**DWH NRDA ANNUAL REPORT**

**INTERIM MONITORING AND ADAPTIVE MANAGEMENT PROGRESS REPORT**

**Project Title**: Conducting habitat suitability analyses to identify optimal oyster restoration locations along the Florida Gulf coast

**Report Year**: 2022

**Introduction:**

1. **Project Overview:** In Florida, there is currently not enough information on suitable locations for oyster restoration projects. Therefore, this restoration planning activity will develop oyster habitat suitability indices for six basins along the Gulf coast which will provide critical information on the most suitable restoration sites and sequencing of NRDA implementation activities. Maps of suitable oyster habitat will be developed and available to the public through the FWC website. These maps and indices will also help guide future oyster restoration efforts in other areas along the Gulf coast of Florida and throughout Florida. The duration of the activity is five years and will involve 1) data compilation, 2) benthic mapping, 3) oyster reef monitoring, and 4) development of a GIS-based habitat suitability index (HSI) maps for six study sites in Florida: Pensacola Bay and St. Andrew Bay in the Panhandle region, Suwannee Sound and the Withlacoochee/ Crystal River area in the North Peninsular region, and Tampa Bay and Charlotte Harbor in the South Peninsular region.
2. **Restoration Objectives, Performance Criteria, and Methods:**
   1. Task 1: Data Compilation: Existing water quality and oyster data from cooperating agencies (e.g., The Nature Conservancy, University of Florida (UF), Coastal & Heartland National Estuary Partnership) will be compiled to analyze historic trends in environmental conditions and oyster population health, abundance, and distribution. Additionally, every attempt will be made to contact and collaborate with agencies or organizations that have ongoing or recent applicable monitoring efforts at any of the six study sites. Compiled data will also be used to adapt and revise the benthic mapping (Task 2) and oyster reef assessment and monitoring plan (Task 3) for each site to address specific data gaps.
   2. Task 2: Benthic Mapping: The data compiled from Task 1, specifically the historic trends in environmental conditions, oyster population health, abundance, and distribution will be used to develop a landscape of available oyster habitat in each region (Figure 1) that we will then use to identify locations/areas for initial qualitative surveys to quickly ground truth. The initial qualitative surveys will be conducted by poling or probing from a boat to determine general benthic composition (e.g., mud, sand, shell, or rock) at subtidal and intertidal locations in all six study sites. Results from these coarse assessments will be used to provide guidance for targeted acoustic mapping at subtidal locations and for aerial/satellite imagery gathered for intertidal locations in all six study sites. Acoustic mapping using side-scan sonar or a shallow-water interferometric multibeam system will be conducted at the targeted areas (Grizzle et al 2017). Ground-truthing of acoustically mapped subtidal reefs will be completed by visual assessment and quadrat sampling by using scuba equipment which will allow for substrate classification as well as oyster density determinations. At intertidal sites, ground truthing will be completed by visual assessment and quadrat sampling at locations with live oysters. The final step of the mapping component will involve synthesis of all data and production of maps detailing the acreage, location, and extent of subtidal and intertidal oyster reefs as well as locations with suitable restoration substrate in all six study sites.
   3. Task 3: Field Assessment and Monitoring:
      1. Field assessment to establish monitoring sites: During the first year of monitoring, a one-time stratified random survey of oysters will be conducted at all six study sites to determine oyster density and size distribution. Survey locations will be selected from the statewide oyster map layer compiled by the FWC-Fish and Wildlife Research Institute (FWRI) Oyster Integrated Mapping and Monitoring Program. Specific sampling stations will be randomly selected from numbered grid squares overlying oyster habitat (Parker 2016). The total number of stations will be determined by reef acreage, but standardized sampling efforts will be applied at all six study sites. Data collection will include classification of bottom substrate. If hard substrate or live oysters are present, up to fifteen replicate quadrats will be randomly deployed and all oysters within each quadrat will be collected for determination of the total number of live oysters and dead oysters (Parker et al 2013). In addition, shell height (SH; maximum linear distance from the umbo to the ventral shell margin) measurements for all oysters 25 mm or larger will be recorded. A maximum of 25 SH measurements will be recorded for spat (oysters < 25 mm). This initial survey will also include field measures of salinity, water temperature, dissolved oxygen concentration, pH, depth, and turbidity. All oyster samples will be processed on site and oysters will be returned to the site they were taken from.
      2. Monitoring: Following the field assessment, longer term monitoring will begin and continue for up to three years. In each region, a minimum of three stations per site will be established, but the total number of stations will vary among regions depending on the size of the estuary or area. Monitoring will include water quality, sedimentation, wave energy, larval supply, and oyster density of size distribution. See Restoration Planning Activity Implementation Plan, “Conducting habitat suitability analyses to identify optimal restoration locations along Florida’s Gulf Coast”, for further details.
   4. Task 4: GIS-Based HSI Model 5: Suitability functions will be developed for environmental variables based on several sources of information. Primarily, we will use the analysis of each region’s historic trends in environmental conditions and oyster population health, abundance, and distribution from Task 1. The suitability functions will also be informed by oyster habitat requirements observed in the field in each region during Tasks 3 and 4. The functions will be used to assign an HSI score ranging from 0 (unsuitable) to 1 (optimal) for each variable (Cake 1983, Barnes et al 2007, Soniat et al 2013, Theuerkauf and Lipcius 2016). HSI scores will then be used to create GIS layers for each environmental variable using historic data and data recorded during field monitoring efforts (Linhoss et al 2016). Once the model is created, data collected during mapping efforts and oyster density surveys will be used to verify the validity of the model (Theuerkauf and Lipcius 2016). Upon completion, HSI models will be made publicly available to aid future restoration efforts.

**Results**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Tasks** | **Status** | **Start Date** | **End Date** | **Description of progress on task *in report year* (if no work was done in report year, put N/A). Include any raw data or documents produced *within the report year* as attachments to the report and reference in this column.** |
| Task 1 | Completed | 1/1/2022 | 12/31/2022 | See attached “Task 1 – Water Quality and Oyster Data Report” that summarizes data compiled for all six study sites with associated data. |
| Task 2 | Ongoing | 1/1/2022 | 12/31/2025 | Information on existing map products was assembled (see attached “Task 2 - Existing Oyster Map Needs”) to help prioritize mapping. Mapping recommendations were drafted noting the need for subtidal and intertidal mapping in the regions (see Discussion section (Task 2) below).  Mapping of intertidal oysters using aerial imagery began in Suwannee Sound, Withlacoochee/Crystal River, and Charlotte Harbor (with some ground truthing). Contract preparation for subtidal mapping began in Suwannee Sound and St. Andrew Bay. |
| Task 3 | Ongoing | 1/1/2022 | 12/31/2026 | Field assessments/monitoring began in all locations except for Charlotte Harbor. See Discussion section (Task 3) below. |
| Task 4 | Ongoing | 3/1/2022 | 12/31/2026 | Initial development of HSI models were tested as aids to site selection for Tampa Bay and Charlotte Harbor. See Discussion section (Task 4) below. |

**Discussion, Conclusions, and/or Project Highlights (reference any data/deliverables produced for the project and include as attachments upon submission of the report):**

**Task 1: Data Compilation**

See attached “Task 1 – Water Quality and Oyster Data Report” that summarizes data compiled for all six study sites with associated data.

**Task 2: Benthic Mapping**

Data compiled for Task 1 were of limited use in guiding mapping of oyster habitat. However, existing GIS layers and aerial imagery were useful in assessing mapping extent and gaps and were used to identify the most data poor locations/areas to ground truth and map. Information on existing map products was compiled (see attached “Task 2 - Existing Oyster Map Needs”) to help prioritize mapping of each region and develop recommendations for subtidal and intertidal mapping.

Mapping recommendations:

* Pensacola Bay: The Pensacola Bay system was recently mapped for both subtidal and intertidal oysters in 2021. Unless further data gaps are identified, no further mapping efforts are recommended for Pensacola Bay.
* St. Andrew Bay: Except for an FWC map of the artificial oyster reef in West Bay and FDEP maps of artificial oyster reefs, available maps for St. Andrew Bay were not created using benthic mapping efforts but rather nautical charts and local knowledge. It is recommended that areas suspected of having subtidal reefs be mapped using the existing maps as a guide. Subtidal mapping efforts will be contracted out and intertidal mapping will be conducted by FWC. The scope of work for subtidal mapping was drafted and is under review by FWC.
* Suwannee Sound: Some intertidal mapping layers in this region were published in 1992 and 2001; these older layers should be updated. Newer mapping layers from 2019, 2021, and 2022 do not need to be updated. The extent and location of inshore subtidal reefs in Suwannee Sound is largely unknown. Subtidal reefs may be common in and near the mouths of tidal creeks - mapping is needed in these areas. Subtidal mapping efforts will be contracted out and intertidal mapping will be conducted by FWC. The scope of work for subtidal mapping was drafted and is under review by FWC.
* Withlacoochee/Crystal River: Intertidal maps for this region are up to date, but some gap-filling is needed to locate oyster reefs in rivers and tidal creeks, as these areas may be beyond the extent of the existing surveys. The extent and location of subtidal reefs in the Withlacoochee and Crystal Rivers are largely unknown. Subtidal reefs may be present in and near the mouths of tidal creeks. Further investigation into the possible presence of subtidal reefs is needed in these areas to determine if subtidal mapping is warranted.
* Tampa Bay: Oyster maps for Tampa Bay are recent, comprehensive, and include a 2020 mapping effort focused on filling data gaps. Unless further data gaps are identified, no further mapping efforts are recommended for Tampa Bay.
* Charlotte Harbor: Available maps provide comprehensive spatial coverage of Charlotte Harbor. However, updated mapping is needed for older datasets from 1999 and 2004 and aerial imagery should be examined for additional oyster reefs that may have been missed in previous mapping efforts. Subtidal mapping was completed recently in 2019. No further subtidal mapping is needed at this time. Intertidal mapping will be conducted by FWC.

**Task 3: Field Assessment and Monitoring**

Data compiled for Task 1, specifically the historic trends in environmental conditions, oyster population health, abundance, and distribution were useful in identifying ongoing and past survey locations in Pensacola Bay, St. Andrew Bay, Tampa Bay, and Charlotte Harbor. However, this was of limited use in the development of the landscape of available oyster habitat in Suwannee Sound and the Withlacoochee/Crystal River area due to limited or no data available. This information and existing maps were used to identify locations/areas for initial qualitative baywide surveys in three regions to ground truth for locating long term monitoring. Additionally, this improved our understanding of these regions resulting in more effective initial surveys.

Table : Regional summary of progress on field assessments and monitoring.

|  |  |  |
| --- | --- | --- |
| **Location** | **Field Assessments** | **Monitoring** |
| Pensacola Bay | Complete | In progress |
| St. Andrew Bay | Complete | Not started |
| Suwannee Sound | Complete | In progress |
| Withlacoochee/ Crystal River area | In progress | Not started |
| Tampa Bay | Complete | In progress |
| Charlotte Harbor | Not started | Not started |

Pensacola Bay

Pensacola Bay has had a significant amount of attention directed toward it in the past few years. FDEP, The Nature Conservancy (TNC), and the Pensacola and Perdido Bay Estuary Program (PPBEP) have all been active in many aspects of assessing and monitoring the system’s condition, including that of oysters. FDEP has overseen the deployment and ongoing assessment of approximately 20,103 cubic yards of crushed granite over an estimated 88 acres of debilitated oyster habitat as part of the *Deepwater Horizon* Natural Resource Damage Assessment (NRDA) project, “Florida Oyster Cultch Placement”, since 2016. TNC developed a GIS-based Habitat Suitability Index for oyster restoration in 2020, utilizing past water quality measurements and local knowledge of the system. PPBEP was established in 2018 to interface with the public on “issues relating to preserving, restoring, improving and maintaining the natural habitat and ecosystem of the bays, estuaries and watersheds of Pensacola and Perdido Bays”.

In 2021, TNC and PPBEP completed one of the largest mapping efforts of the Pensacola system to date. Their contractors utilized side scan sonar to map approximately 6,536 acres, provided ground truthing at 60 study areas, and performed oyster density and size distribution surveys at 28 study areas. This effort covered all the previously identified areas of oyster habitat. This mapping effort contributed strongly to the ability of our team to quickly choose sampling locations for all the components of this task.

The TNC/PPBEP mapping effort revealed that the majority of Pensacola Bay’s oyster habitat is now gone or severely degraded. The only areas to support any significant number of oysters are those that received cultch material in 2016 as part of the NRDA “Florida Oyster Cultch Placement” project. FDEP has been tasked with monitoring oyster populations on these areas until 2026. Considering the severely degraded status of the system, the decision was made to partner with FDEP in their ongoing monitoring and encourage greater data sharing, rather than implement extra surveys with our own staff. Our decision had two main considerations. Firstly, since diver extracted quadrats are destructive, a better stewardship decision was to limit the amount of stress and damage to the existing system from diver extracted quadrats, that are the only reliable method of data collection for subtidal oysters. Secondly, since FDEP utilizes FWRI’s methods for collecting and processing samples, the data they collect is comparable with all our other efforts around the state.

Meetings were held virtually in January and February 2022 with our partners to discuss the selection of monitoring stations using the maps and data provided by TNC/PPBEP. A consensus was reached that the system could be divided into an eastern section, containing East Bay, and a northern section containing Escambia Bay. Each section would have five recruitment monitoring stations (for a total of 10) placed at fixed locations on exiting oyster habitat. These stations would be spread out to provide maximum spatial coverage. Sedimentation monitoring arrays would also be placed at three stations in each section (for a total of 6). These would also be spread out to provide maximum spatial coverage. Modifications to a design previously deployed in Apalachicola Bay were successfully tested in 2022. Initial deployment of recruitment arrays took place in March 2022 with the assistance of PPBEP staff who also assisted in monthly servicing of the arrays.

St. Andrew Bay

FDEP, TNC, the St. Andrew and St. Joseph Bay Estuary Program (SASJBEP), and FWC’s Division of Habitat and Species Conservation (HSC) have all been active over the last couple of years in aspects of assessing and monitoring St. Andrew Bay. FDEP has overseen the deployment and ongoing assessment of approximately 17,000 cubic yards of crushed granite over an estimated 84 acres of debilitated oyster habitat as part of the NRDA program since 2016. SASJBEP was established in 2020 to collaborate with “private, public, and non-governmental stakeholders to improve our common sense, science-based understanding of the needs of the estuary, and to develop, promote and implement projects that protect and restore the health of the bays”. HSC has overseen the deployment and monitoring of the multi-phase “Oyster Reef Habitat Restoration in Saint Andrew Bay” project, which is funded by the Gulf Environmental Benefit Fund (GEBF). This project began in 2015 and has created approximately 5.6 acres of oyster habitat using recycled oyster shell and limestone aggregate.

The most thorough mapping effort of oyster habitat in St. Andrew Bay is represented by the “Oysters in Florida” GIS layer compiled by the FWRI Oyster Integrated Mapping and Monitoring Program (OIMMP). This GIS layer was used to identify potential oyster habitat for the baywide survey. A grid measuring 0.1 x 0.1 nautical miles was placed over this GIS layer and unique numbers assigned to each resulting square. Due to the small size and low number of reefs in St. Andrew Bay, the decision was made to visit each of the reefs individually, excluding those smaller than 2 acres and those being monitored by FDEP or HSC.

The baywide survey was carried out over four days in August and September 2022. At each station, an initial assessment was made using a PVC sounding pole or by scuba diving the existing substrate. At stations whose substrate was determined to be oyster/hard bottom, up to five ¼ m² quadrats were collected. These quadrats were processed on board the research vessel. Data collected included: sample weight and volume, number of all live and recently dead oysters, number of all oyster drills, and the SH of the first 50 oysters encountered. At stations whose substrate was determined to be mud or sand, no quadrats were collected. Water quality was collected at a majority of stations. Depth and location data was collected at all stations.

In total, 45 stations were visited: East Bay (24), North Bay (12), and West Bay (9). Three strata were encountered: Oyster/hard bottom - 21 stations (47%), Mud - 18 stations (40%), and Sand - 6 stations (13%). A total of one hundred quadrats were collected and processed: East Bay (35), North Bay (25), and West Bay (40). A total of 3,792 oysters were collected: East Bay (447), North Bay (1,192), and West Bay (2,153). The majority of those were spat. A total of 60 oysters over 30 mm SH were collected: East Bay (8), North Bay (1), and West Bay (51). No oysters over 75 mm SH were collected.

Data from the baywide survey, FDEP’s annual survey of NRDA restoration areas, and HSC’s annual survey of GEBF restoration areas was compiled to identify the locations of fixed monitoring stations. These data revealed, that like Pensacola Bay, the majority of St. Andrew Bay’s oyster habitat is now gone or severely degraded. The only areas to support any significant number of oysters are those that received cultch material in 2016 as part of the NRDA “Florida Oyster Cultch Placement” project. FDEP has been tasked with monitoring oyster populations on these areas until 2026. Considering the severely degraded status of the system, the decision was made to partner with FDEP in their ongoing monitoring and encourage greater data sharing, rather than implement extra surveys with our own staff. Our decision had two main considerations. Firstly, since diver extracted quadrats are destructive, a better stewardship decision was to limit the amount of stress and damage to the existing system. Since all the areas are subtidal, diver extracted quadrats are the only reliable method of data collection. Secondly, since FDEP utilizes FWRI’s methods for collecting and processing samples, the data they collect is comparable with all our other efforts around the state.

Meetings were held in December 2022 with our partners to discuss the selection of monitoring stations. A consensus was reached that the system could be divided into an eastern section, containing East Bay, a northern section containing North Bay, and a western section containing West Bay. The eastern and western sections would have four recruitment monitoring stations, while the northern section would have three (for a total of 11) placed at fixed locations on exiting oyster habitat. These stations would be spread out to provide maximum spatial coverage. Sedimentation monitoring arrays would also be placed at two stations in each section (for a total of 6). These would also be spread out to provide maximum spatial coverage. Modifications to a design previously deployed in Apalachicola Bay were successfully tested in 2022.

Suwannee Sound

Suwannee Sound is data poor for oyster monitoring and mapping information that is used to guide the development of a sample network for intertidal and subtidal oysters. The region is the most data poor for subtidal oysters. Recent maps of oyster habitat in Suwannee Sound are represented by the “Oyster Beds in Florida” GIS layer compiled by the OIMMP. In many areas these maps are based on old (circa 2001) aerial images, and they show a strong bias towards intertidal oyster reefs. Similarly, monitoring data is limited to intertidal reefs included in the UF’s “Recovery and Resilience of Oyster Reefs in the Big Bend of Florida” project (a.k.a Lone Cabbage Reef restoration project) (anticipated end date of 2023), which is funded by GEBF. Given the presence UF has historically had in this region, we have been meeting regularly to collaborate. Updated findings by Moore et al. (2020) indicate that oyster reefs are in severe decline, especially inshore areas that are becoming more like the degraded offshore reefs. This rapid change to oysters and the lack of data and up to date maps, particularly for subtidal reefs, make the development of representative sample sites over this remote 50+ mile coastline challenging.

As part of a related project funded by GEBF, FWC staff completed a baywide survey in Suwannee Sound in 2021 to ground truth the available maps and begin collecting baseline oyster density, SH, and substrate data for the rest of the region not monitored during the UF project. Stations for the baywide survey were identified using the existing GIS map layer and stratified among shellfish harvest areas. At each station, an initial assessment was made either visually or using a PVC sounding pole to determine the substrate type (oyster, shell hash, sand, mud, or other). At stations whose substrate was determined to be oyster/hard bottom, up to five ¼ m² quadrats were collected and processed on board the research vessel. Data collected included: sample weight and volume, number of all live and recently dead oysters, number of all oyster drills and crown conch, and the SH of the first 50 oysters encountered. Water quality, depth, and location data was also collected at most stations.

During the baywide surveys, substrate type was assessed at 100 stations, oyster/hard bottom substrate was found at 81 stations, and quadrats were processed at 68 stations. Live oyster density ranged from 3 oysters/m2 to 1,609 oysters/m2, and 56.9% of oysters measured were larger than 25 mm, but only 179 oysters (1.4% of total) were of legal harvest size (>75 mm). More detailed information for incorporation into a shell budget model was collected in March – May 2022. Fourteen stations were visited for shell budget sampling, although 5 stations in north and central Suwannee Sound lacked sufficient substrate to sample. Methods like the baywide survey were used, except material from 15 quadrats/station was processed in the lab and substrate weight and volume were separated into categories: live oysters, oyster shell, shell hash, planted cultch, or black (anoxic)/ other substrate. Live oyster density ranged from 26 to 1,268 oysters/m2, but only 1.5% of collected oysters were of legal harvest size. These results were similar to the baywide survey and highlighted the decline noted by Moore et al. (2020) and the need for updated mapping of both intertidal and subtidal oysters.

Based on reef locations identified in that baywide survey, monthly recruitment monitoring was established in January 2022 at 12 fixed stations in Suwannee Sound. The NFWF baywide and shell budget surveys were successful in locating, ground truthing, and developing preliminary strategies for sampling intertidal oysters along with preliminary mapping and ground truthing information, input from local oyster harvesters, and communication with UF regarding submerged oyster reefs in the region. This data helped us understand the sampling universe for intertidal oysters, the number of locations that we can feasibly sample over this large area, and the appropriate number of samples to take at each location. To better target subtidal oysters, subtidal maps need to be further developed for the region to guide sampling efforts.

Withlacoochee/ Crystal River area

The Withlacoochee/ Crystal River area is data poor for baseline oyster data and mapping information. Recent maps of oyster habitat are represented by the “Oyster Beds in Florida” GIS layer compiled by the OIMMP. The intertidal portions of the map are more up to date for the Withlacoochee/ Crystal River area but the extent and location of subtidal reefs are largely unknown. Based on input from commercial fishers and UF, there may be subtidal reefs in and near the mouths of tidal creeks.

In August 2022, we began an initial baywide survey to ground truth and rapidly assess intertidal oyster reefs. Stations were stratified among shellfish harvest areas in the region and sampled following the same protocol as the Suwannee Sound baywide survey. Data collection and analysis is ongoing. To date, substrate has been assessed at 68 stations, oyster/hard bottom substrate (oyster, shell hash, or rock) was found at 44 stations, and five ¼ m2 quadrats were processed at each of 42 stations. These preliminary results are like the Suwannee Sound baywide survey, notably: they demonstrate a bias towards intertidal oyster reefs on the current maps, and they suggest a decline in intertidal/inshore oyster resources, since many (35%) of stations visited did not have suitable oyster substrate to sample. One difference we have noted compared to Suwannee Sound is many (14%) intertidal oyster reefs sampled consist of a thin layer of oysters attached directly to submerged limestone outcroppings, as compared to a biogenic reef structure. This poses a challenge for our current quadrat sampling methods particularly when sampling subtidal reefs that we will need to consider as we re-evaluate and adjust our sampling strategies moving forward.

We began evaluating the data collected on intertidal oysters during the baywide survey, along with available mapping information, input from local oyster harvesters, and communication with UF regarding submerged oyster reefs in the region.

Tampa Bay

In Tampa Bay, a long-term monitoring program run by the FWRI Molluscan Group (for which funding has ended) collected data on abundance, size distribution, and oyster settlement at five relatively high-salinity sites. Using the HSI for Tampa Bay (see below Task 4), prospective sites were selected as potential monthly monitoring sites for spat settlement, wave energy, sediment, and water quality. Site surveys were conducted in summer and fall 2022 to establish an array of stations for monitoring that should more adequately assess the salinity regime from relatively fresh sites (Manatee River), intermediate salinity (Clam Bayou and Weedon Island) and higher salinity sites (Pinellas Point and Maximo Channel spoil island reef). Baywide surveys within the Alafia River visited ~ 40 potential sample sites. At most sites the primary habitat was either mangrove or man-made structures, with scattered oyster present. Within the Braden River tributary to the Manatee River, we visited ~35 potential sites. Oyster reefs were numerous and varied greatly in size. They included both intertidal and subtidal reefs. Within the main channel of the Manatee River, we visited ~59 potential sites and oyster reefs were sparse. Two potential sites for monthly monitoring were selected due to healthy reef and relative ease of access. The primary challenge within the Tampa Bay estuary remains access to patch reefs in very shallow habitats in the upper estuary and river tributaries. In December 2022, we deployed sample gear at six stations within Tampa Bay: settlement, wave action, and sediment traps.

**Task 4: GIS-Based HSI Model**

Although this effort was not anticipated to begin in earnest until the last two years of the study, there was an opportunity to develop and test models to aid in the survey station selection of oyster reefs in Tampa Bay. The Tampa Bay water area was divided into 100m2 grid cells over which the quality of habitat and likelihood of oysters being present was evaluated on a scale of 0 (least suitable) to 1 (most suitable). Habitat suitability was determined through the calculation of the geometric mean of individual parameter suitability indices evaluating the presence of seagrass and navigation channels, water depth, and salinity (Table 2). Similar methodology was used to locate and establish sampling sites in Charlotte Harbor.

Table : Parameters, suitability index minimum and maximum criteria, and sources of data for oysters in Tampa Bay.

|  |  |  |
| --- | --- | --- |
| Parameter | Scoring | Data sources |
| Seagrass presence | 0 = Patchy coverage ≥ 75%, continuous coverage ≥ 50%  1 = Coverage | FWC Seagrass Habitat in Florida, Southwest Florida Water Management District (SWFWMD) |
| Navigation channel presence | 0 = Within 0.5 m of a channel  1 = Greater than 23 m from a channel | FWC Boating and Waterways |
| Water depth | 0 = Depth > 10 m  1 = Depth < 2m | USGS Single-Beam derived bathymetric contours of Tampa Bay |
| Salinity  (s1 \* s2 \* s3) | Annual mean (s1):  0 = 0, 40+ 1 = 10-18  Monthly minimum (s2):  0 = < 4 1 = > 8  Mean monthly May-Sept (s3):  0 = < 5 or > 40 1 = 18/23 | National Water Quality Monitoring Council, USF Water Institute |

Map

Description automatically generated

Figure : The habitat suitability model for eastern oysters in Tampa Bay, Florida. The model evaluates suitability scores (1 = most suitable, red; 0 = least suitable, pale yellow) of seagrass, navigation channel, water depth, annual mean salinity, monthly minimum salinity, and mean monthly salinity from May through September in 100 m2 grid increments

Map

Description automatically generated

Figure : Example of the habitat suitability model (1 = most suitable, red; 0 = least suitable, pale yellow) for eastern oysters in Old Tampa Bay overlayed with oyster observations (blue).

**Data:** See attached documents.

**References:**

Barnes, T., A. Volety, K. Chartier, F. Mazzotti, and L. Pearlstine. 2007. A habitat suitability index model for the eastern oyster Crassostrea virginica, a tool for restoration of the Caloosahatchee Estuary, Florida. Journal of Shellfish Research 26: 949-959.

Cake, E. 1983. Habitat suitability index models: Gulf of Mexico American Oyster. FWS/OBS 82, 1-37.

Grizzle R., K. Ward, and T. Waddington. 2017. Mapping and characterizing restored oyster habitat in Apalachicola Bay Florida. Final Report to the Fish and Wildlife Conservation Commission, Florida.

Linhoss, A.C., R. Camacho, S. Ashby. 2016. Oyster habitat suitability in the northern Gulf of Mexico. Journal of Shellfish Research 35(4): 841-849.

Moore, J.F., W.E. Pine III, P.C. Frederick, S. Beck, M. Moreno. 2020. Trends in Oyster Populations in the Northeastern Gulf of Mexico: An Assessment of River Discharge and Fishing Effects over Time and Space. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science 12:191-204.

Parker, M.L., W.S. Arnold, S.P. Geiger, P. Gorman and E.H. Leone. 2013. Impacts of freshwater management activities on eastern oyster (Crassostrea virginica) density and recruitment: recovery and long-term stability in seven Florida estuaries. Journal of Shellfish Research 32:695-708.

Parker, M.L. 2016. Apalachicola Bay Fishery Disaster Recovery Project Plan – Job 3. Oyster Monitoring. Status Report #4 to the Florida Department of Economic Opportunity, Florida.

Soniat, T.M., C.P. Conzelmann, J.D. Byrd, D.P. Roszell, J.L. Bridevaux, K.J. Suir, and S.B. Colley. 2013. Predicting the effects of proposed Mississippi River diversions on oyster habitat quality; application of an oyster habitat suitability index model. Journal of Shellfish Research 32: 629-638.

Theuerkauf, S.J. and R.N. Liscius. 2016. Quantitative validation of a habitat suitability index for oyster restoration. Frontiers in Marine Science 3:64.