishes And Decapod Crustaceans.” *Journal of Shellfish Research*, vol. 24, no. 4, 2005, pp. 1007–1012., doi:10.2983/0730-8000(2005)24[1007:trooih]2.0.co;2.

US Department of Commerce and National Oceanic and Atmospheric Administration. “NOAA's National Ocean Service Education: Estuaries.” *NOAA's National Ocean Service*, 19 Dec. 2004, oceanservice.noaa.gov/education/kits/estuaries/media/supp_estuar10d_disolvedox.html

Website for meteorological data http://tidesandcurrents.noaa.gov/ Accessed 2018 http://www.intellicast.com/Local/History.aspx?location=USFL0185

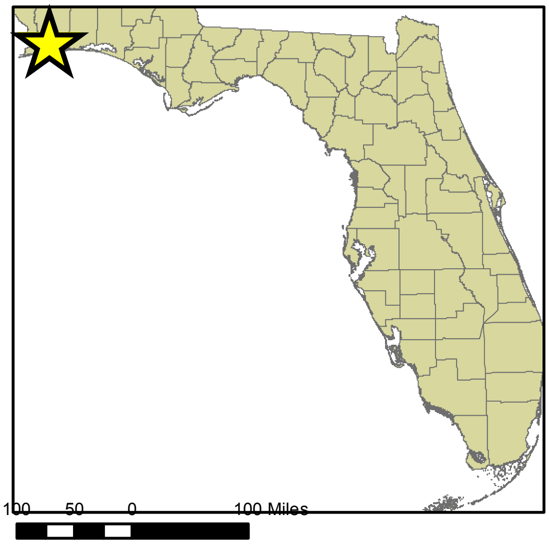
A special thanks for the funding for this project from Estuary Habitat Program by the U.S. Army Corps of Engineers, Mobile District and Biologist Michael Malsom.

Report citation: Reed, Heather. 2019. The 2019 Monitoring report of the City of Gulf Breeze Deadman's Island restoration project, Gulf Breeze, Santa Rosa County, Florida, for the US Army Corps of Engineers, Estuary Habitat restoration program. Ecological Consulting Services, Inc. 40 pp.

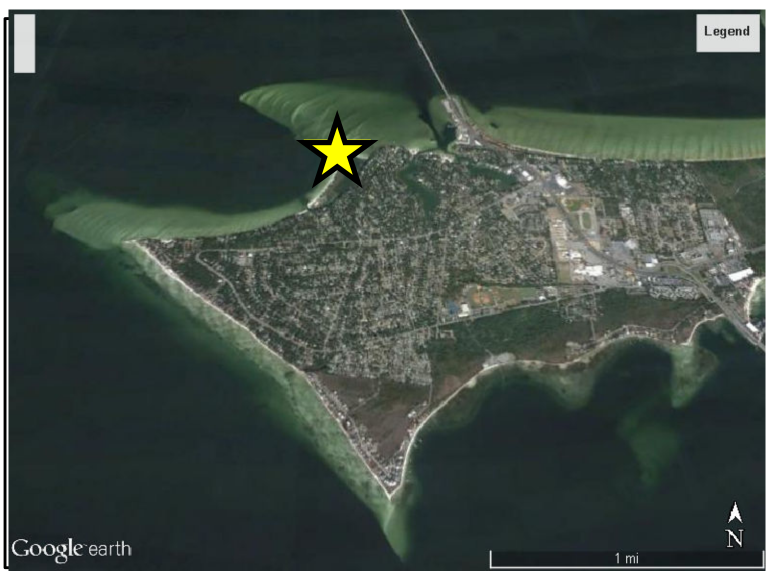
Appendix

1.) Vicinity map

Project Vicinity Map - Deadman's Island, Santa Rosa County



N



Gulf Breeze

Deadman's Island

ECS

Date: 1/12/2017
Prepared By: Heather Reed
www.ecologicalconsultingservices.com