Gulf Coast Ecosystem Restoration Council Grant
Apalachicola Bay Oyster Reef Restoration Project
Monitoring Report

Introduction

The Apalachicola Bay Oyster Reef Restoration Project in Franklin County, Florida was funded by a Gulf Coast Ecosystem Restoration Council (GCERC) grant. As a result of the *Deepwater Horizon* oil spill and associated response activities, oyster and benthic secondary productivity along Florida's Panhandle suffered adverse impacts. This project seeks to foster oyster reef habitat development which will help to recover the losses to oyster habitat and benthic secondary productivity. Monitoring for a two-year period will be conducted to ensure project designs were correctly implemented and to evaluate project effectiveness, as budget allows. Performance criteria will be used to determine project success. Monitoring data and adaptive management principles will be used to evaluate the need for corrective actions and to correct deficiencies as funding allows. This monitoring plan will be implemented by the Central Panhandle Aquatic Preserves (CPAP), which is a division of the Florida Coastal Office (FCO), part of the Florida Department of Environmental Protection (FDEP). The monitoring plan and activities conducted may be modified over time based on management needs for the Oyster Reef Restoration Project.

Project Overview

The objective of this Oyster Reef Restoration Project was to promote reef development for oysters by restoring existing oyster reef habitat that had been degraded, depleted, or reached its productive life span. The restoration work included the placement of suitable cultch material on existing oyster bars for the setting of native oyster larvae and oyster colonization. It included placing approximately 95,000 cubic yards of a lime rock aggregate on an estimated 318 acres of debilitated oyster reefs in the Apalachicola Bay System in Franklin County.

Cultch Sites to be Monitored

The Florida Department of Environmental Protection (FDEP) acted as the administrator for the GCERC project in the Apalachicola Bay System. As a subcontractor, the Florida Department of Agriculture and Consumer Services (FDACS) was responsible for the administration, planning implementation, management, and successful completion of all aspects of the barge cultch planting component.

FDACS's responsibilities included: the review and approval processes for selecting subcontractors; developing the scope of work for the entire project; allocating staff and equipment to participate and manage project operations; scheduling on-site restoration operations; and managing project coordination. FDACS scheduled meetings with subcontractors to establish project schedules and timelines, coordination, operating parameters, and job-related responsibilities. FDACS staff maintained on-site project management and supervision; delineated project planting boundaries and ensured operations conformed to the terms and conditions of the contracted agreements and purchase orders throughout the duration of the project.

FDACS was also responsible for approving work upon completion to determine that the barge cultch planting component was completed in accordance with contract provisions and job specifications. Staff verified that all jobs listed in the scope of work were completed before approving invoices for payment.

From September 26, 2017 through November 30, 2017 (26 working days) the cultch placement of the Apalachicola Bay System, GCERC grant project was completed. Approximately 95,500 cubic yards of lime rock aggregate were deposited onto fourteen degraded or depleted oyster reefs. A total of 318 acres of cultch were planted in the Apalachicola Bay system in Franklin County. This cultching, in areas of Apalachicola Bay where natural reproduction occurs: 1) creates three-dimensional reef structure, 2) stimulates spat setting, 3) accelerates the recovery process, 4) increases natural productivity, 5) sustains oyster fisheries, and 6) enhances ecosystem community functions. The rebuilding of oyster reef infrastructure contributes to a "bottom up approach" to repairing injured, impaired, and damaged natural resources. Improved habitat forms the foundation for oysters, as an engineering species, to contribute to wide reaching fishery and ecological benefits throughout the Apalachicola Bay system. Ecological benefits of cultch deposition are realized through an array of ecological services in the form of increased fishery and wildlife habitat; increased bio-diversity and trophic dynamics; increased filtering capacity to improve water quality and recycle nutrients; and increased structural stability to reduce coastal erosion and to protect nearshore resources. Economic benefits are realized through harvesting, processing and marketing fishery products and felt locally and regionally by all who enjoy high-quality, wholesome Florida seafood and depend upon commercial fisheries for employment and income.

Monitoring Protocols

1. <u>Site Selection</u>
   Prior to sampling, each reef site is divided into midpoints, the number of which depends on the size of the reef being sampled (i.e. a larger reef site contains more midpoints than a smaller site). Using ArcGIS, midpoints are determined to effectively assess the reef area. These midpoints are the exact location to be sampled.

   For each sampling day, four FDEP staff are needed: two divers, one safety diver, and a boat captain. All divers must be certified to dive for FDEP. Similarly, the boat captain must be certified to operate FDEP vessels. All diving is done in accordance to the FDEP's Underwater Operation Manual, which is available at http://www.dep.state.fl.us/admin/Safety/DsaB/files/Underwater_Ops_Manual.pdf.

   Based on weather, winds, and current conditions, the team selects an appropriate site(s) and/or midpoint(s) to sample. Once near the site, the boat captain "zeros out" the boat's position using GPS, getting as close to the designated midpoint's coordinates as possible.

2. <u>Sample Collection</u>
   Two divers enter the water on either side (starboard and port) of the boat. Each diver swims a weighted transect line out 10m from the side of the vessel. Each transect line has a mushroom anchor and dive flag with a float attached to the end. The diver then descends and places a 0.25 m^2 quadrat on the bottom in a haphazard manner near the transect line. Live oysters, shell and associated fauna are removed to the depth of the sediment, placed in mesh collecting bags and delivered to the survey vessel. This is repeated five times on each side of the boat, as well as off the bow of the boat. A total of 15 quadrats (five starboard, five port, and five bow) are sampled for each site midpoint.

The boat captain and safety diver label sample bags as they are being collected. A sample ID is given to each sample (quadrat) that includes the site name, midpoint number, side of the boat, and the sample number. For example, the first quadrat from RESTORE site - Cat Point, Midpoint 1, taken from the starboard side of the boat is given the ID: R-CP-MP1-S1. The team onboard also measures water quality parameters at the surface and bottom of the water column, using a Yellow Springs Instrument (YSI) handheld datasonde, which include: water temperature, dissolved oxygen, specific conductance, salinity, and pH. Weather conditions, wind, current, latitude and longitude are also recorded.

3. <u>Sample Processing</u>

Samples are processed once all the quadrats have been collected for a midpoint. If it is not possible to process samples immediately after sampling, they are frozen until processing can be completed.

First, the sample is weighed using a digital hanging scale. If oysters are present in the collected sample, shell height of the first 100 live oysters is measured to the nearest millimeter (mm). Oyster shell height (Figure 1) is defined as the distance from the umbo to the distal margin of the shell (Bagget *et al*, 2014).

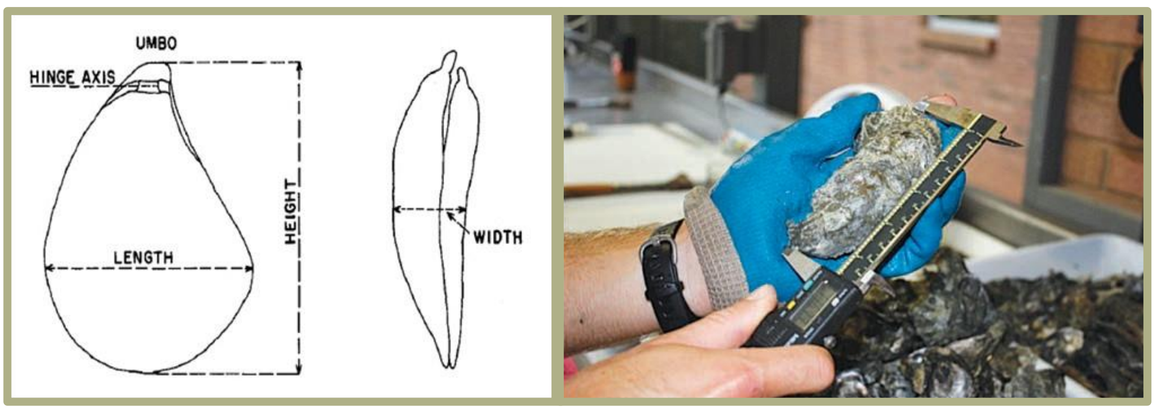

Figure 1: (left) Diagram of the height, length, and width measurements of an oyster shell, from Galtstoff 1964, Chapter 2. (right) An example of shell height measurement in a lab.

If the sample contains more than 100 live oysters, the remaining live oysters are counted. Live oysters are divided into one of three size classes (Table 1): spat (0-25 mm), seed (26-74 mm) and harvestable adult (75 mm and larger). The number of dead oysters in the sample is also counted.

Table 1: Oyster size classes

Size Class	**Oyster shell height (mm)**
Spat	0-25 mm
Seed	26-74 mm
Adult	≥75 mm

4. Data Entry
The oyster size data are entered in to an Excel spreadsheet and entries are separated into the size classes described above. Water quality parameters, weather conditions, wind, currents, latitude and longitude are also entered into Excel. Next, all the data are proofed for quality control/quality assurance, and any errors are corrected. All Excel data and scanned copies of original data sheets are stored on the CPAP server.

5. Data Analysis
Oyster populations will be described by plotting parameters such as: total number of live vs. dead oysters, total number of oysters by size class, density of live oysters, average oyster size, etc.

To determine the relative condition of oyster resources, an estimate of harvestable oysters will be determined using FDACS' Standard Oyster Resource Management Protocol (see Appendix 1). This protocol has been used in Apalachicola Bay since 1982. FDACS uses a scale that states that 400 bags/acre could be harvested from productive artificially constructed reefs within two years of planting cultch. The scale is as follows:

- More than 400 bags/acre = Healthy oyster reefs capable of sustaining commercial harvest.
- More than 200 bags/acre = Oyster reefs capable of sustaining limited harvest.
- Less than 200 bags/acre = Below level necessary to support commercial harvest.
- Less than 100 bags/acre = Oyster reefs considered depleted.

After the first two years of sampling, oyster populations will be compared using the Kruskal-Wallis test to determine significant differences between length-frequency distributions between reef sites.

6. Determining Spatial Extent of Cultched Areas
Mapping of the cultched reefs will be conducted using high-resolution side scan sonar imagery collected using a Humminbird® side imaging system. Data will be imported and analyzed using spatial analysis software or another equivalent method as appropriate. Maps will be created depicting the extent of created or enhanced oyster reefs. At year one and year two of the project, the oyster cultch spatial extent will be analyzed to determine any spatial changes in the reef areas.

Note #1: Originally, the spatial extent of all cultched reefs was to occur during the six-month, one-year, and two-year monitoring periods; however, due to unforeseen circumstances (staff medical issues, Hurricane Michael, and boat repairs), mapping of the cultched reefs was not completed at the six-month mark. As a result, mapping will be completed at year one, year two, and if approved, additional mapping will occur beyond the year two sampling period. The funding allocated to the six-month mapping component will not be expended.

7. Generation of Technical Reports
CPAP will submit a monitoring report within 45-days of each monitoring event to the RESTORE Project Manager detailing the recruitment, size, frequency of live oysters, frequency of dead oysters, and status of the shell material deployed. This report will include an estimate of

harvestable oysters at each site, as well as the water quality and environmental parameters measured, and any recommendation for improving the enhanced site's productivity.

Monitoring Schedule

Safety will be the top priority when determining sampling dates, as this type of monitoring is extremely weather dependent. Monitoring will occur on three separate occasions: six months, one year, and two years after the cultch was laid.

Apalachicola Bay

The Apalachicola Bay system is a wide, shallow estuary that covers an area of approximately 210 square miles behind a chain of barrier islands (Gorsline, 1963). Its primary source of fresh water is the Apalachicola River. The estuarine system may be divided into four sections based on both natural bathymetry and man-made structural alterations; East Bay, St. Vincent Sound, Apalachicola Bay, and St. George Sound. Apalachicola Bay has over 4,000 acres of historically viable oyster reefs, with the bulk of the acreage included in the main bars of Cat Point, East Hole and Dry Bar. Approximately 95,000 cubic yards of a lime rock aggregate were placed on an estimated 317 acres of debilitated oyster reefs in the Apalachicola Bay during October 2017. See Figures 2-5 for maps of cultched sites in Apalachicola Bay. GPS coordinates for each monitoring site's midpoint(s) are located in Table 2.

Environmental conditions as well as historical productivity and recruitment were considered when selecting the oyster reefal complexes to be restored. Based on this and input from the Franklin County Seafood Workers Association (FCSWA), the following fourteen (14) viable oyster reefal complexes in the Apalachicola Bay System were chosen for cultch deposition:

West Side

- Eight Mile: An unconsolidated natural oyster reefal complex, lying in an east-west configuration; surrounded by a soft mud substrate. The reef is in St. Vincent Sound, in an Approved shellfish harvesting area.
- Nine Mile - King: An unconsolidated natural oyster reefal complex. Reef is comprised primarily of a series of small, natural oyster reefs (lumps/knobs), lying in a north-south configuration; each surrounded by a soft mud substrate. The reef is in St. Vincent Sound, in an Approved shellfish harvesting area.
- Nine Mile B: An unconsolidated natural oyster reefal complex. Reef is comprised primarily of a series of small, natural oyster reefs (lumps/knobs), lying in a north-south configuration; each surrounded by a soft mud substrate. The reef is in St. Vincent Sound, in an Approved shellfish harvesting area.
- Cabbage Top: An unconsolidated natural oyster reefal complex. Historically, portions of the reef have received restoration by cultching. Reef is comprised primarily of a natural and planted oyster shell matrix. The reef is in St. Vincent Sound, north of St. Vincent Island, off Cabbage Top proper, in a Conditionally Approved shellfish harvesting area.

- North Spur #2: A series of reefs around a natural reefal complex; historically, portions of the reef have received extensive restoration by cultching. Reef is comprised primarily of a natural and planted oyster shell matrix. The reef is located mid-bay, in Apalachicola Bay, in a Conditionally Approved shellfish harvesting area.

East Side

- Hotel Bar #1: Reef is a large consolidated natural oyster complex; portions of the reef have received extensive restoration by cultching. The substrate is primarily a natural and processed oyster and clam shell matrix. The surrounding bottom is generally firm with sand shoals landward of the reef. The reef is located offshore of St. George Island, between the Intracoastal Waterway (ICWW) and northern shoreline of St. George Island, near the Bryant Patton Bridge; in an Approved shellfish harvesting area.
- Hotel Bar #2: Reef is a large consolidated natural oyster complex; portions of the reef have received extensive restoration by cultching. The substrate is primarily a natural and processed oyster and clam shell matrix. The surrounding bottom is generally firm with sand shoals landward of the reef. The reef is located offshore of St. George Island, between the ICWW and northern shoreline of St. George Island, near the Bryant Patton Bridge; in an Approved shellfish harvesting area.
- East Hole #1: Large consolidated natural reefal complex; historically portions of the reef have received extensive restoration. The reef is comprised primarily of a natural and planted oyster shell matrix. The surrounding bottom is generally firm. The reef is located north of St. George Island and east of the Bryant Patton Bridge; in a Conditionally Approved shellfish harvesting area.
- East Hole #2: Large consolidated natural reefal complex; historically portions of the reef have received extensive restoration. The reef is comprised primarily of a natural and planted oyster shell matrix. The surrounding bottom is generally firm. The reef is located north of St. George Island and east of the Bryant Patton Bridge; in a Conditionally Approved shellfish harvesting area.
- South Bulkhead: Large consolidated natural reefal complex; historically portions of the reef have received restoration. The reef is comprised primarily of a natural and planted oyster shell matrix. The surrounding bottom is generally firm. The reef is located north of St. George Island and east of the south end of Bird/Bulkhead Island; in a Conditionally Approved shellfish harvesting area.
- Monkey's Elbow: Large consolidated natural reefal complex; historically portions of the reef have received restoration. The reef is comprised primarily of a natural and planted oyster shell matrix. The surrounding bottom is generally firm. The reef is located north of St. George Island and east of the north end of Bird/Bulkhead Island; in a Conditionally Approved shellfish harvesting area.
- Peanut Ridge: Large consolidated natural reefal complex; historically portions of the reef have received restoration. The reef is comprised primarily of a natural and planted oyster shell matrix. The surrounding bottom is generally firm. The reef is located mid-bay, east of the Bryant Patton Bridge; in a Conditionally Approved shellfish harvesting area.
- Cat Point Spur: Consolidated natural reefal complex; historically portions of the reef have been restored. The reef is comprised primarily of a natural and planted oyster shell matrix. The

surrounding bottom is generally firm. The reef is located mid-bay, east of the Bryant Patton Bridge; in a Conditionally Approved shellfish harvesting area.

- Cat Point: A large natural oyster reefal complex; historically portions of the reef have received extensive restoration and re-seeding. Cat Point bar is the prominent natural feature separating eastern Apalachicola Bay and St. George Sound. The reef is comprised primarily of a natural and planted oyster shell matrix. The surrounding bottom is generally firm. The reef is in the western end of St. George sound and south of the city of Eastpoint, in a Conditionally Approved shellfish harvesting area.

Figure 2: Map of RESTORE reefs in Apalachicola Bay prepared by FDACS. North Platform bar is not included in this report since the cultch placement for this site was funded through an alternate source.

RESTORE Reefs (West)

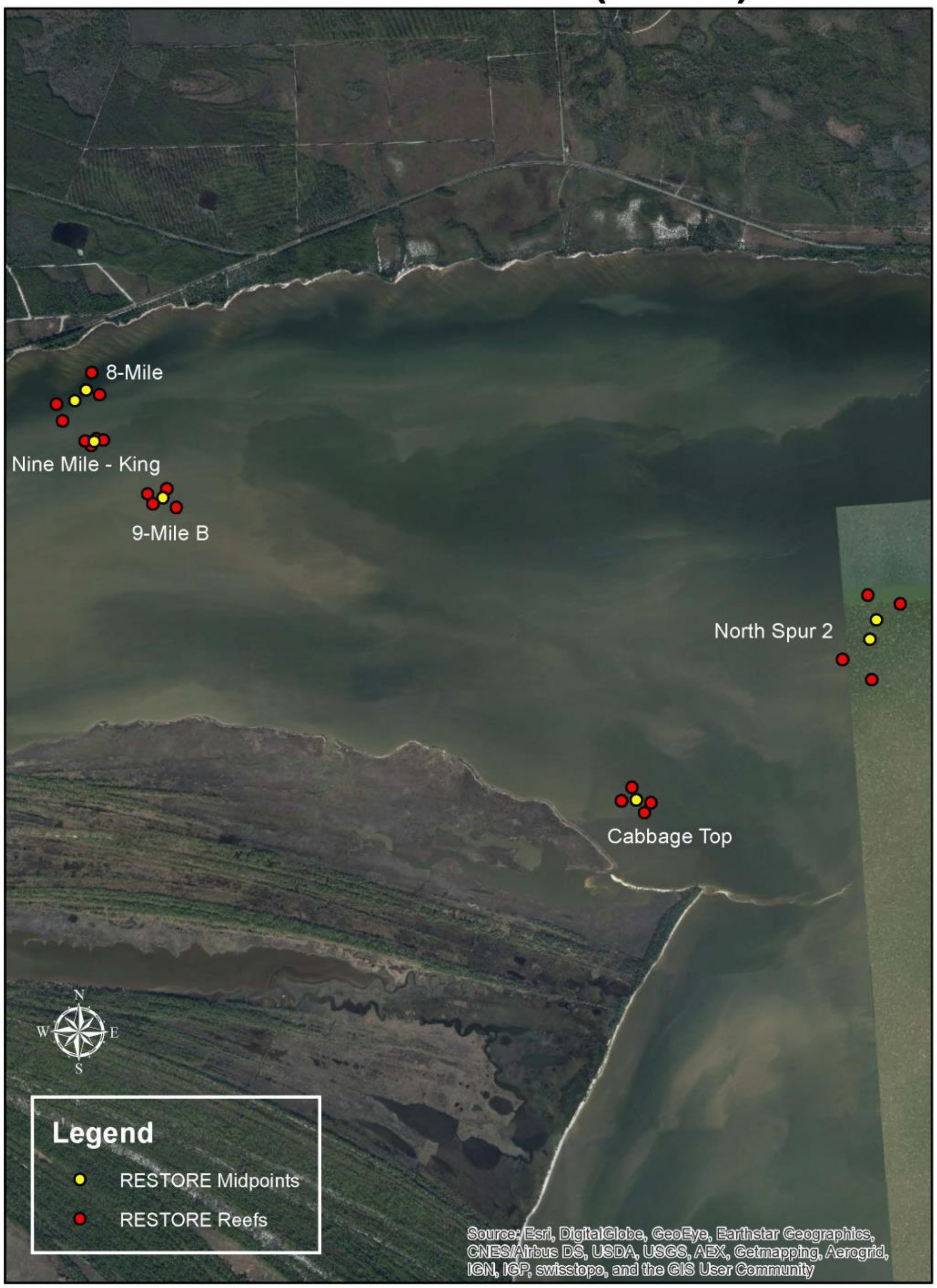

Figure 3: Map of midpoints on the west side of Apalachicola Bay.

RESTORE Reefs (East)

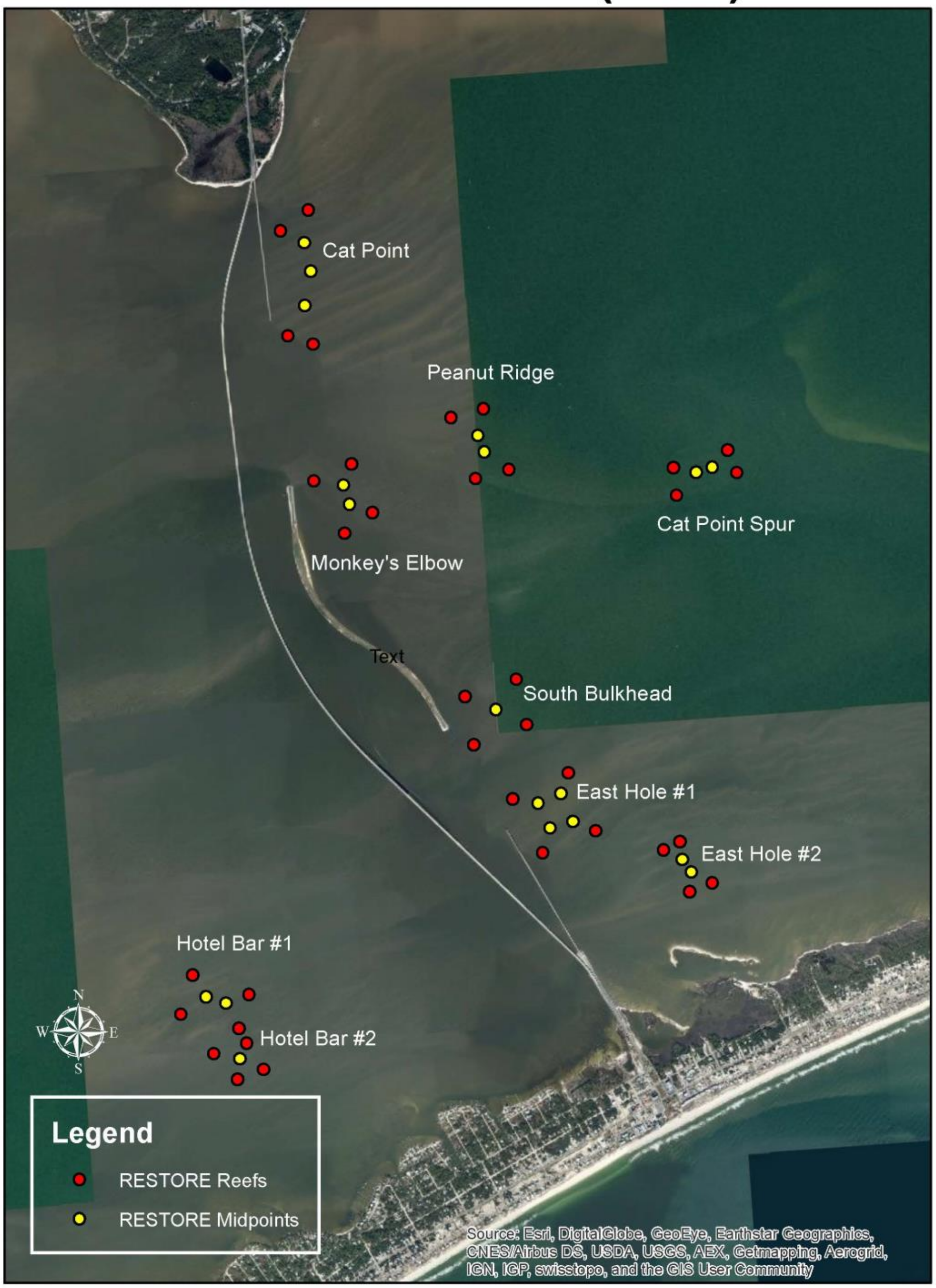

Figure 4: Map of midpoints on the east side of Apalachicola Bay.

Table 2: Coordinates for RESTORE monitoring sites in Apalachicola Bay

Monitoring Site	Latitude	Longitude
West		
Cabbage Top, Midpoint 1	29.68027	-85.08
Eight Mile, Midpoint 1	29.71115	-85.1232
Eight Mile, Midpoint 2	29.71185	-85.1222
Nine Mile B, Midpoint 1	29.70388	-85.1166
Nine Mile-King, Midpoint 1	29.70817	-85.1218
North Spur #2, Midpoint 1	29.69046	-85.0602
North Spur #2, Midpoint 2	29.69181	-85.0596
East		
Cat Point, Midpoint 1	29.71458	-84.8849
Cat Point, Midpoint 2	29.71672	-84.8843
Cat Point, Midpoint 3	29.71851	-84.8846
Cat Point Spur, Midpoint 1	29.70239	-84.8576
Cat Point Spur, Midpoint 2	29.70265	-84.8564
East Hole #1, Midpoint 1	29.68236	-84.8707
East Hole #1, Midpoint 2	29.68287	-84.869
East Hole #1, Midpoint 3	29.68105	-84.8682
East Hole #1, Midpoint 4	29.68076	-84.8699
East Hole #2, Midpoint 1	29.67819	-84.8606
East Hole #2, Midpoint 2	29.67736	-84.86
Hotel Bar #1, Midpoint 1	29.6717	-84.8955
Hotel Bar #1, Midpoint 2	29.67121	-84.8941
Hotel Bar #2, Midpoint 1	29.66765	-84.8934
Monkey’s Elbow, Midpoint 1	29.70315	-84.883
Monkey’s Elbow, Midpoint 2	29.70192	-84.8827
Peanut Ridge, Midpoint 1	29.70567	-84.8731
Peanut Ridge, Midpoint 2	29.70461	-84.8727
South Bulkhead, Midpoint 1	29.68843	-84.8732

Results

From June – September 2018, 14 reef sites with a total of 26 midpoints (390 quadrats) were sampled for this project in Apalachicola Bay.

Note #2 - On October 10, 2018, Hurricane Michael impacted the Florida Panhandle as a Category 4 hurricane. As a result of the storm surge, the freezers used to store samples were tipped over, damaged beyond repair and without power for several days. Samples from three sites (East Hole #1, East Hole #2, and Monkey's Elbow) thawed, and became very difficult to process, as the oyster flesh had either washed away during the storm or been consumed by maggots. A total of 76 (19.5%) samples were affected, and for this reason, data at these sites are considered suspect. Specifically, the accuracy of the live vs. dead counts, oyster density, and shell height data remains unclear since the oyster samples were altered during the thawing process.

A total of 1705.54 kg (3760.07 lbs.) of oysters/shell material/rock was collected from Apalachicola Bay. The average sample weight across all sites was 4.27 kg, and Table 3 shows the average sample weight per site. South Bulkhead had the heaviest average sample weight at 7.10 kg, while 9 Mile B had the lightest at 0.02 kg.

Table 3. Average sample weights from all RESTORE reefs (Refer to Note #2).

Site	**Average Sample Weight (kg)**
8 Mile	4.02
9 Mile B	0.02
9 Mile-King	1.01
Cabbage Top	5.88
Cat Point	3.85
Cat Point Spur	4.15
East Hole #1	5.66
East Hole #2	4.22
Hotel Bar #1	3.87
Hotel Bar #2	3.77
Monkey's Elbow	4.64
North Spur #2	5.92
Peanut Ridge	4.05
South Bulkhead	7.10

Over the course of the first round of sampling, a total of 19,811 live oysters and 2,292 dead oysters were collected in Apalachicola Bay (Figure 5).

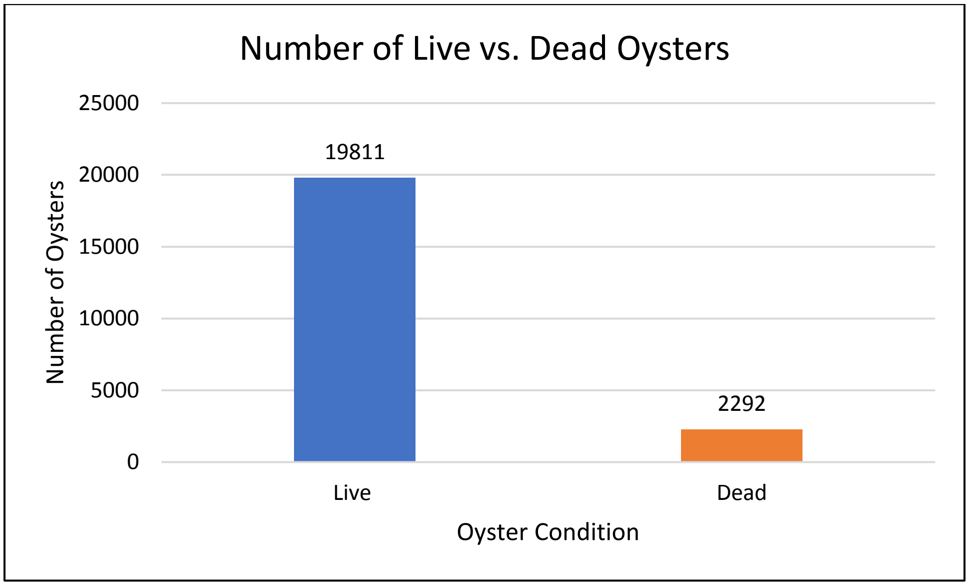

Figure 5: Number of live vs. dead oysters (Refer to Note #2).

A comparison of size classes of live oysters shows that spat-sized oysters were the most prevalent size class (Figure 6). Of the live oysters collected, 83.66% (n=16,573) were spat-sized, 1.41% (n=3,238) were seed sized, and none were adult sized. The absence of adult sized individuals is expected for the first round of sampling, as it takes approximately 18 months for oysters to reach adult size in Apalachicola Bay (Ingle 1950; Ingle and Dawson 1952).

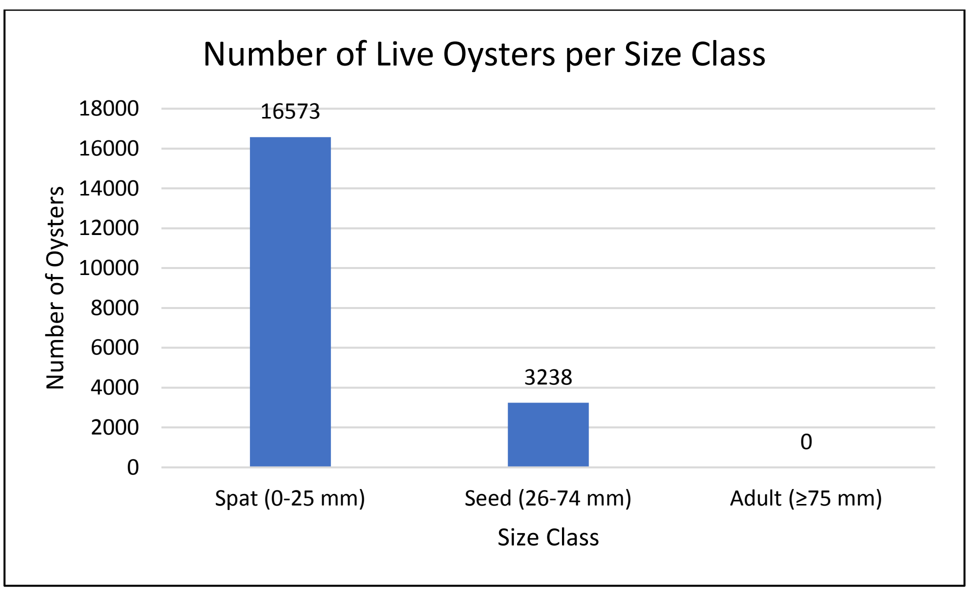

Figure 6: Number of live oysters per size class (Refer to Note #2).

Anecdotally, local oyster harvesters have said that the oyster populations on the west side of the bay have been declining more quickly than the east side. To test this theory, we divided our sites by their geographic location in Apalachicola Bay. Those located to the east of the Apalachicola River (Cat Point, Cat Point Spur, East Hole #1, East Hole #2, Hotel Bar #1, Hotel Bar #2, Monkey's Elbow, Peanut Ridge, and South Bulkhead) were considered "east" sites, and those located to the west of the river (8 Mile, 9 Mile B, 9 Mile-King, Cabbage Top, and North Spur #2) were considered "west".

A comparison of the number of live oysters collected by side of bay shows that approximately 90% of the oysters collected (n=17,828) were collected on the east side of the bay, while 1,983 (10.01%) were collected on the west side (Figure 7). A two-sample t-test assuming unequal variance shows that the difference in number of live oysters from east sites versus west sites is statistically significant (p=0.002).

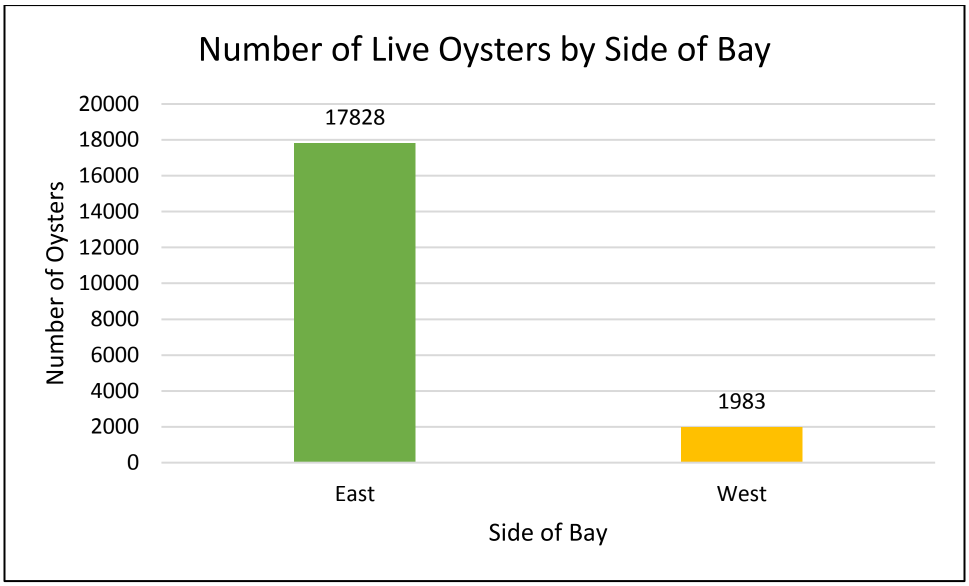

Figure 7: Number of live oysters by side of bay (Refer to Note #2).

A size class comparison of live oysters by side of bay (Figure 8) further shows that the east side contributed more spat and seed sized oysters when compared to the west side. Of the spat collected, 91.09% (n=15,096) were collected on the east side, while 8.91% (n=2,732) were collected on the west side. Similarly, most of the seed-sized oysters (84.37%, n=2,732) were collected from the east side of the bay, while the west side accounted for only 15.63% (n=506) of seed-sized oysters. No adult oysters were collected during the first round of sampling, which is to be expected.

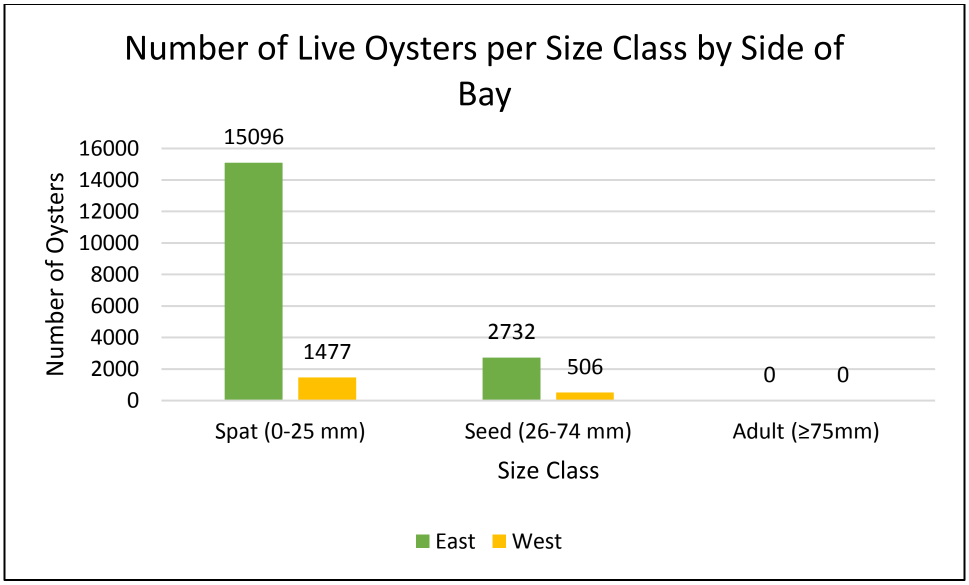

Figure 8: Number of live oysters per size class by side of bay. (Refer to Note #2).

It should be noted that the east side of Apalachicola Bay consisted of nine reefs and 285 quadrats, while the west side had five reefs and 105 quadrats. To account for any bias based on the difference in sampling effort, estimates of the density of live oysters (live oysters/m²) were calculated. The estimated average density of live oysters for the entire bay was 197.15 oysters/m². The estimated average density of oysters on the east side (270.04 oysters/m²) was much higher than the west side of the bay (65.95 oysters/m²) (Figure 9). A two-sample t-test assuming unequal variance showed that the difference in estimated average densities at east sites versus west sites was statistically significant (p-value=0.003).

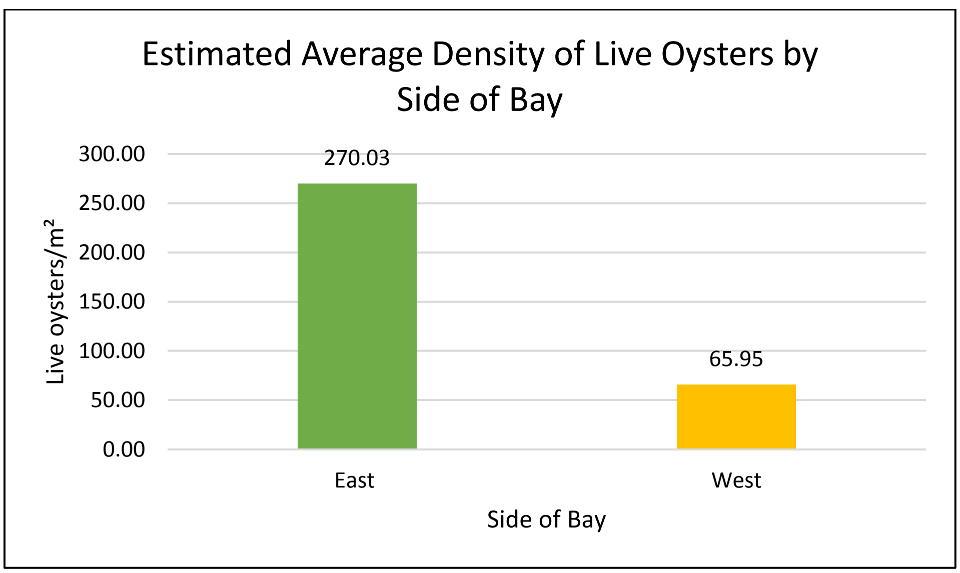

Figure 9: Estimated average density of live oysters by side of bay (Refer to Note #2).

Figure 10 shows the highest number of spat-sized oysters were collected at East Hole #1 (See Note #2) (n=3068), followed by Hotel Bar #1 and Cat Point Spur (n=2687 and n=2486, respectively). South Bulkhead contained the highest number of seed-sized oysters (n= 648) while Cat Point (n=515) and Monkey's Elbow (n=508) (See Note #2) had the next highest numbers of seed-sized oysters. 9 Mile-King was the only site where no live oysters were collected.

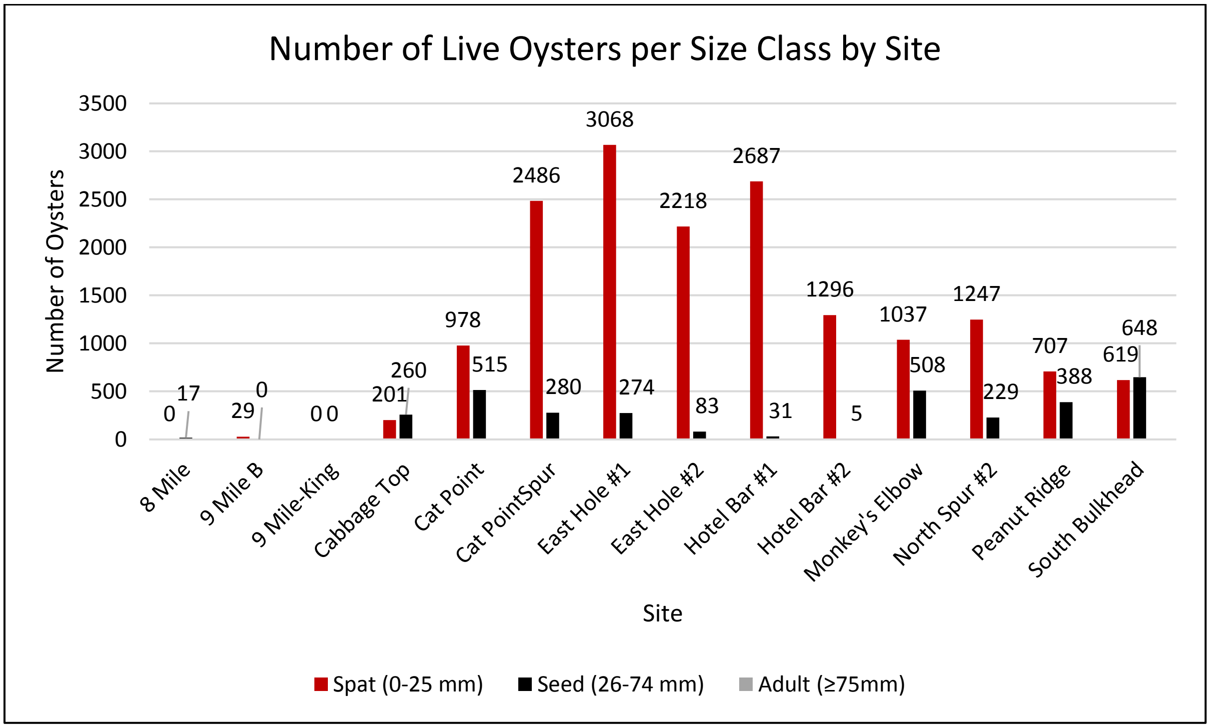

Figure 10: Number of live oysters per size class by site (Refer to Note #2).

As previously stated, most of the live oysters collected during this round of sampling were spat sized. To further investigate the size distribution of live oysters in the bay, shell height distribution was plotted (Figure 11). Most of the oysters measured (n=4211) had a shell height between 16-20 mm. The shell height distribution follows a normal bell curve, with fewer larger oysters. This large number of spat sized individuals is expected for the first round of sampling, as it takes approximately 18 months for oysters to reach adult size in Apalachicola Bay (Ingle 1950; Ingle and Dawson 1952). If restoration is successful, it is expected that the bell curve will shift to the right as time passes and this recruitment class of oysters grows into adults.

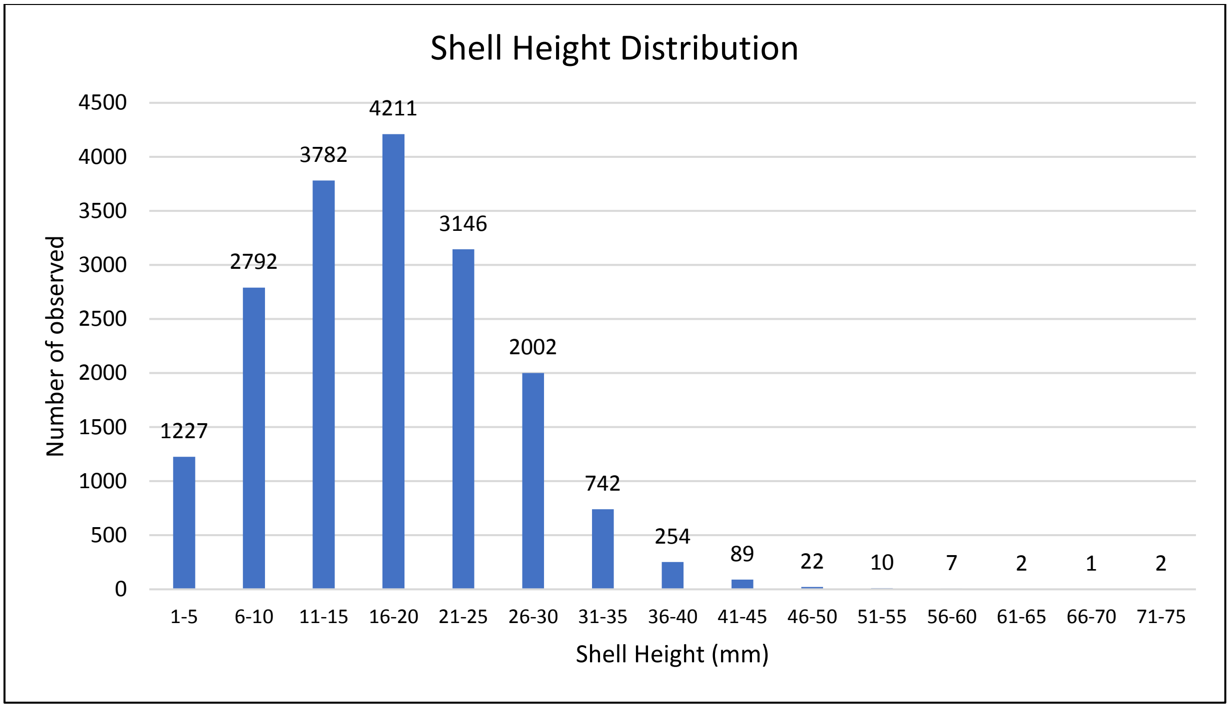

Figure 11: Shell height distribution for the entire bay (Refer to Note #2).

FDACS Standard Oyster Resource Management Protocol

FDACS protocols were used to estimate the number of bags of harvestable oysters per site (see Appendix 1). The calculations that were performed to estimate the number of bags per acre of legal harvest-sized oysters are shown in Table 4.

None of the sites sampled contained live adult (≥ 75mm) oysters. Therefore, all sites contained an estimated 0 bags per acre (Table 4). Since the reefs had been cultched less than 18 months prior to the time of sampling, adult sized oysters on these reefs were not expected. If restoration is successful, the presence of adult sized oysters is expected at Year Two of monitoring.

Table 4: FDACS protocols to estimate bags/acre of harvestable oysters (Refer to Note #2).

Site	Total # of quads	Total # of live oysters	Mean Shell Height (mm)	Density (live oysters/m²)	Oysters ≥75mm (%)	Harvestable oysters/m²	Harvestable oysters/acre	Bags per acre (harvestable oysters)
8 Mile	30	17	37.82	2.27	0	0	0	0
9 Mile B	15	29	8.07	7.73	0	0	0	0
9 Mile-King	15	0	.	0.00	0	0	0	0
Cabbage Top	15	461	23.49	122.93	0	0	0	0
Cat Point	45	1493	23.51	132.71	0	0	0	0
Cat Point Spur	30	2766	18.12	368.80	0	0	0	0
East Hole #1	60	3342	17.93	222.80	0	0	0	0
East Hole #2	30	2301	15.06	306.80	0	0	0	0
Hotel Bar #1	30	2718	11.44	362.40	0	0	0	0
Hotel Bar #2	15	1301	9.04	346.93	0	0	0	0
Monkey's Elbow	30	1545	22.70	206.00	0	0	0	0
North Spur #2	30	1476	11.57	196.80	0	0	0	0
Peanut Ridge	30	1095	22.95	146.00	0	0	0	0
South Bulkhead	15	1267	24.83	337.87	0	0	0	0

Water Quality Monitoring

Water quality parameters (temperature, dissolved oxygen (DO), salinity, and pH) were recorded at each site midpoint, both at the surface and on the bottom of the water column (Table 5). This data provides a "snapshot" of the conditions at the time of sampling; as additional sampling occurs, the data, combined with other water quality data being collected in the bay, will be analyzed to investigate long-term trends in water quality at each site and across the bay.

Table 5: Water quality parameters at RESTORE Oyster Cultch sites in Apalachicola Bay.

Site	Midpoint	Sample Position	Depth (m)	Temperature (Celcius)	DO (%)	DO (mg/L)	Specific Conductivity	Salinity (ppt)	pH
8 Mile	MP1	Surface	0.1	27.9	92.4	6.74	22730	13.66	7.96
8 Mile	MP1	Bottom	1.2	28.4	71.8	5.18	24298	14.59	7.73
8 Mile	MP2	Surface	0.1	27.9	92.4	6.74	22730	13.66	7.96
8 Mile	MP2	Bottom	1.3	28.4	71.8	5.18	24298	14.59	7.73
9 Mile B	MP1	Surface	0.1	29.4	98.7	6.18	55562	36.73	7.91
9 Mile B	MP1	Bottom	1.6	29.4	97.5	6.1	55659	36.80	7.96
9 Mile-King	MP1	Surface	0.1	28.1	102.7	7.45	22995	13.83	8.09
9 Mile-King	MP1	Bottom	1.4	28.7	78.0	5.5	26231	15.97	7.87
Cabbage Top	MP1	Surface	0.1	30.1	77.6	4.87	55434	36.60	7.94
Cabbage Top	MP1	Bottom	1.0	30.0	89.3	5.22	55437	36.62	8.04
Cat Point	MP1	Surface	0.1	28.8	81.3	5.7	28661	17.58	7.96
Cat Point	MP1	Bottom	1.6	29.0	74.1	5.12	29229	17.97	7.91
Cat Point	MP2	Surface	0.1	28.8	81.3	5.7	28661	17.58	7.96
Cat Point	MP2	Bottom	1.4	29.0	74.1	5.12	29229	17.97	7.91
Cat Point	MP3	Surface	0.1	28.8	81.3	5.7	28661	17.58	7.96
Cat Point	MP3	Bottom	1.4	29.0	74.1	5.12	29229	17.97	7.91
Cat Point Spur	MP2	Surface	0.1	29.1	98.6	6.9	27758	16.98	8.18
Cat Point Spur	MP2	Bottom	1.8	29.0	90.9	6.37	27938	17.10	8.15
Cat Point Spur	MP1	Surface	0.1	29.1	98.6	6.9	27758	16.98	8.18
Cat Point Spur	MP1	Bottom	2.0	29.0	90.9	6.37	27938	17.10	8.15
East Hole #1	MP1	Surface	0.1	29.2	89.8	6.01	38031	24.03	8.09
East Hole #1	MP1	Bottom	1.1	29.3	87.6	5.88	38042	24.04	8.08
East Hole #1	MP3	Surface	0.1	29.4	88.6	5.96	36821	23.15	8.08
East Hole #1	MP3	Bottom	1.5	29.4	85.8	5.75	37266	23.50	8.06
East Hole #1	MP4	Surface	0.1	29.4	88.6	5.96	36821	23.15	8.08
East Hole #1	MP4	Bottom	1.5	29.4	85.8	5.75	37266	23.50	8.06
East Hole #1	MP2	Surface	0.1	29.2	89.8	6.01	38031	24.03	8.09
East Hole #1	MP2	Bottom	1.0	29.3	87.6	5.88	38042	24.04	8.08
East Hole #2	MP2	Surface	0.1	29.0	91.0	5.95	46703	30.23	8.08
East Hole #2	MP2	Bottom	1.6	29.0	89.9	5.88	46710	30.23	8.05
East Hole #2	MP1	Surface	0.1	29.0	91.0	5.95	46703	30.23	8.08
East Hole #2	MP1	Bottom	1.2	29.0	89.9	5.88	46710	30.23	8.05
Hotel Bar #1	MP2	Surface	0.1	30.1	107.4	7.18	38105	24.02	8.16
Hotel Bar #1	MP2	Bottom	1.8	30.1	89.3	5.65	49638	33.19	8.02
Hotel Bar #2	MP1	Surface	0.1	31.3	106.7	6.93	39451	24.98	8.16
Hotel Bar #2	MP1	Bottom	1.3	30.3	111.9	7.35	40422	25.57	8.17
Hotel Bar #1	MP1	Surface	0.1	30.1	107.4	7.18	38105	24.02	8.16
Hotel Bar #1	MP1	Bottom	1.6	30.1	89.3	5.65	49638	33.19	8.02
Monkeys Elbow	MP1	Surface	0.1	28.9	84.2	5.53	45375	29.26	8.00
Monkeys Elbow	MP1	Bottom	1.8	28.9	80.6	5.26	47531	30.88	7.99
Monkeys Elbow	MP2	Surface	0.1	28.9	84.2	5.53	45375	29.26	8.00
Monkeys Elbow	MP2	Bottom	1.7	28.9	80.6	5.26	47531	30.88	7.99
North Spur #2	MP1	Surface	0.1	29.9	104.9	6.53	55376	36.58	8.09
North Spur #2	MP1	Bottom	1.5	29.6	88.2	5.49	55546	36.72	8.03
North Spur #2	MP2	Surface	0.1	29.9	104.9	6.53	55376	36.58	8.09
North Spur #2	MP2	Bottom	1.7	29.6	88.2	5.49	55546	36.72	8.03
Peanut Ridge	MP1	Surface	0.1	29.0	89.1	6.09	33730	21.75	8.09
Peanut Ridge	MP1	Bottom	1.7	29.0	87.5	5.98	33731	21.05	8.10
Peanut Ridge	MP2	Surface	0.1	29.1	90.1	6.15	33924	21.18	8.10
Peanut Ridge	MP2	Bottom	1.6	29.1	89.4	6.09	33923	21.18	8.08
South Bulkhead	MP1	Surface	0.1	29.8	93.7	6.29	35725	22.41	8.15
South Bulkhead	MP1	Bottom	1.1	29.8	91.4	6.14	35725	22.41	8.10

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Appendix 1 – FDACS Standard Oyster Resource Management Protocol

Introduction: The Florida Department of Agriculture and Consumer Services (FDACS) shares responsibility for managing oyster resources in Apalachicola Bay with the Florida Fish and Wildlife Conservation Commission (FWC); more specifically, the Division of Aquaculture manages oysters from both resource development and public health protection perspectives.

Oyster Resource Assessments: The Division has conducted oyster resource surveys on the principle oyster-producing reefs in Apalachicola Bay since 1982. This information is used by resource managers to reliably predict trends in oyster production; to monitor oyster population dynamics, including recruitment, growth, natural mortality, standing stocks; and to determine the impacts of climatic events such as hurricanes, floods, and droughts.

Continuous monitoring and data analyses have allowed resource managers to develop a scale using defined sampling protocol to determine the relative condition of oyster resources based on estimated production parameters. Estimated production exceeding 400 bags of oysters per acre is applied as an indicator of healthy oyster reefs capable of sustaining commercial harvesting. Accordingly, oyster populations are 1) capable of supporting limited commercial harvesting when stocks exceed 200 bags/acre, 2) below levels necessary to support commercial harvesting when stocks fall below 200 bags/acre, and 3) considered depleted when marketable stocks are below 100 bags/acre. Generally, production from Cat Point Bar has been the most accurate indicator of oyster production in Apalachicola Bay, but East Hole Bar and St. Vincent Bar are also reliable indicators of the condition of oyster resources throughout the Bay. This scale forms the basis for the Standard Resource Management Protocol provided in Subsection 68B-27.017, Florida Administrative Code (FAC), which is used as the criteria for setting the number of harvesting days in the Winter Harvesting Season in Apalachicola Bay. Subsection 68B-27.017(2)(a), FAC, provides that oysters may be harvested for commercial purposes on any day of the week from November 16 to May 31 of each year when the Bay is not closed for public health purposes and when the oyster resources on Cat Point Bar and East Hole Bar can sustain a harvest of 300 bags of oysters per acre.

CREATION OF POPULATION ESTIMATES

Background: In 1985, hurricanes Kate and Elena devastated a majority of the oyster reefal complexes in Apalachicola Bay. In 1986, comprehensive management programs and regulatory restrictions were implemented to foster resource recovery and facilitate restoration. During this period, a massive oyster reefal complex refurbishment project was undertaken wherein; 385 acres were planted, using 96,230 cubic yards of clam shell.

Evaluating: Oyster populations were compared using the Kruskal-Wallis test to determine significant differences between length-frequency distributions among replicate samples and between successive sampling intervals.

Transects were established across the restored reef and quadrats were selected along transects by tossing a PVC grid from the survey vessel.

Specifics: a weighted 0.25m^2 PVC grid was used to delineate sample quadrats. Samples were collected by divers; live oysters, shell and associated fauna were removed to a depth of 15cm, placed in mesh collecting bags and delivered to the survey vessel. Live oysters were measured to the nearest lower 0.5cm length.

Oysters ≥25mm were used in population estimates.
Oysters 50-70mm were used to predict growth rates, mortality rates and recruitment into marketable size classes.
Oysters $\geq$75mm were used to provide estimates of marketable oysters/m^2 and densities were extrapolated to calculate potential production levels.

Ingle and Whitfield (1968 & 1973) estimated that about 400bu/acre could be harvested from productive artificially constructed reefs within two years of planting cultch. A scale was developed using field surveys of natural and constructed bars in Apalachicola Bay to determine the relative condition of oyster resources based on production estimates.

Production:
Estimates:

- >400 bags/acre – healthy oyster reefs capable of sustaining commercial harvest
- >200 bags/acre – capable of sustaining limited commercial harvest.
- <200 bags/acre – below level necessary to support commercial harvest
- <100 bags/acre – considered depleted

CALCULATIONS FOR ASSESSING POPULATION ESTIMATES FROM FIELD SURVEYS

Example from Cat Point 09/08 data set:

Date	Quadrats (Total #)	Oyster (Total #)	Mean Length	Density (/m)	>50mm (%)	$\geq$75mm (%)	(/m)	1000x (/ac)	Bags (/ac)
09/08	20 [1]	616 [2]	55.2 [3]	123.2 [4]	66.2 [5]	17.21 [6]	21.2 [7]	85.8 [8]	381 [9]

[1] Total # of quadrats sampled
[2] Total # of all oysters in all quadrats
[3] Mean Length derived from Statistical Analysis Software programs
[4] Total Oysters/No. of Quadrats; Oysters/0.25m^2 x 4 = Oysters/m^2
[5] % > 45mm on histograms (use cumulative %)
[6] % > 70mm on histograms (use cumulative %)
[7] % >70mm [6] x Density [4] = Oysters $\geq$75 m^2
Example: 0.1721 x 123.2 = 21.20 (/m)
[8] % >70mm [6] x Density [4] x 4,047 = oyster $\geq$75mm / acre; divided by 1,000
Example: 0.1721 x 123.2 x 4,047 = 85,807.4; /1,000 = 85.8 (/ac)
[9] Oysters/Acre divided by 225 oysters/bag
Example: 85,807.4 /225 = 381.36

Explanations:

[1] Total # of quadrats sampled:

The total number of quadrats collected at a sampling station may vary by date based on field conditions, time constraints and sampling rationale (pollution events). This will obviously affect total number of oysters collected and then also affect density of oysters per meter square. This must be taken into consideration when comparing/contrasting multiple sites over time.

[2] Total # of all oysters in all quadrats

As with the total number of quadrats, the total number of oysters collected at a sampling station may vary by date based on field conditions, time constraints and sampling rationale (pollution events). This will also obviously affect the density of oysters per meter square. This must be taken into consideration when comparing/contrasting multiple sites over time.

[3] Mean Length

[5] % >45mm (info to generate histograms)

[6] % >70mm (info to generate histograms)

The entire aforementioned are derived from Statistical Analysis Software (SAS) programs.

[4] Total Oysters/No. of Quadrats; Oysters/0.25m^2 x 4 = Oysters/m^2

Intuitively, the total number of oysters per quarter-meter square quadrat is multiplied by 4 in order to acquire total number of oysters per meter square.

[7] % >70mm [6] x Density [4] = Oysters >75 m^2

The percentage of oysters greater than 70 mm (~ 3 inches; standard legal size oyster) multiplied by the density yields the number of legal size oysters per meter. This information is key for assessing population trends and assessing the productivity of a given oyster reefal complex.

[8] % >70mm [6] x Density [4] x 4,047 = oyster >75mm / acre

The percentage of oysters greater than 70 mm (~ 3 inches; standard legal size oyster) multiplied by the density, and then multiplied by 4,047 (no. of square meters in an acre) yields the total number of oysters per acre.

[9] Oysters/Acre divided by 225 oysters per bag

Through historical sampling of oyster catch volumes it has been determined that the average 60 lb. bag contains approximately 225 legal sized (3 inches or greater) oysters or the approximate number of legal sized oysters which could be contained in two (2) five gallon buckets. The value of legal sized oysters per acre total is the most important result from our calculations as it allows us to make management decisions related to the oyster fishery.