ANNUAL REPORT TO TRIUMPH GULF COAST INC.

Project #69: Apalachicola Bay System Initiative (ABSI)
Awardee: Florida State University
Reporting Period: March 16, 2024-March 15, 2025

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EXECUTIVE SUMMARY

The Apalachicola Bay System Initiative (ABSI) was originally a 5-year project that was due to terminate in June 2024. In March 2024, the ABSI leadership requested a project amendment to extend the end date to December 31, 2025, and re-budget the remaining funds to accommodate the work planned during the extension. The amendment was approved by the Triumph Gulf Coast Board on April 10, 2024. The requested time extension of 18 months will allow completion of the remaining deliverables and enhance the outcomes of our ongoing work.

The fully executed ABSI Grant Award Agreement included a performance metric (8.3c) that stipulated provision of assistance and support to local business that were affected by the oyster population decline. In addition to Covid restrictions throughout 2020, our progress on business engagement was further limited by the continued decline and subsequent closure of the oyster fishery at the end of 2020. Many harvesters had moved on to other fisheries or occupations after the oyster collapse, and uncertainty remains as to when, or whether, oyster populations will recover sufficiently to support a commercially viable fishery. The Apalachicola Bay oyster fishery was declared a Federal Fishery Disaster in 2013 and millions of dollars were spent on oyster restoration. Despite this investment, oyster populations continued to decline and in 2020 the fishery was closed for five years to allow populations to recover.

Restoration research conducted by ABSI developed improved restoration designs that have supported oyster recruitment and growth and provided a better understanding of optimal restoration elements: stability, persistence, reef height and predator refuge. The ABSI restoration approach has been adopted by the Florida Fish and Wildlife Commission for their large scale 2024 restoration project (~ 90 acres). Because of these improved restoration methods, there is reason for optimism that the oysters could recover sufficiently to support a fishery. Since the oyster fishery collapse, Franklin County has shifted more towards tourism and away from its traditional fisheries-dependent economy, and oyster aquaculture has expanded to help fill market demand for Apalachicola oysters. ABSI leadership has engaged the Florida State University Jim Moran College of Entrepreneurship to address ABSI performance metric (8.3c), and work with Franklin County to re-invigorate the traditional working waterfront culture and economy.

ABSI deliverables to be addressed during the extension period

1. Oyster communities and their environment.

For the past four years, ABSI has conducted bay-wide subtidal oyster population surveys using hand tongs through collaboration with a local oyster harvester. These tong surveys are quicker and less weather dependent than the diver surveys used by FDEP and FWC. They can be processed more rapidly and do not require trained divers. Samples are collected and either processed immediately on the vessel, or if the samples are large, they are brought to the ABSI laboratory, processed, and taken back to the Bay alive within a week of sampling.

The proposed extension will enable us to collect, analyze data and prepare a technical report and/or publication on the status of oysters in the Bay. These data will be made available to the public and resource management agencies to inform fishery management decisions.

In summer 2024, the FWC conducted a pilot project that deployed 30 one-acre limerock reefs (26 for FWC, four for ABSI) and two larger restoration areas using 4-8” limerock. During the proposed extension, ABSI will survey the 2024 FWC larger restoration areas in spring and fall 2025 to provide information on oyster populations on the newly restored habitat.

2. Experimental ecology

This category includes most of the research conducted under ABSI, the details of which are in the annual reports on the ABSI research webpage. Some of the research is thematic (e.g. system ecology, disease dynamics, restoration ecology) and will continue beyond the life of ABSI with support from FSU and external funding. Other projects have specific end points, particularly the graduate student research. An extension and budget revision of the ABSI funds will support fieldwork, sample processing, and data analysis, allowing students to maintain productivity, publish their research and participate in public presentations and outreach.

There are three additional focal areas of research that will be completed during the extension.

a) ***Assess the value of hatchery oysters in population recovery***: The ABSI hatchery has produced spat on shell and seed for experiments to determine the efficacy of using this approach to enhance oyster population recovery; however, these have been marginally successful because the substrate in the Bay was unstable, and the experiments were buried and/or lost. The FWC has provided ABSI with exclusive use of four acres limerock reefs and access to the larger areas to conduct experiments. The new reefs will provide stable substrate for evaluating the use of spat-on-shell for restoration and conducting other experiments using hatchery oysters.

b) ***Develop framework for Apalachicola Bay Report Card***: Part of the ABSI mission is to understand the overall health of the Apalachicola Bay System (ABS). Although several research projects address elements of this question, ABSI has not taken a holistic approach to this complex issue. Members of the Franklin County Commission have requested a routinely updated index to track the condition of the Bay, so during the ABSI extension, we will develop the framework for an ecosystem "Report Card" for the ABS. Creation of ecological Report Cards has been applied to restored and recovering estuaries to assign objective measures of health. Dr. Breithaupt (ABSI faculty) will conduct a local to global review of coastal report cards to identify: 1) the variables that are tracked, 2) the stakeholders and process involved in deciding on a variables that are meaningful to each ecosystem, 3) the data collection entities, 4) the frequency of Report Card production, 5) the spatial and temporal resolution of the reporting units, and 6) the logistical processes of collecting, standardizing, and evaluating the data in a way that can be understood by stakeholders. The report will also evaluate how many of these data types are already collected for Apalachicola Bay and identify data gaps. Deliverables will be a review of Report Card creation processes and a road map for implementing an ecological report card for the Apalachicola Bay System. This review will help the community stakeholder group, Partners for a Resilient Apalachicola Bay, implement a regional Report Card. The tool will help evaluate the ecological, economic, and cultural well-being of the ABS.

c) ***Shell recycling for reef replenishment***: Reef replenishment using natural shell is a traditional component of oyster fishery management and essential to habitat maintenance under harvest. The Apalachicola Bay shell retention and replenishment program closed in 2011 and has not been replaced. Shell recycling programs in other areas have replaced government funded programs and generated significant and sustained funding streams that provide employment (including creation of new businesses) and material for oyster reef restoration. A small shell recycling program (OYSTER: Offer Your Shells To Enhance Restoration) is operated through Franklins Promise OysterCorps4 program and reclaims shells from 2-3 area restaurants. This program has the potential to generate additional jobs for Franklin County youth and replace, in part, the previous reef replenishment program. A recent review of shell recycling programs5 identified several strategies to increase the capacity of this program, engage and retain more restaurants and encourage the public to recycle their shells. We will work with the OysterCorps during the proposed extension period to support and enhance their recycling efforts, and to help obtain additional funding to maintain and expand the program.

3. Coupled Ecosystem-Life History Model.

Three models have been or are being developed by ABSI: 1) freshwater flow, 2) bio-physical and 3) habitat suitability. Aspects of these models have been incorporated into the others as where appropriate; for example, the freshwater model informs the hydrodynamic model, which incorporates ABSI oyster physiology data to create a larval dispersal model. Outputs from the combined models will be used in the oyster habitat suitability model.

An oyster population model developed by Dr. Ed Camp (University of Florida) was developed to model management strategies as requested by the ABSI Community Advisory Board. Dr. Fabio Caltabellotta (ABSI Postdoc) developed a decision support tool that can be used through cell phones and computers. This tool uses Dr. Camps' model to develop a user-friendly public interface that will allow resource managers and the public to explore the effects of different management strategies on oyster populations in the Bay. This application was incomplete when Dr. Caltabellotta left for a permanent position. Dr. Camp has agreed to finish this project so the app is widely available to the public. This tool will be invaluable when adjustments in management strategies arise.

4. Targeted outreach to the community.

Community outreach has always been a major component of ABSI, with a dedicated web presence within the FSUCML website. The ABSI outreach will continue for the duration of the project through social media, web-based information, and in-person representation at festivals and other events in Franklin and Wakulla Counties. Science updates will continue at Franklin County and City Commission meetings and other civic groups as requested.

5. Economic Revitalization Programs for Franklin County

The Jim Moran College of Entrepreneurship at Florida State University proposed a plan to support the Franklin County community and the restoration of its oyster fishing industry through entrepreneurial capacity building, upskilling, and economic development to revitalize and transform Apalachicola communities. Their proposal comprises two programs

1) Accelerate Franklin, focuses on nascent entrepreneurs looking to take existing idea-stage, micro- and small- ventures and build them into sustainable ventures. This 9-month program uses a cohort model to offer participants hands-on learning, access to vetted, qualified mentors, and access to a national community of other aspiring entrepreneurs. The program can serve small established fishing operations as well as other community members interested in starting new ventures relating to the area's oyster heritage and the commercial potential a restored Apalachicola Bay provides.
2) Small Business Executive Program for Franklin County (SBEP); This was designed to accommodate the schedules of established small business owners. The SBEP is ideal for CEOs, founders, entrepreneurs, presidents of small businesses, and immediate successors of businesses. When working with new community partners, they begin with a 90-day community engagement period, during which they meet with key stakeholders and conduct community focus.

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APALACHICOLA BAY SYSTEM INITIATIVE (ABSI) ANNUAL REPORT 2023-2024

1. Introduction

The Apalachicola Bay System Initiative was awarded in March 2019 and completed the fifth and final year of the study in June 2024. In March 2024, the ABSI leadership requested a project amendment to extend the end date to December 31, 2025, and re-budget the remaining funds to accommodate the work planned during the extension. The amendment was approved by the Triumph Gulf Coast Board on April 10, 2024. The requested time extension of 18 months allowed completion of the remaining deliverables, added new objectives and includes a strategy to address the award performance metric.

Assessment of inter-tidal and sub-tidal oyster communities continued over the past year, along with monitoring of ABSI restoration experiments. The restoration research developed designs that supported oyster recruitment and growth and provided a better understanding of stability, persistence, reef height and predator refuge. The ABSI restoration approach was adopted by the Florida Fish and Wildlife Commission for their large scale 2024 restoration project. These areas of elevated stable material have allowed ABSI to initiate a study of reef-associated community development and another that investigates the effect of reef height on abundance of commercial crab species. The expanded restoration area and continued harvest closure have allowed oyster populations in the Bay to recover, potentially enough to support limited harvest.

Experimental ecology studies over the past year have investigated physiological responses of oysters to environmental stressors and predation, and whether hatchery raised bay scallop juveniles can help restore depleted populations. The ABSI Research and Restoration Hatchery is providing support for several ABSI projects, but encountered some problems over the past year with protozoan contamination in the algae room that caused larval cultures to fail. The hatchery objectives for the remainder of the project are to continue supporting student research, create oyster seed for a survival and growth experiment, and generate spat on shell for a study to determine whether using hatchery oysters for restoration is viable and cost effective in Apalachicola Bay. One of the original objectives of ABSI was to understand whether the ABS is broadly ‘unhealthy’, whether primarily the oysters were depleted but the system was otherwise functional, or whether the loss of the foundation species (oysters) has caused a reduction in the health of the ABS. Estuarine Report Cards have been used by managers and researchers to developing metrics that provide insight into the status of the target estuary. Dr Breithaupt (FSUCML faculty) is developing a framework for an ABS report card that resource managers can use to track ABS ecosystem health. ABSI has also initiated a small shell recycling program to determine which sources are most cost effective and what the shell collection capacity might be for a larger program. Shells collected by ABSI will be used for sub-tidal habitat replenishment or ABSI related research.

Throughout the life of the project, ABSI has generated multiple models that help us understand the hydrodynamics, environmental conditions and oyster larval dispersal in the Bay. The models are being integrated into a habitat suitability model that will provide insight into the abiotic and biotic conditions in the ABS and how they may affect oyster populations.

Community outreach and stakeholder engagement are critical components of ABSI and the team has been active throughout the project and these activities will continue for the life of the project.
Since the oyster fishery collapse, Franklin County has shifted more towards tourism and away from its traditional fisheries-dependent economy, and oyster aquaculture has expanded to help fill market demand for Apalachicola oysters. ABSI leadership has engaged the Florida State University Jim Moran College of Entrepreneurship to address ABSI performance metric (8.3c), and work with Franklin County to re-invigorate the working waterfront culture and economy.

This report will cover activities conducted under ABSI during the reporting period and includes new initiatives as well as updates to existing projects. Previous versions of projects and experiments can be found in earlier reports. The sections follow the structure of the 2024 Amendment outlined in the executive summary.

2. Oyster communities and their environment

2.1 The application of drones for monitoring intertidal oyster habitats (Jenny Bueno, Ph.D. candidate, FSU)

The following manuscript on this work was published in 2024:

Bueno, Jenny, Sarah E. Lester, Joshua L. Breithaupt, and Sandra Brooke. 2024. "The Application of Unoccupied Aerial Systems (UAS) for Monitoring Intertidal Oyster Density and Abundance." *Remote Sensing in Ecology and Conservation*, August, rse2.417. https://doi.org/10.1002/rse2.417.

Abstract: The eastern oyster (*Crassostrea virginica*) is a coastal foundation species currently under threat from anthropogenic activities both globally and in the Apalachicola Bay region of north Florida. Oysters provide numerous ecosystem services, and it is important to establish efficient and reliable methods for their effective monitoring and management. Traditional monitoring techniques, such as quadrat density sampling, can be labor-intensive, destructive of both oysters and reefs, and may be spatially limited. In this study, we demonstrate how unoccupied aerial systems (UAS) can be used to efficiently generate high-resolution geospatial oyster reef condition data over large areas. These data, with appropriate ground truthing and minimal destructive sampling, can be used to effectively monitor the size and abundance of oyster clusters on intertidal reefs. Utilizing structure-from-motion photogrammetry techniques to create three-dimensional topographic models, we reconstructed the distribution, spatial density and size of oyster clusters on intertidal reefs in Apalachicola Bay. Ground truthing revealed 97% accuracy for cluster presence detection by UAS products and we confirmed that live oysters are predominately located within clusters, supporting the use of cluster features to estimate oyster population status. We found a positive significant relationship between cluster size and live oyster counts. These findings allowed us to extract clusters from geospatial products and predict live oyster abundance and spatial density on 138 reefs covering 138 382 m^2 over two locations. Oyster densities varied between sites, with higher live oyster densities occurring at one site within the Apalachicola Bay bounds, and lower oyster densities in areas adjacent to Apalachicola Bay. Repeated monitoring at one site in 2022 and 2023 revealed a relatively stable oyster density over time. This study demonstrated the successful application of high-resolution drone imagery combined with cluster sampling, providing a repeatable method for mapping and monitoring to inform conservation, restoration and management strategies for intertidal oyster populations.

2.2 Spatial patterns of intertidal oyster reef clusters (Jenny Bueno, Ph.D. candidate, FSU)

Introduction

Despite the important role of oysters, populations have globally declined due to natural and anthropogenic factors (Beck *et al.*, 2011). This decline has prompted various efforts to restore and mitigate declining populations (Baggett *et al.*, 2015). To increase the success of these restoration efforts, it is important to understand the distribution and patterns of oysters. Research has shown that elevation, reef size, height, and orientation are important indicators of oyster performance (Lenihan, 1999; Colden *et al.*, 2016; Colden, Latour and Lipcius, 2017; Baillie and Grabowski, 2019).

These factors can be assessed to reveal how these certain habitat characteristics can influence the persistence of oysters at a larger spatial scale across an estuary. By combining newer technologies, such as drones, with key spatial ecological concepts (Bueno *et al.*, 2024), we can investigate how factors like elevation, reef size, reef type, reef complexity, and distance to other habitats influence the distribution of oyster clusters, or aggregations of oysters, at the estuarine scale. Additionally, this approach allows us to determine whether these predictors hold across different sites or if site-specific differences exist. Therefore, this project will use drone technology to capture and analyze oyster clusters and examine their spatial distribution across three sites in Apalachicola Bay and St. Mark's.

Objectives

1. Investigate the elevation range at which oyster clusters are most prevalent.
2. Examine whether reefs with greater topographic support higher densities of oyster clusters.
3. Assess whether larger reefs support higher densities of oyster clusters compared to smaller reefs.

4. Examine the relationship between oyster cluster density and the proximity of reefs to other habitats, including nearby reefs, marshes, and open water.
5. Examine potential spatial variability in the factors driving oyster cluster density across multiple study sites, considering differences in elevation, reef size, and proximity to other habitats.

Methods

Three sites located across Apalachicola Bay and St. Marks were selected to assess the distribution of clusters. This study will use the data from Bueno et al., (2024) for East Cove and Alligator Harbor and conduct further analysis. Additionally, drone imagery for a third site, Oyster Bay in St. Marks, was collected in November 2024 to generate orthomosaics and digital elevation models (DEMs). These products were then used to extract oyster clusters following methods by Bueno et al., (2024). Two response metrics will be evaluated using the clusters from all three sites.

First, we will calculate the density of clusters at the reef level by dividing the total number of clusters found on each reef by the reef's area. The second response metric will be the density of clusters across different elevation ranges. This will be done by using the DEM (NAVD 88 meters) from which the clusters were extracted. The DEM will be divided into elevation ranges starting from 0 m, with intervals of 0.25 m. The density will be computed by dividing the number of clusters within each range by the area of that elevation range for each reef.

Reef height will be calculated by taking the top of the reef elevation and subtracting from the bottom of the reef using the extracted elevation ranges. Orthomosaics will be classified to determine reef size and identify habitats such as open water, enclosed water areas, other reefs, marshes, and additional key habitats. After classification, rasters will be converted to polygons, and the distance to each habitat will be calculated. Once the predictors are extracted and compiled, models will be developed to assess spatial patterns of oyster clusters.

2.3 Assessing Intertidal Oyster Reef Condition (Dr. Josh Breithaupt, FSUCML Faculty, Erin Tilly, FSU Undergraduate Student)

Introduction

The decline, collapse, and current closure of the subtidal oyster fishery in Apalachicola Bay is well documented. However, there are numerous inter-tidal oyster reefs in the region, and much less is known about the condition of these reefs, including whether they are in decline compared to historical conditions and whether restoration efforts are needed. The objective of this study is to collect data about oyster cluster characteristics and reef sediment composition of intertidal reefs in Franklin County to understand their variability and make comparisons to other regions where intertidal reef monitoring and restoration has occurred. The research questions of this work are as follows: 1) What is the condition of intertidal oyster reefs across the region? 2) Do spatial density and size characteristics of oyster clusters affect sediment physical and chemical properties? 3) How does the condition of Franklin County reefs compare to the condition of dead and restored intertidal reefs elsewhere in Florida? 4) Does the origin of organic matter (terrestrial detritus vs. marine phytoplankton) deposited on intertidal oyster reefs vary across the region?

Five intertidal reef complexes were sampled across Franklin County (Fig. 1) for comparison of above-ground (live oyster size and abundance, cluster size, and burial depth) and below-ground (density, grain size abundance, organic matter and nutrient concentration, and stable isotopic composition) reef characteristics. The origin of organic material deposited on intertidal reefs is being investigated through stable isotope analysis of sediment organic carbon and nitrogen. A series of severe droughts that reduced the flow of the Apalachicola River, potentially limiting organic material flow into the bay (Camp et al., 2015) is thought to have contributed to the 2012 oyster population collapse. Depending on the findings of this study, identifying reefs influenced predominantly by marine waters and the organics within them may help identify sites for restoration that will be more resistant to the adverse effects of droughts.

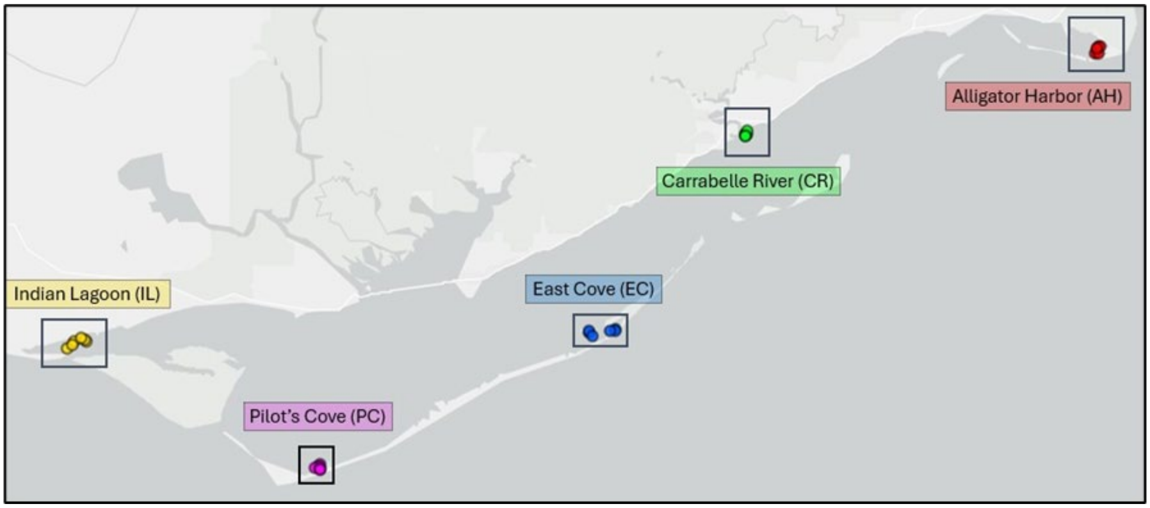

Figure 1. Location of five intertidal reef complexes (colored squares) and six reefs (circles within squares) across Franklin County that were sampled for this study Most of the project results have been provided in the previous report (ABSI Annual Report 2024). All results have been compiled except for the nutrient and stable isotopic composition of the coarse sediment. These analyses are ongoing and are expected to be completed by the end of July 2025. The following are new results not included in last year's report.

Cluster and Live Oyster Characteristics of Intertidal Reefs

There was a wide range in the median (± difference between 1st and 3rd quartiles) spatial density and size of oyster clusters on intertidal reefs across sites within the region. The spatial density of clusters ranged from lows of 1.0 (-1.0, 2.3) and 5.5 (-5.5, 3.0) m^{-2} at AH and EC, respectively, to highs of 7.0 (-4.0, +4.3) and 7.0 (-3.0, +38.5) m^{-2} at IL and PC, respectively. Although PC had the highest cluster density, median cluster size on those reefs was smaller than in the other regions with median volume and height of 0.50 (-0.36, 0.70) L and 6.00 (-2.00, 3.00) cm, respectively. In contrast, AH had low cluster density with the highest median cluster size and high at 1.0 (-1.0, 2.3) m^{-2}, 5.07 (-3.32, 2.29) L, and 14.25 (-4.13, 3.75) cm respectively. Pilot's Cove, in addition to having the smallest clusters, also had the shallowest burial depth of 0.0 (0, +0.68) cm. In contrast, clusters at AH and CR had the greatest burial depths of 3.00 cm (Fig. 2)
Abundance of live adult oysters (> 25 mm length) ranged widely across the region from a low in IL with almost no live oysters (0.0 (0.0, 16.0) m^{-2}) to a high in EC with 96.0 (-56.0, 100.0) m^{-2}. Spat (< 25 mm length) abundance followed a similar pattern from a low of 0.0 (0.0, 16.0) m^{-2} at IL to a high of 148.0 (-108.0, 164.0) m^{-2} at EC. Live adult oyster counts were not obtained at the PC site, but were estimated using the observed relationships between live oyster counts and average total cluster volume (median cluster volume multiplied by median number of clusters per quadrat) at EC, CR, and AH:
Live oyster count = 44.82 x ln(Cluster Volume) + 19.28 (R^2 0.81; p 0.001)

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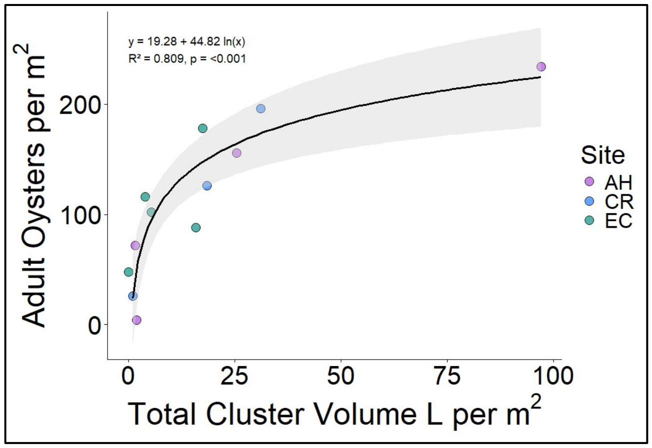

Figure 2. Predictive relationship between reef cluster volume and number of live adult oysters

Nutrient and Stable Isotopic Composition of Fine Sediments.
Reef substrate material was separated into four size classes: large shell fragments (>2cm) were removed by hand and the remainder of the sample was mechanically sieved into three sequential size classes using a shaker: fine shell (>710µm), coarse sediment (>63µm), and fine sediment (<63µm). Thus far results are available for the fine sediment fraction and are in process for the coarse sediment fraction. The fine sediment fraction is considered most representative of oyster metabolic activity that produces feces and pseudo-feces. Results of this analysis of the fine sediment fraction identified strong differences in the source and origin of organic matter across the region, suggesting differences in diet as well as sediment biogeochemical cycling (Fig. 3). The coarse sediment fraction is more indicative of passive deposition and settled material and will provide a more complete picture of reef organic matter that drives belowground biogeochemistry.

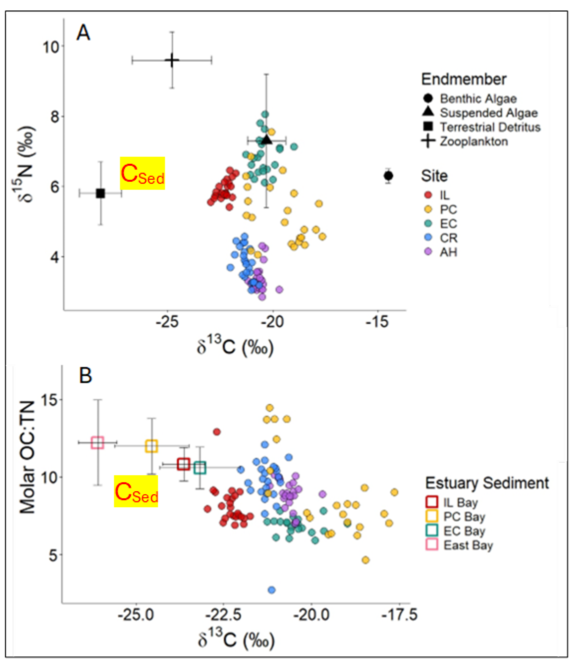

Figure 3. Comparison of **A)** $\delta^{13}C$ and $\delta^{15}N$ of intertidal reef fine sediments (colored circles) with potential regional sources (black shapes) $\delta^{13}C$ and molar C:N of intertidal reef fine sediments and benthic estuary sediments. Our hypothesis that coarse sediment will look like terrestrial detritus and benthic sediments, indicated by C_{Sed} in both panels.

Project Timeline
This project is being led by undergraduate student Erin Tilly as part of her Honors in the Major Thesis; most of this manuscript is already written. The final lab analyses on the coarse sediment fraction will be completed by end of summer 2025 and we expect the manuscript to be submitted for peer review this Fall.

2.4 Historical changes in benthic sediments of the Apalachicola Bay system (Dr. Josh Breithaupt, FSUCML Faculty, Kevin Engelbert, FSU MS Graduate Student)

Introduction
The purpose of this project was to investigate if eutrophication has occurred in the Apalachicola Bay region in the past half century by examining benthic sediment throughout Apalachicola Bay, St. Vincent Sound, and St. George Sound to determine if changes in sediment organic carbon (OC) concentrations are evident (Fig. 4). Bay sediment characteristics are influenced both by source inputs that may occur via riverine or marine deposition, and by trophic processes that intercept or rework organic matter before or after it reaches the bottom. Two potentially important regional changes that were investigated are: 1) changes to floodplain-derived detritus and sediments to the Bay, and 2) changes to the system-wide oyster population and a resulting decrease in the metabolic processing and sequestration of organic matter. Most results have been provided in the previous report (ABSI Annual Report 2024). Both approaches demonstrated a significant OC increase of up to fivefold. Up to 90% of the study area has experienced a net increase since 1959 as

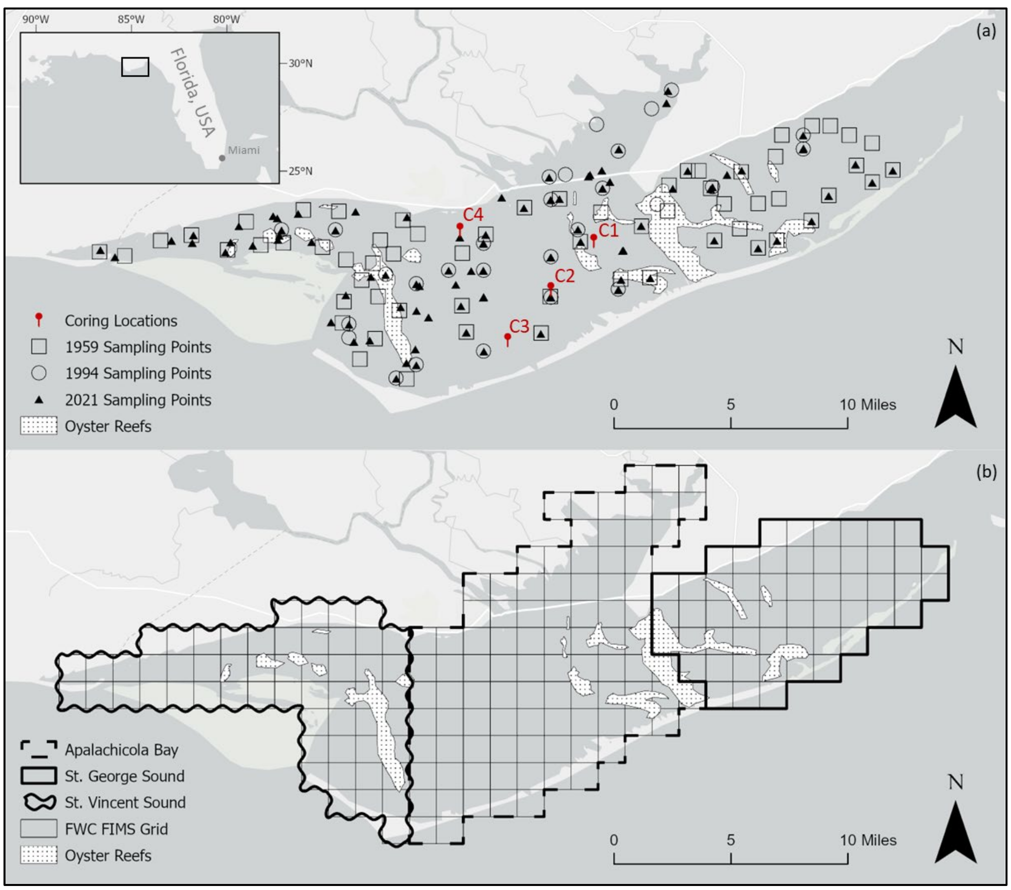

Figure 4. a) Locations of surface sediment collection in 1959, 1994, and 2021 in the Apalachicola Bay system. The largest oyster reefs of the bay are outlined. Red points identify locations of the dated sediment cores 1 – 4 (C1 – C4) used in the second stage of this study. **b)** Application of the FWC FIMS spatial grid divided into three subregions for the comparisons, including St. Vincent Sound (west), Apalachicola Bay (central), and St. George Sound east).

determined by Approach 1. Median OC content increased over three-fold from 6.6 mg g^{-1} in 1959 to 22.1 mg g^{-1} in 2021. Ranges of OC concentrations were almost always at intermediate levels (10-35 mg g^{-1}). Areas that were identified to have the greatest increase in OC concentration since 1959 were confirmed by central AB cores C1, C2, and C3. This suggests that this area of Apalachicola Bay may continue to store OC and be approaching the critical, higher range (> 35 mg g^{-1}) which is indicative of environmental stress.

The factors that might have contributed to the rising OC concentrations were increased nutrient availability, erosion of coastal marshes, and changes in river flow. The higher nutrient availability could have led to higher primary productivity and decreased organic matter degradation. The erosion of coastal marshes could have introduced fresh organic material into the lagoon. Finally, dam construction and dredging activities might have altered the historical pattern of organic matter delivery as the timing of organic matter increase coincided at the onset of these events. $\delta^{13}C$ values in cores indicated a mix of terrestrial and marine sources, with cores closer to the mainland having a higher terrestrial input (~71.71%).

Project Timeline

Kevin Engelbert defended his MS thesis for this project and graduated from FSU in the Summer 2024 semester. The thesis is currently being formatted for submission to the journal Ecosystems in 2025.

2.5 Monitoring sub-tidal oyster habitats (Dr. Sandra Brooke FSUCML faculty and the ABSI technician team)

Introduction

Sub-tidal monitoring has traditionally been done using SCUBA, but this approach is weather dependent, requires specific skills and expensive equipment, and is potentially hazardous given the low visibility and strong currents in Apalachicola Bay. Recent monitoring has also focused on specific areas that were replanted under grant funding and therefore do not provide a broad spatial perspective of the status of sub-tidal oyster populations.

Objectives

1. Expand the current understanding of the extent and status of oyster habitat and populations
2. Detect spatial patterns in oyster abundance and size distribution
3. Identify sites for oyster reef restoration experiments

Methods

The first subtidal surveys were conducted from late fall 2020 to early spring 2021 and consisted of 132 sites (Reported in the 2021 ABSI Annual Report). The initial objective of this sampling survey was to acquire an understanding of the status of oyster habitat and populations in the Bay. Target sites were driven by local knowledge and were not scientifically randomized or structured. Despite these limitations, the survey provided useful data that would have been challenging to acquire using SCUBA in the same timeframe. At each station, six replicate single tong samples were taken from the bow, middle and stern of both sides (port and starboard) of the vessel. The following parameters were recorded for each tong sample: volumes and mass of total material, material type (shell, rock, other); numbers of spat (<25 mm), sub-legal oysters (25-75 mm), market-sized oysters (> 75mm), and boxes (dead, articulated shells). Predators were identified and counted. In addition, cultch planting and type of cultch (shell, limestone, fossil shell) planted were recorded.

The second surveys occurred in the fall of 2021 to early spring 2022 and consisted of 117 sites (Reported in the 2022 ABSI Annual Report). These comprised 82 known sites from the first survey, and 35 unknowns. Sites were selected using two shapefiles, created in ArcGIS Pro, which had "known" and "unknown" site designations. The "known" locations are places where live oysters were present in the first round of tonging, were identified through side-scan sonar mapping as potential oyster substrate or are areas that were part of the FDEP restoration projects (funded by the RESTORE Act and Natural Resource Damage Assessment). The mapping data used included side-scan sonar collected by the National Oceans and Applications Research Center in 2021 and FDEP side-scan data from their RESTORE project. The "unknown" locations are areas of historical oyster habitat (according to FWC maps) but where no contemporary data was available. Tonging samples for the second round of subtidal sampling were collected in the same manner as the first, however, the height of the first 100 oysters was measured to generate a size-frequency distribution of the population. Remaining oysters and boxes were counted.

The third round of tonging surveys were conducted from January to March 2023 and comprised 227 locations throughout Apalachicola Bay. Areas of similar habitat type were identified, and a power analysis was conducted using samples from the previous two years to determine adequate sampling effort for each substrate type and region. This approach provided a statistically supportable assessment of substrate type and quantity, and oyster abundance and size distribution throughout the Bay. Tonging samples for round three subtidal sampling were collected the same way as round two, but additional information collection included the size classification (spat, sub-legal, market) of boxes. This allows more insight into the mortality occurring in different size classes.

The fourth tonging surveys were conducted from March to April of 2024 and consisted of 66 sites focused on FDEP and FWC restoration plant sites (Fig. 5). Mapping data from FDEP side scan was used to create accurate polygon shapes (ArcGIS Pro) of each reef and to assess hardness throughout the reef area (ReefMaster 2.0). Using the coverage and hardness maps, sites were selected to target planted limestone areas within the restoration reef boundaries. Tonging samples for round four subtidal sampling (Fig. 6) were collected similar to round two and three, however, the height of all oysters was measured and recorded, unless under 10mm (all <10mm oysters were counted). Data collected also included size classification (spat, sub-legal, market) of boxes, as done in round three tonging collections. A composition of material collected (shell, limerock, shell hash, and other) at each site was visually estimated.

The fifth round of tonging surveys began in January of 2025 and are anticipated to reach completion in early April 2025, with ~185 sites throughout the bay being sampled (Fig. 7). Sample selection followed a similar process as round three, with a power analysis determining effort distribution across habitat types and geographic areas. Sample processing followed procedures from round four tonging surveys, with all oysters >10mm measured, oysters <10mm counted, and boxes classified as spat, sub-legal, or market.

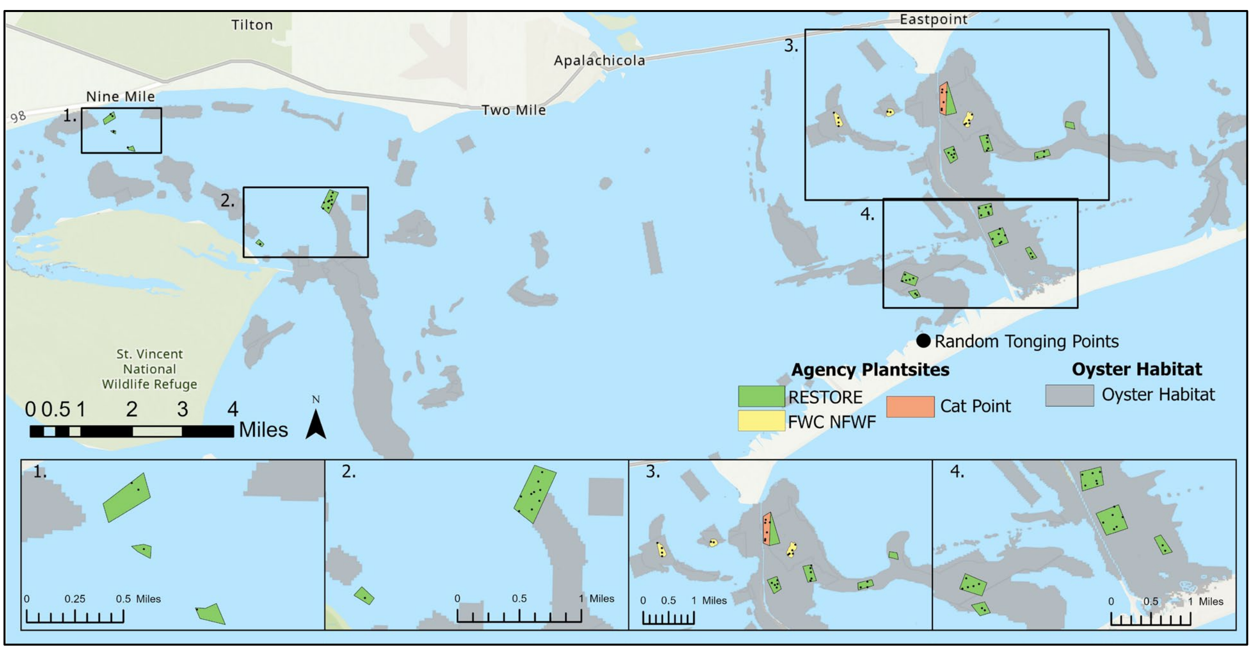

Figure 5. Subtidal tonging locations from year four showing agency planted sites (colored polygons) and tonging point locations (black dots). These were collected in a nested random design, with higher intensity sampling on limerock restored areas.

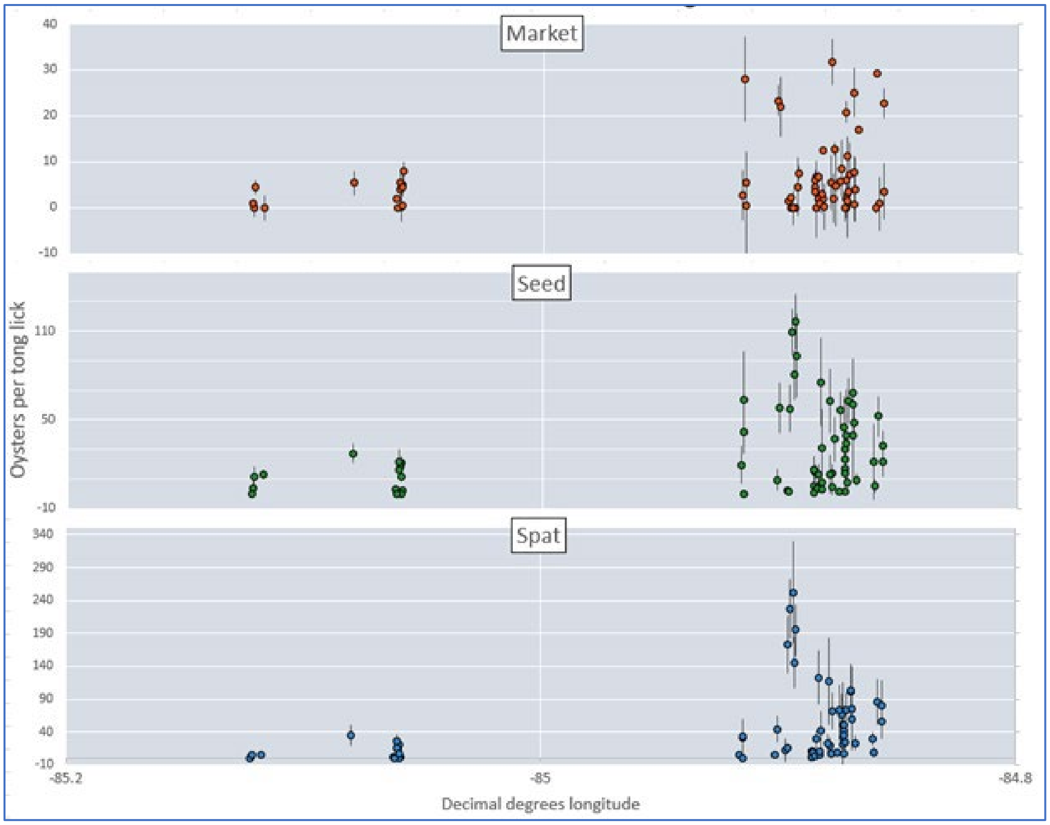

Figure 6. Average number of oysters per tong sample (~0.5 m^2) at different locations across Apalachicola Bay. The eastern side of the Bay is performing better than the west with several sites above the FWC threshold for a limited harvest.

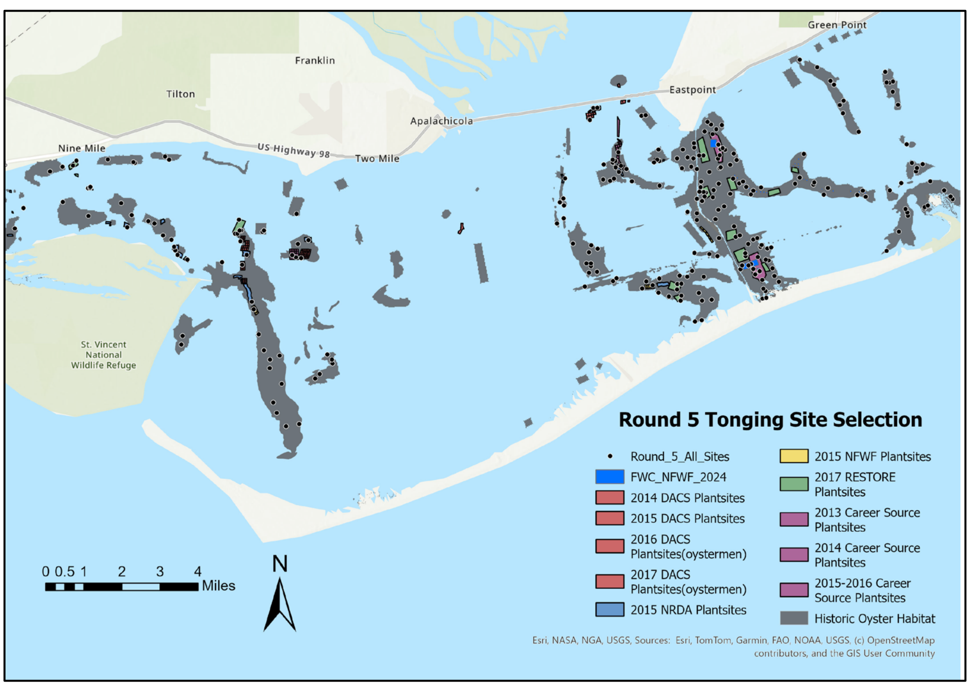

Figure 7. Subtidal tonging locations for round five tonging efforts, distributed across historical habitat and restored/planted areas. Sampling is projected to be completed by April 2025.

Results and discussion

The 2023 tonging data was presented in the 2024 annual report but as with previous surveys, these data show that the distribution of oyster populations in Apalachicola Bay is spatially heterogeneous and very few areas supported market sized oysters. These data show much higher recruitment (spat), more sub-legal, and marginally more market sized oysters in the eastern versus western sections of the Bay. Anecdotal information from before the 2012 fishery collapse estimated that approximately 25 market sized oysters would be a common expectation for a single tong sample. Historical oyster habitat and areas planted with shell or fossil shell had few oysters, and many no longer have stable material to support oyster recruitment and growth. These observations are supported by the most recent subtidal tong sampling in 2024-2025.

Future work includes a fifth round of tonging in Spring 2025, and spatial analysis of all data to identify statistical differences between regions and substrate type and to assess changes since the oyster fishery was closed in December 2020. Environmental data from ANERR instruments, the FIM Kriging analysis and the hydrodynamic model will be used as factors in the analyses to identify potential environmental drivers of the observed oyster distributions.

2.6 Restoration experiments (Sandra Brooke FSUCML faculty and the ABSI technician team)

2.6.1 First oyster restoration experiment (2021)

Introduction

The 2012 collapse of the Apalachicola oyster fishery has been relatively well studied and it has become clear that the collapse was caused by a combination of factors each exhibiting varying levels of influence and perhaps acting synergistically. After the collapse, millions of dollars in restoration funding were released from the Fishery Disaster fund, and Deepwater Horizon oil spill funding. These projects included deployment of cultch and post- deployment monitoring. All the projects met their construction objectives, but the oysters did not recover. These studies used a similar traditional approach of placing a thin layer of material over a large area. Studies in the Chesapeake Bay (Colden et al 2017) showed that 0.3 m was the minimum height to allow oysters to survive and prevent burial by sediment. The restoration experiments were designed to investigate the efficacy and persistence of different materials and assess recruitment, survival and growth of oysters on the different materials

Methods

Thirty experimental reefs were created in Apalachicola Bay in early summer (May 26 – June 24) of 2021; fifteen were placed on northern Dry Bar in the western Bay and another 15 at Peanut Ridge in the eastern Bay (Fig. 8). These two locations were selected to assess the success of different materials under different abiotic conditions. Each reef (100 m^2) was built to a target height of 0.5 meters. Three materials were used: natural shell, which is a traditional cultching material but is unstable in strong currents and not available in large quantities, small limerock (~5 cm diameter), which similar in chemical composition to natural shell but heavier and easier to obtain, and larger limerock (~15 cm diameter) which is stable and provides interstitial spaces for reef associated animals to inhabit. Reef sites were created by employing local oysterman to transfer and deploy material within the boundaries of each reef site.

Monitoring of the restoration reefs has been conducted six times to date: September-October 2021, April-May and August–September 2022, October 2023, April-May 2024 and September 2024. The first monitoring was conducted using scuba divers but subsequent monitoring used tong sampling, with a diver comparison with tonging in 2022. All data collected prior to 2024 has been reported in previous ABSI Annual reports so the focus of this report will be the results of the 2024 sampling.

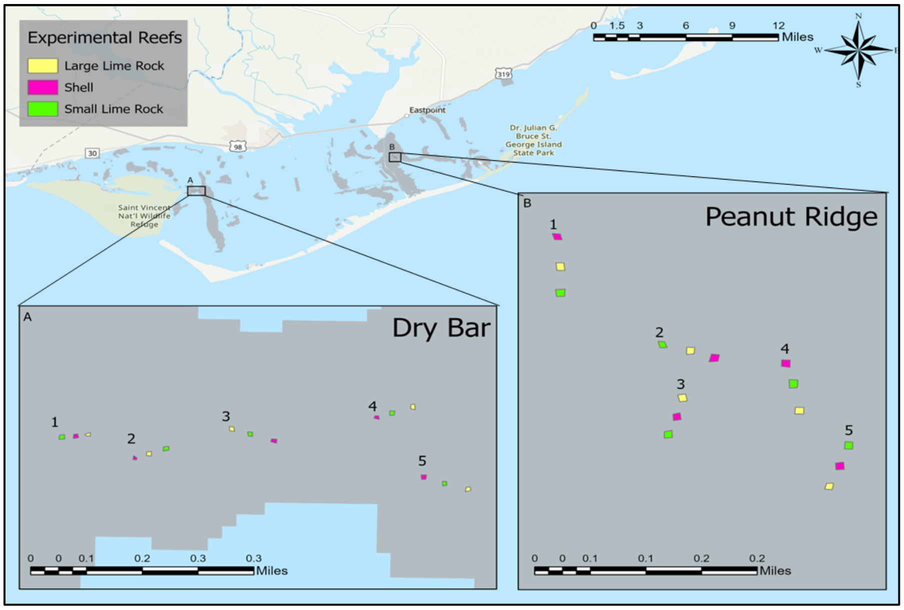

Figure 8. Experimental reef sites at Dry Bar and Peanut Ridge. Three materials (large limerock, shell and small limerock) were used with five replicate reefs at each site.

Results and discussion.

Environmental conditions differ between the Dry Bar and Peanut Ridge areas; the southern end of Dry Bar has high salinity (> 25) as it is influenced by marine waters flowing through West Pass from the Gulf of Mexico. The northern section of Dry Bar however, can have low to moderate (10-25) salinities depending on river outflow. Peanut Ridge has moderate salinities (15-25) and generally much stronger current and wind-driven waves than Dry Bar. Surveys to date show that the eastern bars generally have more oysters than the west, despite similarities between restoration materials used and timing of material deployment. The western Dry Bar reefs showed overall lower performance with fewer total oysters (Fig. 9) and smaller average shell height (Fig. 11) than the eastern Peanut Ridge reefs (Fig. 10 and 12). Differences among materials were observed with large limerock supporting significantly larger oysters in the earlier surveys.

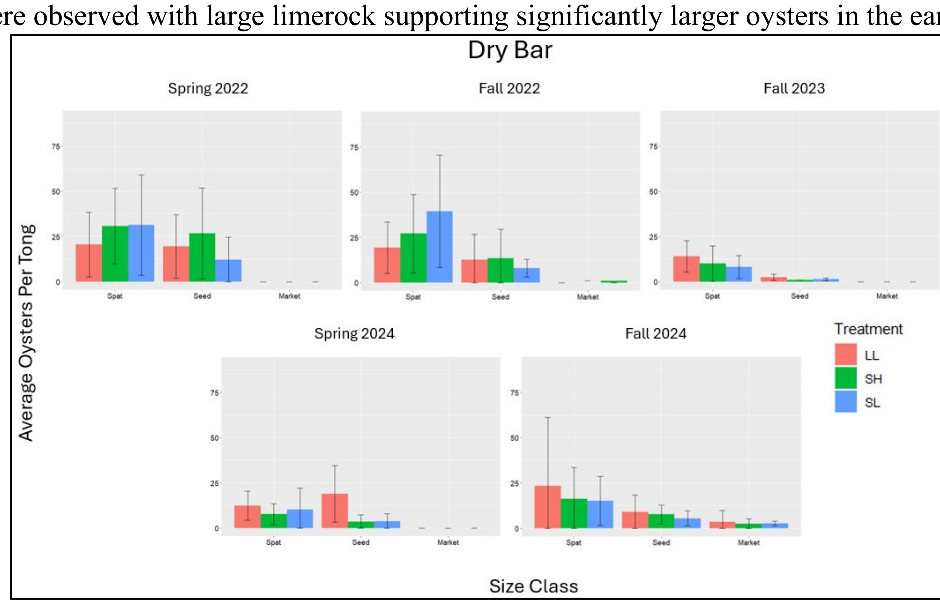

Figure 9. Mean size class by treatment and season for Dry Bar (tonging data). Size classes are defined as (<26mm), seed (26-75 mm), and market (>75 mm).

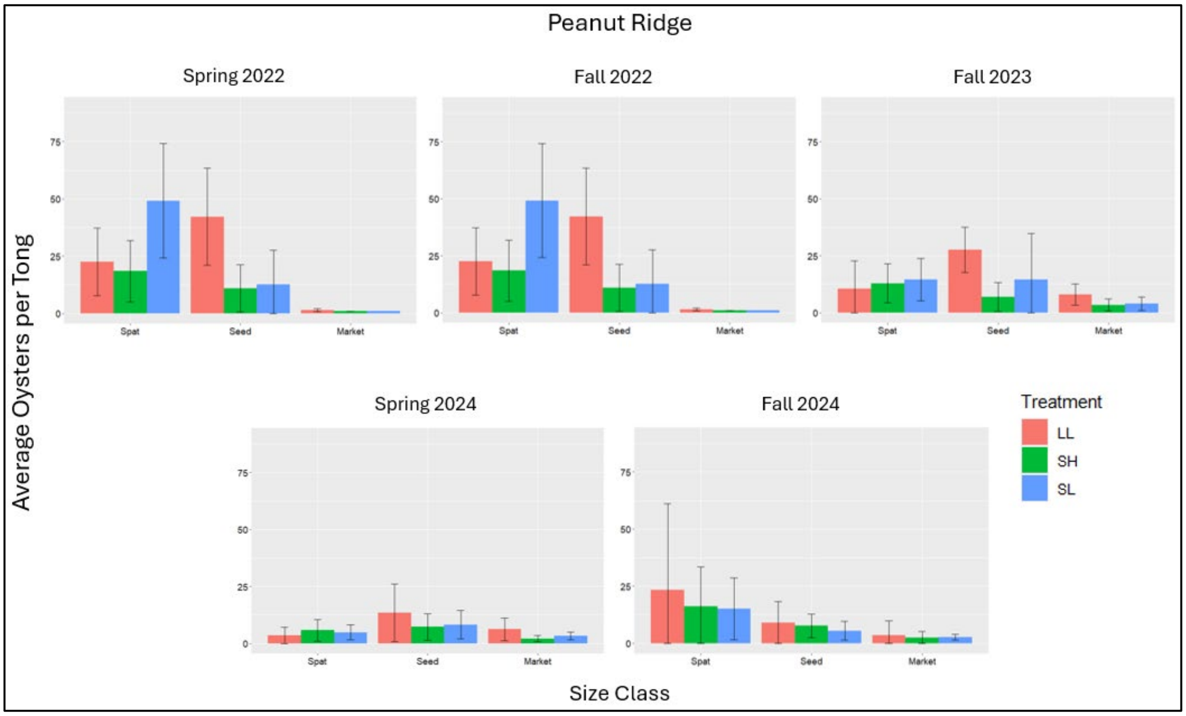

Figure 10. Mean size class by treatment and season for Peanut Ridge (tonging data). Size classes are defined as (<26mm), seed (26-75 mm), and market (>75 mm).

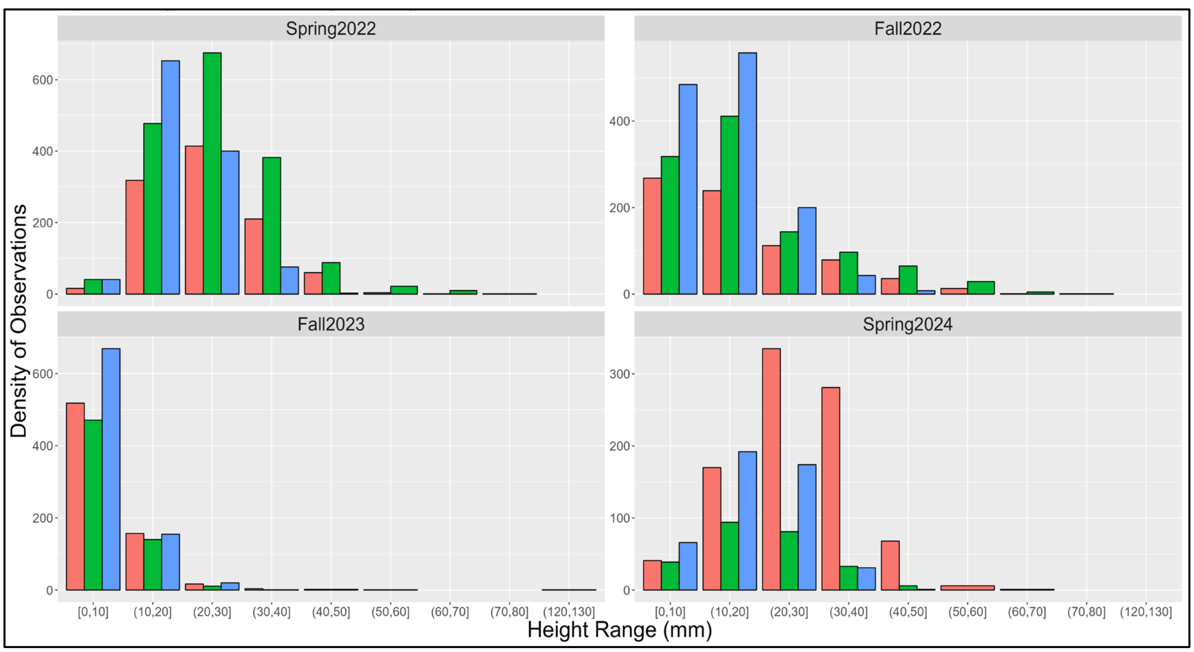

Figure 11. Oyster heights distribution in 10mm increments by treatment at Dry Bar. Treatments are large limestone (LL), shell (SH), and small limstone (SL)

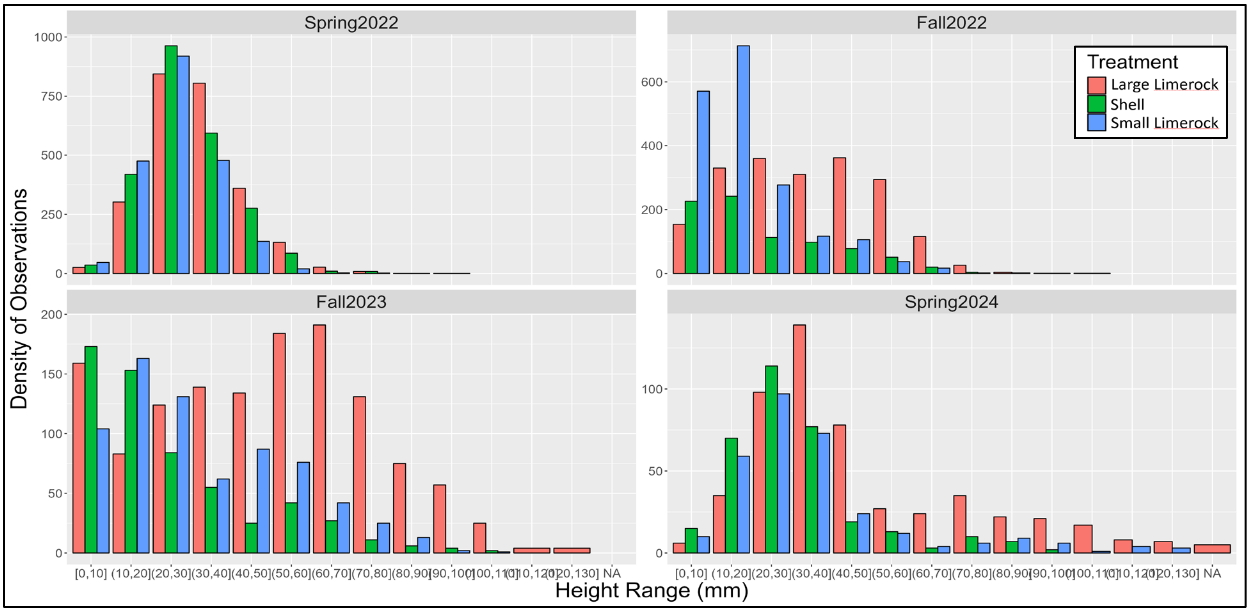

Figure 12. Oyster heights dirstibution in 10mm increments by treatment at Peanut Ridge per season. Treatments are large limestone (LL), shell (SH), and small limstone (SL).

After sampling this experiment for four years, there are several observations that can be made.

1. Shell material dispersed quickly at Peanut Ridge where currents are consistently strong, but remained in place better at Dry Bar. The small limerock had high spat set but did not support larger oysters and tended to 'pack down' over time and lose structural complexity. The large limerock performed best at Peanut Ridge, supporting multiple cohorts and some oysters > 130 mm, but material performance was inconsistent at Dry Bar
2. Peanut Ridge performed better than Dry Bar with some market sized oysters sampled after 1 year.
3. Dry Bar produced almost no market sized oysters and rarely any greater than 50 mm, but number of spat was similar to Dry Bar.
4. The material performance varied depending on site. At Peanut Ridge there was no significant difference in size distribution between treatments after the first year, but the fall of 2022 and 2023 showed significant difference among all treatments, and spring 2024 (3 years post-deployment) showed significantly larger size distributions on Large Limerock than the other two treatments
5. For Dry Bar, the samples from spring 2022, fall 2022 and fall 2023 showed significant differences among all treatments with none clearly performing better than the others. Fall 2023 showed no differences among treatments. At this site, the optimal material varied with sampling period.
6. The number of oysters overall decreased over time at both sites and across treatments. Peanut Ridge showed continual recruitment and overall increase in size over the course of the experiment. Dry Bar showed continual recruitment but very few oysters reached market size.

An initial high recruitment rate followed by decline over time is not unusual for newly planted material. The clean material provides space for a high initial spat set, but as the oysters grow, habitat becomes limiting and fewer new spat recruit each season. Meanwhile, ideally the size classes grow larger and the overall size increases. This is the pattern we observed at Peanut Ridge, but at Dry Bar, recruitment remained consistent but the oysters did not reach market size. During the fall 2024 sampling the reefs at Peanut Ridge appeared to have been tumbled as bare white rock was observed in the tong samples. There were also very few market sized oysters, which was unexpected given the previous samples and it is unclear why this happened. The fall 2024 sample was the last for this experiment and a manuscript on the restoration experiments is in progress.

2.6.2 Second restoration experiment (2023)

Introduction

The second restoration experiment developed from results of the first experiment, specifically the better performance of the large limestone at Peanut Ridge in the eastern Bay. The large limestone provided superior stability and habitat for spat to settle and grow. When deployed as a reef, the stacked rock creates a complex structure with spaces for reef associates to colonize and predator refuge for small oysters. This experiment compared the performance of limestone versus concrete of a similar size. Concrete is less expensive, readily available, and avoids the environmental impact of mining. The addition of shell will test the cost-benefit and efficiency of enhancing the stable rock foundation with a layer of natural recruitment substrate.

Methods

Sixteen experimental reefs comprised of four treatments (four replicates each) were created in the Cat Point region of Apalachicola Bay in April-May 2023 (Fig. 13). Reef areas were spaced evenly (approximately 55m of N-S buffer space between each) to allow for flow dynamics, and each reef (128m^2) was constructed to a height of approximately 0.4m. Reef construction treatments included: Large limerock (5-8" diameter) to a height of 38cm, concrete (4-6" diameter) to a height of 38cm, large limerock to a height of 30cm with 8cm of cured oyster shell on top, and concrete to a height of 30cm with 8cm of cured oyster shell on top. Reefs were monitored via tonging, performed by one oysterman using tongs with a consistent gape (0.5m^2). Reefs will be monitored bi-annually (Spring and Fall) to assess their performance.

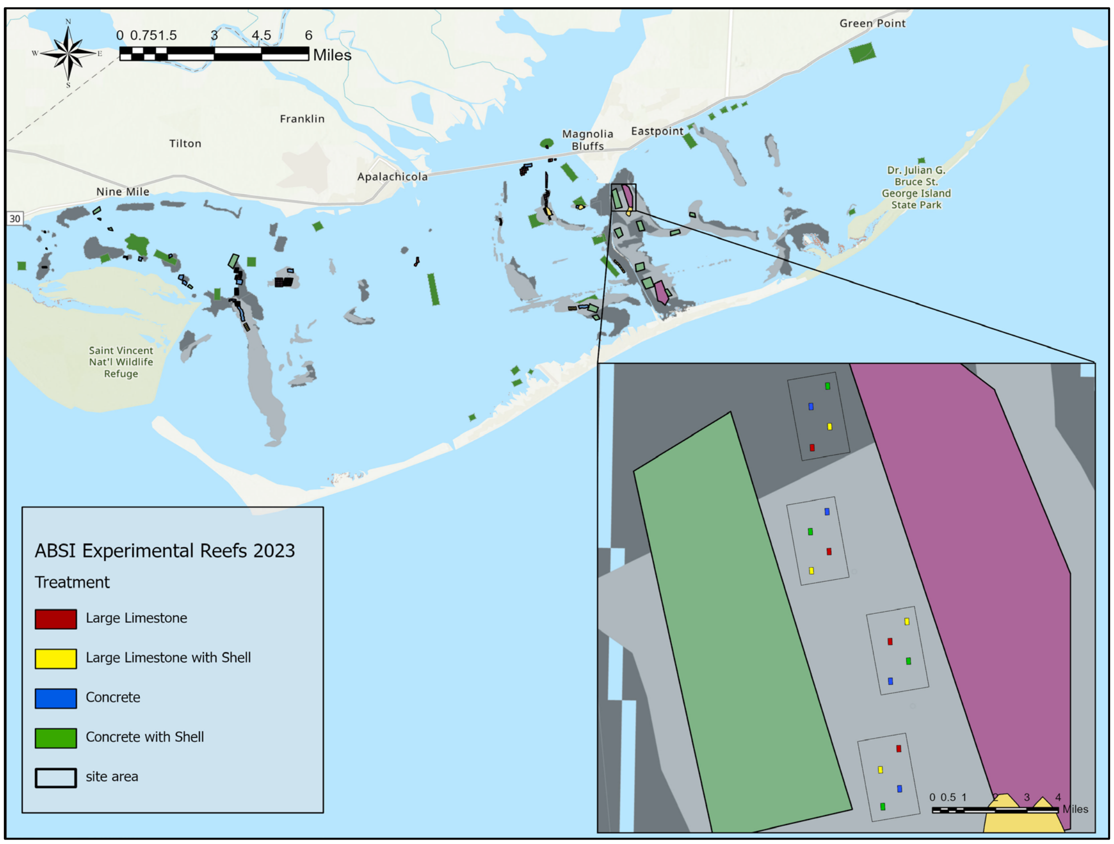

Figure 13. Deployment locations and substrate materials of sixteen ABSI restoration reefs deployed near Cat Point, Apalachicola Bay, Fl.

Results and discussion

The first round of monitoring was completed in October of 2023 using the same data collection methods from round two of Restoration Experiment I. The second and third round of monitoring was completed with the same sampling methods in April and November of 2024, respectively. The fourth round of monitoring will be completed in April of 2025. Water quality parameters were also measured to provide context for oyster habitat conditions.

To date three monitoring events have been conducted. While preliminary data shows there is no significant difference between treatments in each size class, the concrete and concrete with shell treatments tend to have a higher density of oysters across monitoring events (Fig. 14). This trend is also seen in the size-frequency distributions (Fig 15) as either the concrete or concrete with shell have a higher count of oysters per 10mm increment. This follows a similar trend as the previous experiment at Peanut Ridge where the first 18 months showed increasing oyster size. The spring 2024 recruitment was particularly good and is also reflected (to a lesser extend in the first restoration experiment sites. The fourth round of data collection (Spring 2025) will provide more insight to these trends and allow for statistical analysis of size distribution curves to further quantify the efficacy of material types on Cat Point.

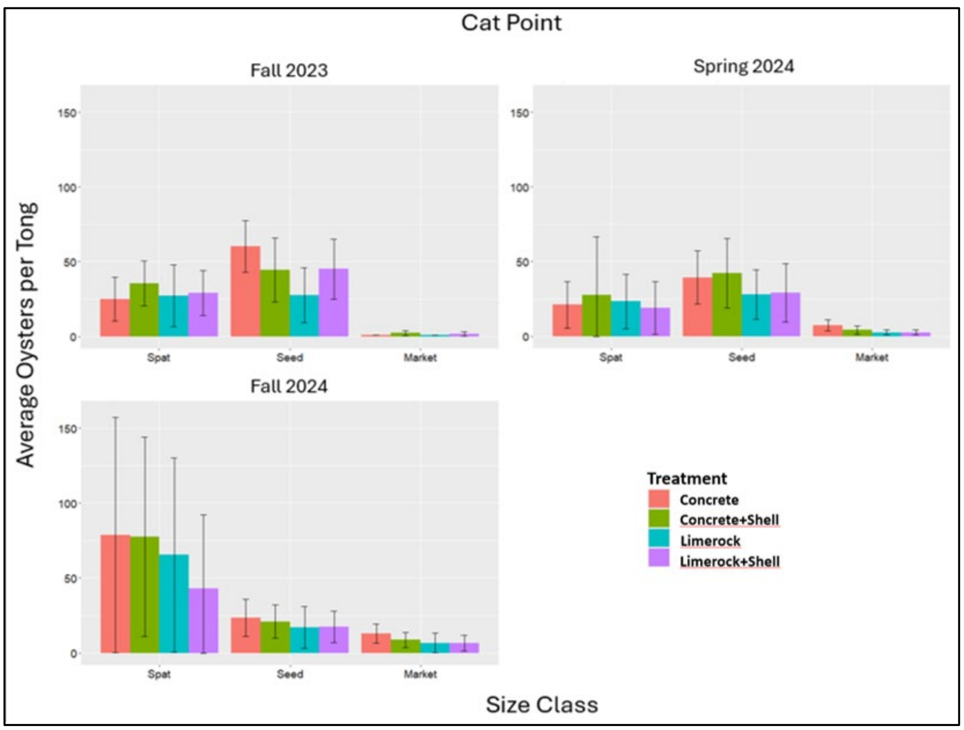

Figure 14. Mean size class by treatment and season for Cat Point. Size classes are defined as spat (<26mm), seed (<26mm), and market (>75mm). Treatments include concrete (C), concrete with shell (CS), limestone (LR), and limestone with shell (LS).

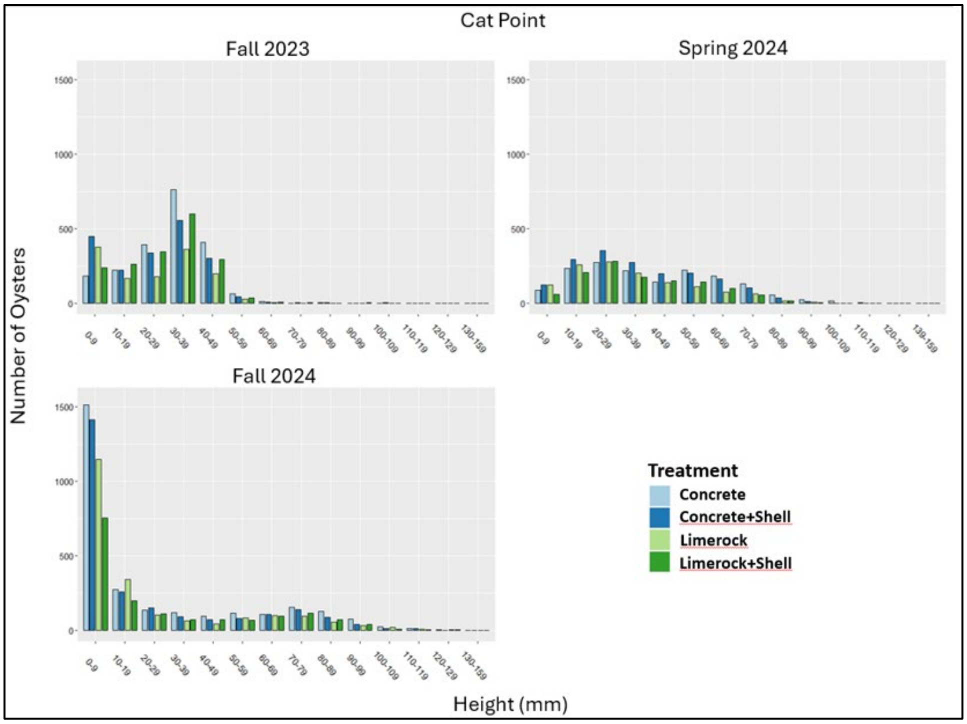

Figure 15. Oyster heights size distribution in 10mm increments by treatment at Cat Point for three seasons. Treatments include concrete (C), concrete with shell (CS), limestone (LR), and limestone with shell (LS).

2.7 Oyster community development on high relief structures (Dr. Sandra Brooke and Dr. Andrew Shantz, Courtesy Research Faculty, FSUCML)

Introduction

Oysters are the foundation species in Apalachicola Bay but are only part of this productive and valuable ecosystem. In addition to oysters, the estuary supports numerous economically important species and is critical nursery habitat for numerous commercially important fishes. Effectively restoring the lost ecosystem goods and services provided by Apalachicola Bay will require understanding how different restoration approaches influence the development of oysters and associated reef communities.

Objectives

1. To utilize existing data to assess how the decline of oyster populations in Apalachicola Bay have impacted the broader ecological community, particularly commercially and recreationally important species
2. Identify how high relief prefabricated restoration modules contribute to oyster population development in different parts of the Bay

Research on the first objective was reported in the ABSI 2022 Annual Report. Part 2 began in March 2022.

Methods

Part 2 of this project began in March 2022 with the planned deployment (under the Florida DEP scientific exemption) of two types of restoration modules: reefballs and layer cakes (Fig. 15) at six study sites: three on Dry Bar and three on the eastern bars (Fig. 17), spanning a gradient of environmental conditions. Reef balls were deployed in April 2022 at all six sites, and layer cakes were deployed in October 2022 at three sites in West bay and two sites in East bay. These units are complex and difficult to assess using traditional approaches, so benthic community development will be monitored using photogrammetry. Prior to deployment, each unit was labeled and approximately 100 overlapping high-resolution images were taken to cover from every aspect and angle. These images were used to create three-dimensional (3-D) models of the units (Fig. 18) using Agisoft Metashape Professional software. Units were removed twice annually at consistent intervals; images taken and 3-D models constructed. Changes in total volume and surface area will be calculated to quantify reef accretion rates at each site.

All photogrammetric sampling events have been completed as of Fall 2024. Modelling is currently underway for the final sampling event, and analysis and comparisons will continue as models are finalized. To understand the recovery potential of the broader fish and invertebrate community, sampling trays filled with shell were deployed next to the restoration modules. Trays were recovered twice (late 2022 and mid 2023) to assess community composition and succession of associated species. Sample processing and data analysis is currently underway. Deployments are being paired with in situ temperature and salinity dataloggers to record local conditions. Data will be analyzed to understand how environmental conditions influence the recovery and colonization of sites across the bay. Combined with ABSI monitoring surveys, these data will help understand how environmental characteristics influence habitat use and recovery of associated oyster reef communities and identify the most promising sites for successful future restoration.

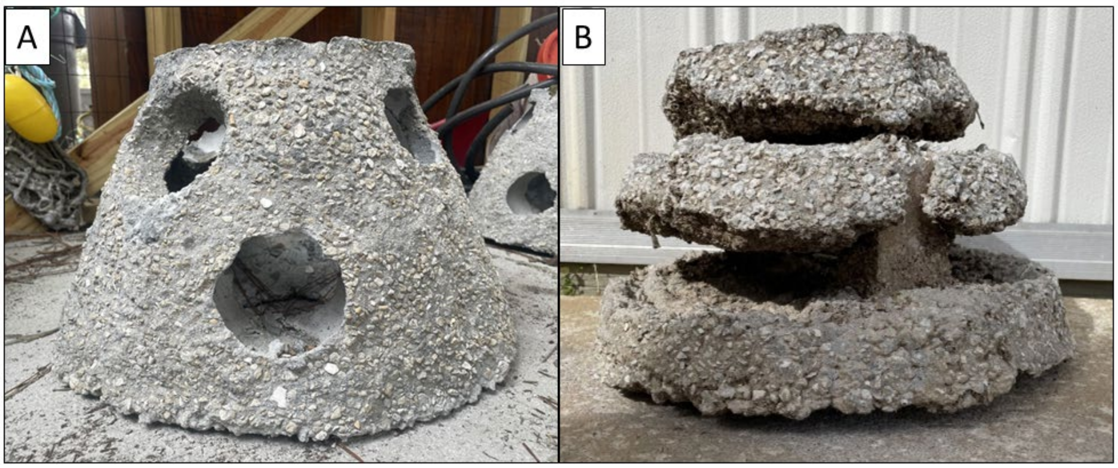

Figure 16. Restoration structures prior to deployment. A) Oyster Reef Ball, B) Layer Cake. Units were deployed in groups of four of each type at three sites in the West bay and three in the East.

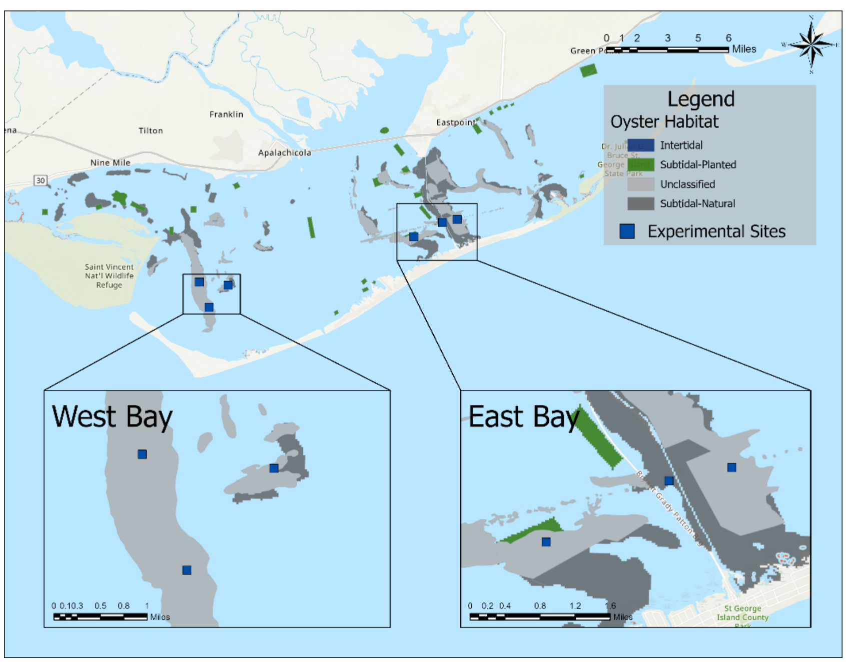

Figure 17. Subtidal reef balls and layer cakes experimental sites.

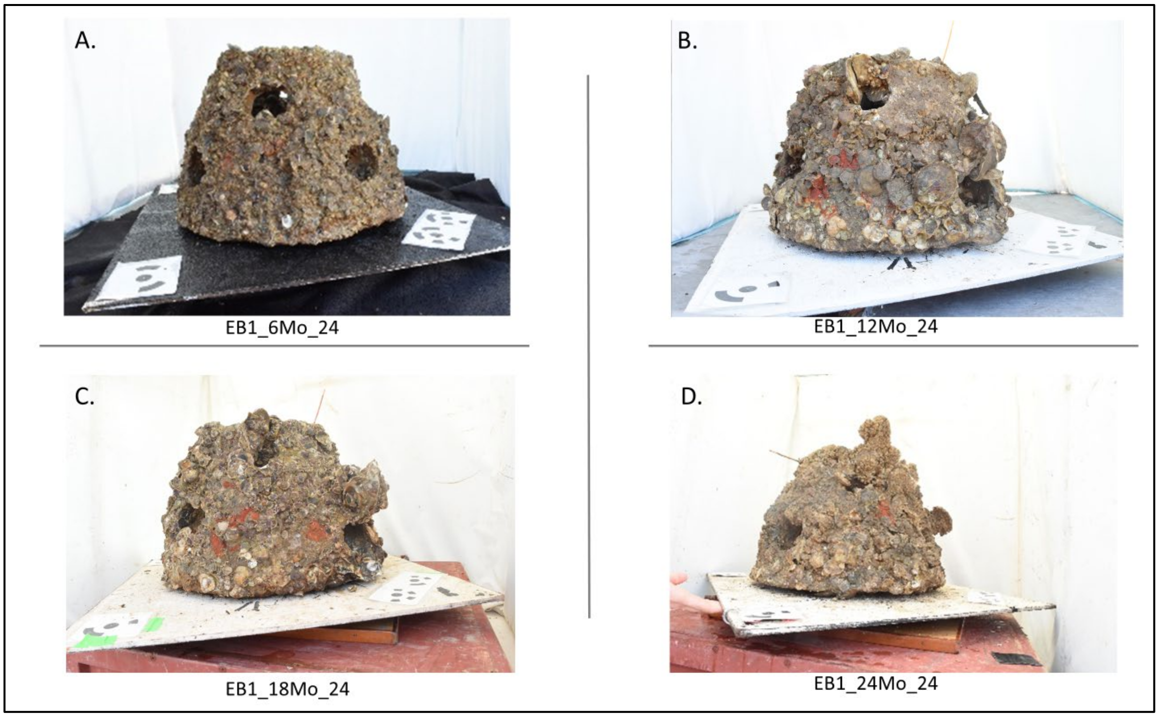

Figure 18. Reef Balls from Peanut Ridge. Labels indicate site, time after deployment and structure number. **A)** East Bay 1, 6 months of deployment, **B)** East Bay 1, 12 months of deployment **C)** East Bay 1, 18 months of deployment **D)** East Bay 1, 24 months of deployment

Results and Discussion

Reef ball and layer cake structures showed similar trends in benthic accretion rates, with both surface area and volume generally increasing over time. While oyster growth was not specifically quantified, oyster growth appeared to be higher in the Eastern vs Western sites (Fig. 19), following the trend identified in tonging data of longitudinal differences in wild oyster populations.

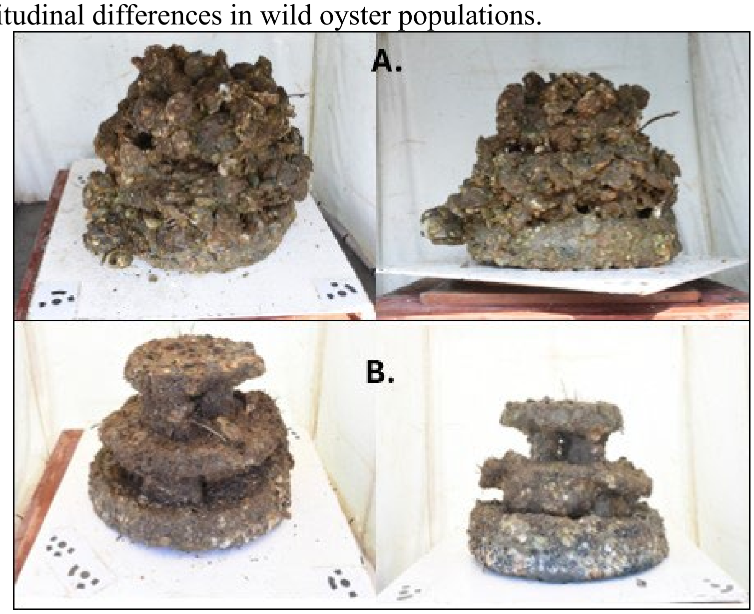

Figure 19. Comparison of layer cake structures after 24 months of deployment in A.) eastern Apalachicola Bay and B.) Western Apalachicola Bay. Accretion and growth are consistently higher in eastern sites vs. western sites.

On average, sites in the eastern Bay had larger surface area and volume measurements than those in western Bay after 18 months of deployment (Fig. 20). Further analysis of regional water quality data is currently underway to identify potential drivers of observed differences in accretion rates across the study area.

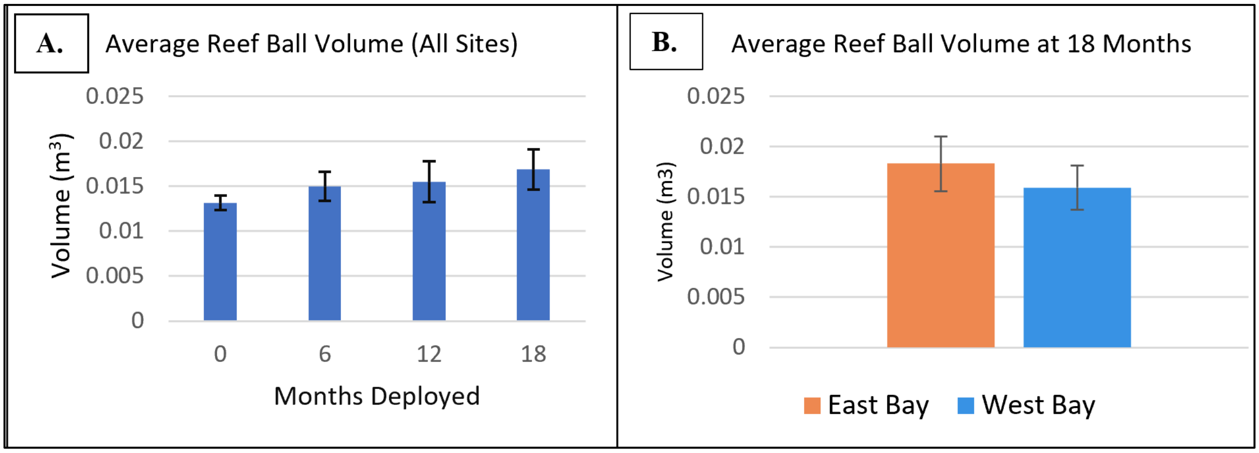

Figure 20. A.) Average reef ball volumes across all sites over 18 months of deployment. B.) Average volume of reef balls in East bay vs. West bay at 18 months of deployment.

2.8 Communities associated with restored oyster reefs (Dr. Sandra Brooke and ABSI technician team)

Introduction

Oysters are ecological engineers, creating their own unique reef as well as community within. The relationship between oysters and their community associates is extremely dynamic and can show unique differences seasonally. Oysters provide habitat and refugee to a variety of marine fishes and invertebrates, while also serving as a food source or host to other organisms. Planted limestone in Apalachicola Bay provides a solid substrate for oysters to settle and grow on. The solid elevated surface provides protection from sedimentation and high currents, providing refuge for oyster growth. Our goal is to monitor the growth and mortality of oysters within each planted reef as well as identify and track the community of associate benthic fauna throughout the reef as reefs through time post material deployment. Obtaining a thorough inventory of the reef community will assist in understanding oyster reef health and their dynamic relationship with these associated organisms.

Methods

In 2024, the Florida Fish and Wildlife Commission (FWC) planted approximately 88 acres of 4-6" Kentucky limestone across 30 sites in eastern Apalachicola bay for the purpose of oyster restoration. Two of these reefs were selected as study areas: Cat point, with 16 acres of plant area, and East Hole, with 32 acres of plant area. Using GIS mapping software, each planted area was divided into 1-acre sections after excluding an exterior buffer zone of 10m from overall planted area. Within each of four randomly selected 1-acre plots, 5 random points were selected for tray location (Fig. 21). At each location, 0.25m^2 mesh lined trays were deployed by divers excavating reef material to the size of the tray (Fig. 22). Once trays were placed, divers replaced the excavated reef material back into the tray, maintaining the same relief elevation as the reef. Upon retrieval divers securely fasten the mesh sample bag and brought reef material, oysters, and community associate contents to the boat. Samples were then taken back to the lab to be processed, where each sample is thoroughly rinsed with salt water to remove any organisms, algae, or mud. Rinsed water is sieved down to 1mm. Sieved material is sorted, and organisms are preserved in 70% ethanol until identification can be made. Once properly identified, wet weight, dry weight, and abundance of each species or class of fauna are recorded. Mass and volume of reef material (limestone) and oysters, shell height of all live and box oysters were measured and recorded. Samples were photographed for analysis of barnacle and encrusting organism coverage. A subsample of 15- 20 oysters were taken to assess boring organisms within the oyster shells. Water quality parameters are also monitored. One HOBO logger is deployed at each study reef to monitor temperature and conductivity, recording once every hour for the duration of the study

Tray deployment occurred in December of 2024, and they are scheduled to be monitored every 6-8 weeks. At deployment a base line sample was taken to assess initial growth point of oysters at each 1-acre plot. Methods for the base line sample only included recording live and box oyster heights. The first full monitoring event took place in February of 2025, with the second occurring in March of 2025. The third through fifth sampling events are scheduled for April-July, and data analysis will take place after data has been finalized.

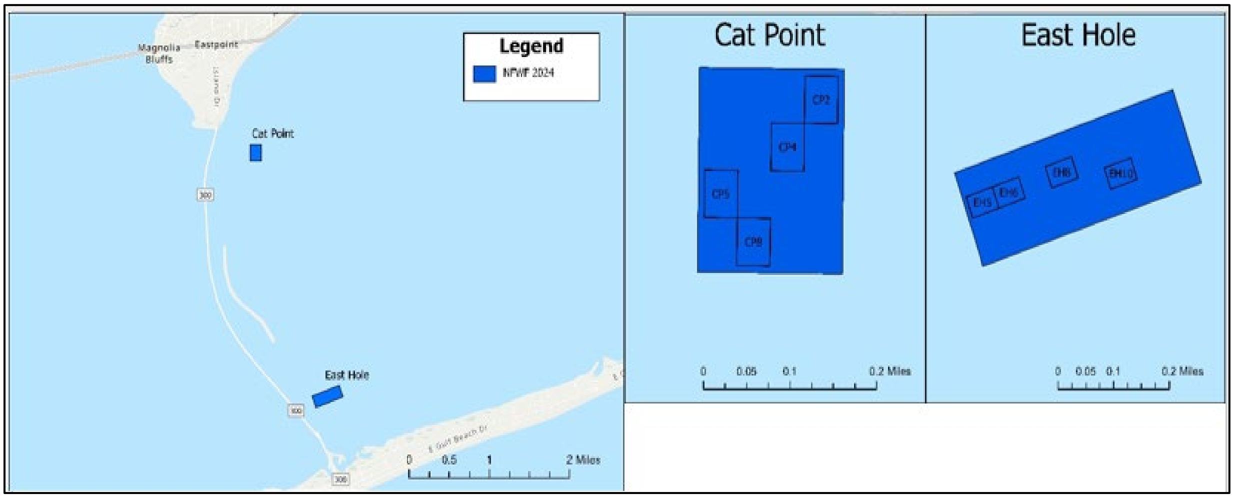

Figure 21. FWC Kentucky limestone planted reefs at Cat Point and East Hole. 1-Acre plot outlines of study area in each reef.

Figure 22. Left: Example of mesh lined tray that is deployed within the oyster reef. Right: Samples of planted Kentucky limestone showing sample size for each tray

Results and Discussion

Monitoring is still ongoing. Oyster height data is currently being entered and going through the QA/QC process. Community associate's data is in the identification stages, with those that have been identified to the lowest feasible level being assessed for abundance and wet/dry mass. Figure 23 shows a sample from one of the trays collected from East Hole showing sub-legal oysters after 3 months of deployment

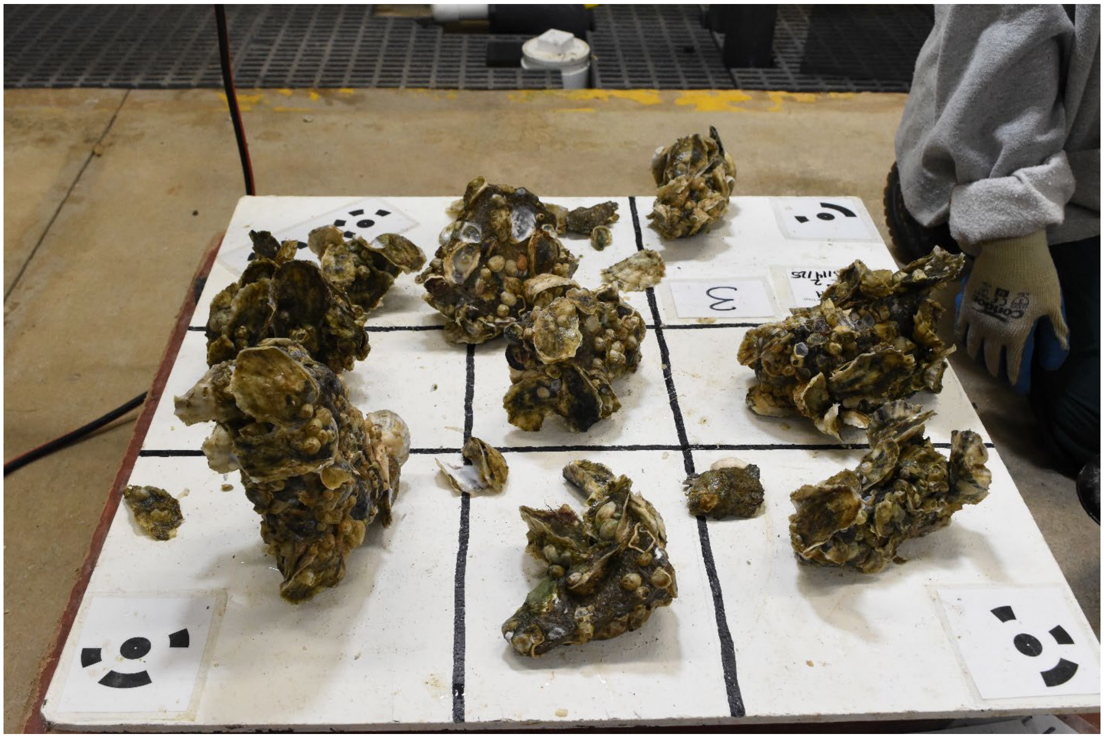

Figure 23. Sample photo from an East Hole collection three months post deployment (December 2024-March 2025)

2.9 Temporal trends in commercial crab abundance in Apalachicola Bay (Adin Domen, MS Student, FSU)

Introduction

This research project is focused on measuring the success of introduced and restored oyster reefs in the Apalachicola Bay. This is measured by the systems' ability to support and maintain economically important crustacean species. Due to the fisheries collapse in 2012, and the close of wild oyster harvest in 2020, the local community's economy has suffered as a result. Many former oystermen have turned to harvesting crustacean and fish species as a supplement to the income they would receive from the wild oyster harvest. A study asked Apalachicola resource managers how they viewed a successful restoration of Apalachicola Bay, with nearly all of them emphasizing the importance of re-establishing a sustainable fishery (Brown et al. 2021). Without the successful restoration of habitat for these economically important species to utilize, the stability of these marine communities will be compromised. The eastern oyster, *Crassostrea virginica,* is considered a foundation species due to its ability to enrich the environment, provide ecological services, and its commercial value. Along with oyster reefs providing habitat for many ecologically and economically important species (Ozbay et al., 2014). Recent studies have supported the idea that oyster reefs are an essential fish habitat due to their importance in ecosystem-level processes and habitat for fishes. Oyster reefs produce vital habitat for commercially, recreationally, and economically important finfish and crustacean species (Coen et al., 1999). Unfortunately, there has been a global decline in oyster reefs of approximately 85%, this has reduced the ability of this habitat to provide key ecosystem services and functions (Hanley et al., 2016). With such a great decline of these essential habitats, organizations such as ABSI, FWC, and FDACS have stepped in and restored degraded oyster reefs and have introduced new reef habitats at varying heights. I aim to survey these introduced and restored habitats for abundance and size of *Callinectes sapidus* (Blue Crabs) and *Menippe mercenaria* (Stone Crabs) to measure the effect of reef height on these species.

Methods

Study sites are referred to in a categorical manner in this section, however the heterogeneity of the reef heights is recognized and assumed planned reef heights aren't equivalent to actual heights of the reefs. For this reason, reef heights are measured at each site and trap at the time of sampling and are treated as a continuous variable when data are analyzed.

Reef habitats are broken down into 4 categories: High-relief, Mid-relief, Low-relief, and bare substrate (control). These habitats were either previously productive oyster bars that have been restored or newly introduced restoration reefs. All sites are located in Apalachicola Bay proper and St George Sound. There's a total of 78 reefs and 18 randomly chosen bare substrate sites that are sampled (n= 96).

Three commercial grade (61 x 61 x 30cm) wire blue crab traps are placed at each of the randomly selected reef habitats. This style of trap is used for both Blue Crab and Stone Crab sampling. This decision was made after the 1st round of sampling for Blue Crabs, when the effectiveness of catching Stone Crabs was realized. This makes sampling logistics simpler and more cost effective. Traps are baited with 2 menhaden (*Brevoortia patronus*) and soaked for 2 days as this is customary practice by commercial/recreational crab harvesters (local crab harvester Shannon Hartsfield anecdote) and are pulled and sampled for CPUE/abundance and crab size. CPUE is measured by taking the mean number of crabs caught (abundance) in all three crab traps. Size is measured by using carapace width (CW) to the nearest cm and mass to the nearest gram; all organisms are released alive after being counted and measured. Eighteen traps are set concurrently allowing for 6 reefs to be sampled at a time. After the 2-day soak period, traps are pulled, sampled, then redeployed at a new set of 6 randomly selected sites.

Blue crabs are targeted between the months of June– September, as blue crab landings were reported to be highest in the summer months (Steele and Bert, 1998). Traps are placed directly adjacent to the reefs approximately 9m apart for both target species; this is customary practice by crab harvesters. Stone crabs are targeted between October – May, these dates are consistent with Florida's stone crab season set by FWC. Reef heights are established the same way during the sampling of both species, allowing for height comparisons to be made.

Using sonar side scan mapping data uploaded in ArcGIS, the edges of the reefs are identified, and traps are dropped adjacent but off the reef. A measuring pole is used to measure the depth of the water column from the surface to the seafloor next to each trap. We then pull onto the nearest edge of the reef corresponding to each trap and measure the water column from the surface to the top of the reef. The difference between these two measurements is used to determine reef height.

This process has been completed from late July 2024 – February 2025 and will be repeated in June 2025 – early 2026, to detect if the newly planted reefs in 2024 will show a difference in CPUE and size from year 0 to year 1, once oysters have established themselves on the reefs. The first round of sampling for both species has been completed.

Preliminary Data

After completing the first round of sampling for both species from July 31st, 2024 – February 21st, 2025. A Generalized Linear Model (negative binomial, log-link) was used to assess the effect of month and species on crab abundance (Fig. 24). The analysis detected a significant difference in crab abundance with time (p = 0.0034), with no significant difference in abundance between species (p = 0.560).

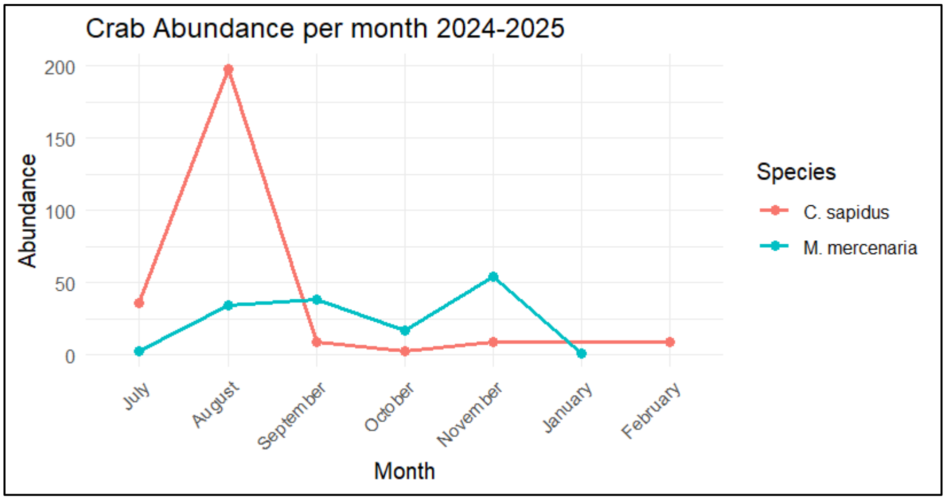

Figure 24: Trends in crab abundance from July 2024 to February 2025. The y-axis indicates the monthly catch of *Callinectes sapidus* (blue crab) and *Menippe mercenaria* (stone crab).

Future Work

Starting in June 2025 I will begin the second round of sampling for *Callinectes sapidus* (blue crab) and starting October 2025 the second round of *Menippe mercenaria* (stone crab) sampling will take place. Crab abundance will be correlated with reef height to determine whether there is a significant difference of commercial crab occurrence with reef relief and duration of deployment.

3 Experimental Ecology

3.1 Salinity and predation risk drive allocation trade-offs in juvenile eastern oysters (Donaven Baughman, PhD Candidate, FSU)

Introduction

The goal of this project is to understand how salinity levels and the presence of a gastropod oyster predator (Florida crown conch – *Melongena corona*) interact to alter feeding rates of juvenile eastern oysters (*Crassostrea virginica*). Predators are known to impose non-consumptive effects on their prey that alter development and life history of prey species through risk-induced changes in behavior or physiology (Lima, 1998). Oysters are known to close their shell valves in suboptimal abiotic conditions (Casas *et al*. 2018) and in the presence of predators (Carroll & Clements, 2019), which may reduce food intake and alter energetic dynamics of oysters. Results from this project will provide essential data that documents the impacts of suboptimal salinity regime and predation risk on feeding rates of juvenile oysters, which by altering energy gain, may impact how well oysters grow, survive, and reproduce.

Methods

Juvenile oysters (~10 mm shell height) were spawned from broodstock oysters collected in Apalachicola Bay, settled as larvae at the FSUCML bivalve hatchery, and grown in waters off the FSUCML in aquaculture cages until reaching spat size. Juvenile oysters were brought into the lab and separated haphazardly into 36, 5-liter aquaria. Aquaria were previously filled with seawater mixed to varying salinity regimes (low 12-17 ppt, medium 22-27 ppt, high 32-36 ppt) and allowed to cycle for two weeks prior to introduction of animals. Each aquarium contained 30 juvenile oysters, while half of the aquaria contained one adult *M. corona* that was allowed to roam the aquarium (n = 6 replicate aquaria per salinity/predator combination). Oysters were suspended in a mesh bag to maximize filtration rates and protect oysters from potential mortality caused by *M. corona* predation. Over the course of 8 weeks, the feeding rate of juvenile oysters in each cage was tracked in three separate trials. In each trial, all aquaria were inoculated with

~100,000 cells of *Tisochrysis lutea* microalgae. A 5mL sample of water was collected from each aquarium immediately after inoculation with algae, then 1-hour and 2-hours later. At each timepoint, water samples were analyzed for cell density (cells/mL) using the Countess III automated cell counter (Thermo Fisher Scientific, MA). Feeding rate (number of *Tisochrysis* cells consumed per hour) was calculated as the change in algal density (decrease in number of cells/mL) over the two-hour feeding period. For each trial, a generalized linear mixed effects model with Gamma error and log link (trial A) or Gaussian error and identity link (trial B and C) was used to determine the effects of salinity regime and predation risk on oyster feeding rates. Salinity regime and predator presence were used as fixed effects in the model, while tank was a random effect to account for non-independence of feeding rates of oysters from the same tank.

Results

Salinity regime and predation risk both impacted feeding rates of juvenile oysters, but their interaction did not. In trial A, in the high salinity regime, feeding rates of juvenile oysters exposed to predators was 53% lower for predator-exposed oysters than non-exposed oysters ($p < 0.05$), however the interaction of salinity regime and predation risk was only marginally significant ($p = 0.06$). In trial B, non-exposed oysters in low salinity consumed 17% less algae than non-exposed oysters in medium ($p < 0.05$), but not high salinity. There were no significant effects of salinity or predation risk on oyster feeding rates in trial C (Fig. 25).

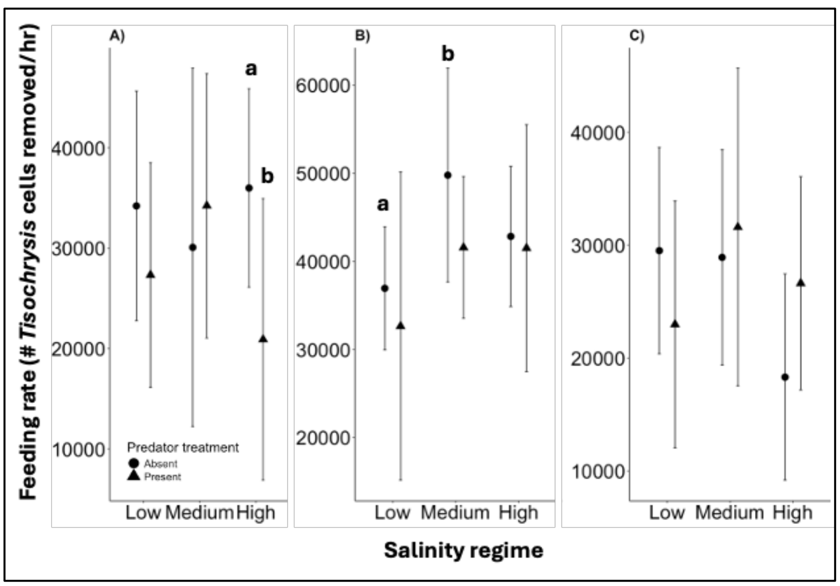

Figure 25: Average feeding rates (number of *Tisochrysis lutea* cells removed/hr) of juvenile eastern oysters (*Crassostrea virginica*) exposed to three salinity regimes (low 12-17 ppt, medium 22-27 ppt, high 32-36 ppt) and the presence (triangles) or absence (circles) of risk cues from the predatory gastropod *M. corona.* Bars represent 95% confidence intervals.

Discussion

Overall, these results suggest that feeding rates of juvenile oysters are impacted by both salinity regime and predator presence. However, we did not detect a significant interaction term. Although the interaction of salinity and predator presence was not significant, the effect of predators on reducing filtration rates of juvenile oysters in trial A was present only in high salinity, and the effect of low salinity reducing filtration rates in trial B was present only in the no-predator treatment. These results suggest that salinity and predators interact to alter feeding rates of juvenile oysters, however detecting these interactive effects statistically is challenging due to the high variability between feeding rates across treatment combinations.

3.2 Oyster stress response and physiological tolerances (Emily Fuqua, Ph. D. Candidate, FSU)

3.2.1 Temperature tolerance of larval oysters, Crassostrea virginica

Introduction

Eastern oyster (*Crassostrea virginica*) populations have historically supported valuable wild fisheries; however, populations have collapsed across this region, including the previously highly productive Apalachicola Bay. Estuaries are being impacted by development, water management, and climatic changes, all of which can impact the sensitive early life history stages of this foundation species. This study provides information on physiological tolerances to environmental conditions of larval eastern oysters from the Florida panhandle in the eastern Gulf of Mexico.

Methods

Wild oysters were used to produce larvae, which were cultured at a range temperatures (14, 16, 18, 20, 22, 24, 26, 28, 30, and 32°C). Survival and growth of larvae were measured throughout the culture period. The 14°C treatment had significant mortality throughout the treatment period and insufficient larvae survived this treatment for data collection after day six. During data analysis and model selection, the 14°C survival data point was identified as a potential outlier, however, this point could also indicate an ecologically relevant temperature—the lower lethal temperature for larval oysters in this region. Due to the implications of including this point in the analysis, the results below are presented both including and excluding the 14°C in the survival dataset.

This study provides key physiological information needed to understand eastern oyster biology and population dynamics. Additionally, this study demonstrates potential physiological tradeoffs for larval eastern oysters across gradients in temperature, which is known to vary throughout seasons in which larval eastern oysters occur.

Results

When analysis includes 14°C, temperature had a significant relationship with larval survival ($G_2 = -2848.8$, $P = 0.001$; Fig. 26A). Larval survival followed a negative parabolic pattern with increasing temperature and peaked at 78% survival between 22 and 26°C (Fig. 26A). Survival in 14°C followed a steady decrease from the beginning of the treatment exposure period and was 6.5% on day 6 of larval culture, potentially indicating a lower lethal temperature for early-stage veliger larvae. When analysis excludes 14°C, temperature had a non-significant, linear relationship with larval survival ($G_1 = -30.85$, $P = 0.68$) and ranged 45.8 to 78.3% in larval cultures between 18 to 32°C.

Temperature had a significant relationship with early larval growth rate ($G_1 = 0.0003$, $P < 0.001$; Fig. 26B). Growth rate followed an exponential curve with increasing temperature within the range tested in this study (14—32°C; Fig. 26B). Growth rate was negligible, ranging 0.0004—0.002 mm day^{-1} between 14 and 24°C, and as temperature increased larval growth rates increased rapidly (Fig. 26B). Early larval growth rate was greatest in 32°C at 0.018 mm day^{-1}, indicating 42.5 times increase in growth rate at the highest temperature tested (Fig. 26).

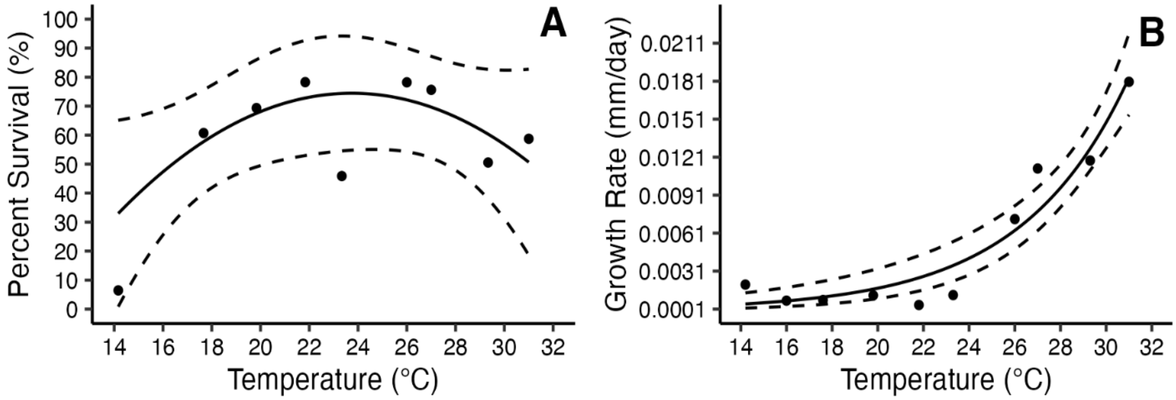

Figure 26: Larval oyster percent survival (A; left) and growth rate (B; right) across temperature range tested (14–32°C). Points on graphs represent survival of treatments estimated from subsamples (A) and growth rate of larvae (mm day^{-1}) in treatments estimated from shell height measurements (B). Solid black lines represent the best fit generalized linear models for survival and growth, and dashed lines represent 95% confidence intervals of those models.

3.2.2 Effects of temperature, salinity, and interactions on the physiology of young adult oysters

Introduction

Impacts of anthropogenic activities, such as freshwater management, fishing, and climate change, are rapidly and irrevocably changing coastal ecosystems. These environmental changes are driving alterations in the physiology of coastal organisms which ultimately scales to changes in population and community dynamics. However, many management and conservation strategies do not include plans for environmental change and the physiological consequences on organisms, which may make them more effective as the environment continues to change. While temperature and salinity have been studied extensively separately in *C. virginica*, how these stressors interact to frame the metabolism of this species is not well understood but has implications for critical population rates such as mortality and reproduction. Additionally, stress caused by suboptimal temperature and salinity can alter survival and growth, particularly in larval and juvenile stages of invertebrates, and sublethal stress on metabolism is not well understood for the eastern oyster. So, the purpose of this research is to identify and characterize the effects of two main environmental stressors, temperature and salinity, on the physiology and metabolism of *Crassostrea virginica*.

Methods

Young adult oysters (23 weeks old; 20-25 mm in shell height; N = 120 total) were exposed to a large gradient of salinities (10, 12, 14, 16, 18, 20, 22, 24, 26, or 28) at 2 different temperatures (20 and 30°C). Each salinity/temperature combination was randomly assigned 3 independent replicate tanks that housed 2 oysters each. Oysters were acclimated to experimental treatments for 2 weeks before respirometry trials and condition index measurements were held. Survival was monitored throughout the experiment.

Results

All oysters survived at all salinity/temperature combinations, so neither temperature nor salinity affected survival of oysters. Sublethal effects included changes in oyster condition index and oxygen consumption rates. Temperature significantly affected condition index of oysters (G_1 = -0.58, P = 0.006; Fig. 2), but salinity did not (G_1 = -0.096, P = 0.26; Fig. 27). Condition index also did not show a significant interaction of temperature and salinity (G_1 = -0.001, P = 0.9; Fig. 27). Oysters at 30°C had a significantly lower condition index across all salinities, indicating elevated temperature caused oysters to draw on tissue energy stores (Fig. 27). Oxygen consumption rates were significantly affected by both temperature (G_1 = -5.3, P <

0.001) and salinity (G_1 = -0.88, P = 0.02), but no significant interaction between the two factors was present (G_1 = -0.06, P = 0.51). Oxygen consumption rates of oysters at 30°C were significantly higher across all salinities tested, which indicates significantly higher energetic expenditure at this temperature. Physiological, sublethal effects results indicate that for this life stage and in the range of salinities and temperatures tested, the multi-stressor effects are additive, not synergistic or antagonistic.

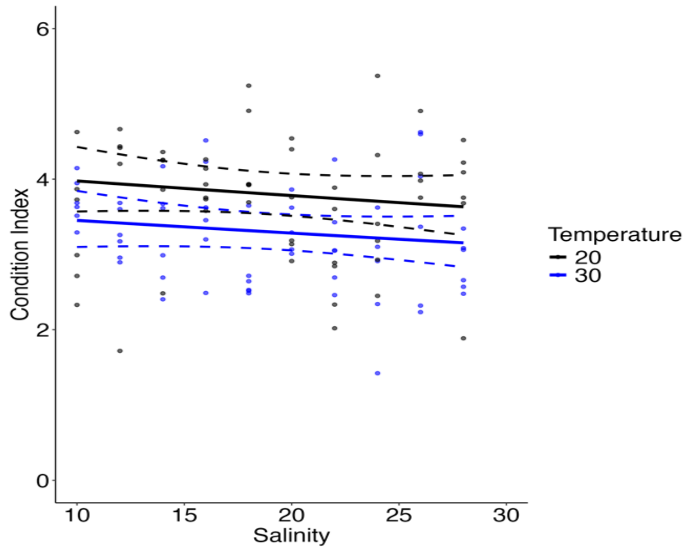

Figure 27: Condition index of oysters from a range of salinities (10 to 30) at two different temperatures (20 and 30°C) 20°C is indicated by black, and 30°C is indicated by blue. Points indicate the condition index of a single individual. Solid lines represent the best fit generalized linear model, and the dashed lines are the 95% confidence interval for the model

3.2.3 Carry-over effects of larval culture salinity

Introduction

Anthropogenically induced environmental change has placed significant pressure on estuarine ecosystems and in many cases, has been a large contributor to population declines of important estuarine species, such as oysters. Restoration programs focused on severely depleted oyster populations in estuarine environments are using hatchery-sourced animals to supplement low levels of wild recruitment. However, carry over effects, when early life experiences affect later life responses, are well known to affect the success of cultured individuals in the wild. Since hatcheries strive for consistent and stable culture conditions, carry over effects from their larval environment may affect the physiological performance and success of post-metamorphosed oysters transplanted into variable, estuarine systems. The objective of this study was to investigate carry-over effects on larvae exposed to a range of salinities, which is an important environmental stressor on natural populations.

Methods

Oyster larvae were grown across a range of salinities (10, 12, 14, 16, 18, 20, 22, 24, 26, and 28 ppt) through metamorphosis. Oysters were set in their larval culture salinity treatment and then acclimated to ambient flow-through salinity over a 2-day period post-metamorphosis. Post-metamorphosed oysters were grown in the FSUCML shellfish hatchery until all treatments measured >1mm, and then oysters were placed in floating aquaculture cages and transplanted onto two field sites with different average salinities. Bags were cleaned every 10-14 days. After a 3-month field period, oysters were brought back into the lab for physiological measurements including respirometry trials and growth and condition index measurements.

Larval culture salinity could be an important factor in growth performance immediately post-metamorphosis, which is a highly vulnerable time for oysters being transplanted into natural systems, and on later physiological performance. Long term physiological performance of animals depended on both the early culture environment and the subsequent field conditions. Because of the interaction of culture conditions and transplant site conditions, care should be taken to select culture conditions that match those at target relocation sites.

Results

Larval culture salinity had a significant relationship with larval performance metrics, including larval growth rate (G_{-2} = -0.000048, P < 0.001), survival (G_{-2} = -0.514, P = 0.0007), and development to competency (G_{-2} = -0.286, P < 0.001). Corresponding performance peaks in larval survival and proportion competent larvae combined with fast growth rates at those salinities indicate a physiological optimum for the larvae in mid-range salinities.

After settlement and metamorphosis, larval culture salinity significantly affected post-metamorphic growth rate during the first growth sampling period in a common environment, up to 30 days post-metamorphosis (G_{-2} = -0.0002, P = 0.0007; Fig.28). However, after 30 days post metamorphosis in a common environment, larval culture salinity no longer significantly affected post-metamorphosed oyster growth rate (G_{-1} = -0.000019, P = 0.73). This trend continued through the field grow-out period, and larval culture salinity did not significantly affect oyster growth rates in the field (G_{-2} = 0.002, P = 0.07). Oyster growth rates in the field were significantly affected by site (G_{-1} = -0.0053, P = 0.0002), but no significant interaction between larval culture salinity and outplant site was found (G_{-2} = -0.0006, P = 0.45). After the field grow out, larval culture salinity did have a significant effect on oxygen consumption rates of oysters (G_{-3} = -3.77, P = 0.036). Field site also significantly affected oxygen consumption rates (G_{-2} = -3.07, P = 0.031), and a significant interaction was present between larval culture salinity and outplant site (G_{-1} = -2.89, P = 0.011). Analysis showed the early larval salinity environment interacted with the outplant site environment to shape oxygen consumption in post-metamorphic oysters even after 4 months of no longer being cultured at the larval treatment salinities.

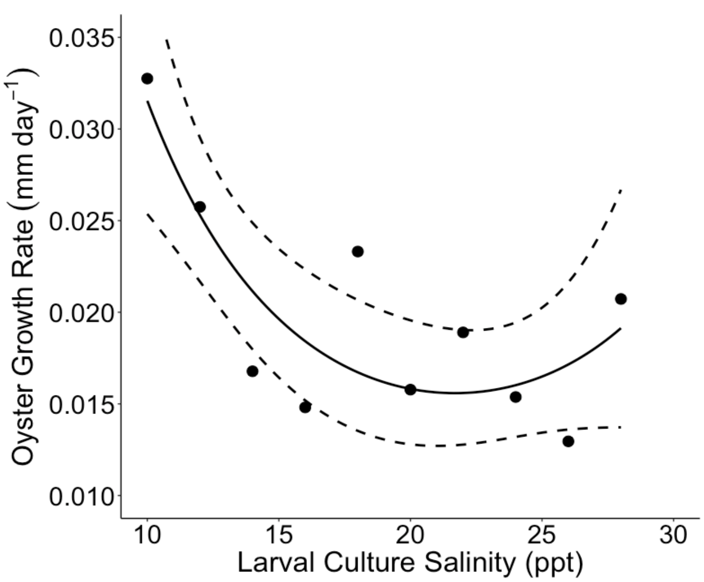

Figure 28: Effect of larval culture salinity (ppt) on early post-metamorphosed oyster growth rate (mm day^{-1}) before 45 days. Points represent average post-metamorphosed oyster growth of each treatment. Solid line represents best fit glm, and dashed lines are calculated 95% confidence interval of the model.

Condition index of oysters was also significantly affected by larval culture salinity (G_{-3} = -22.31, P < 0.001; Fig. 29) and outplant site (G_{-2} = -19.01, P < 0.001; Fig. 29), with a significant interaction between the two fixed effects (G_{-1} = -4.95, P = 0.005; Fig. 29).

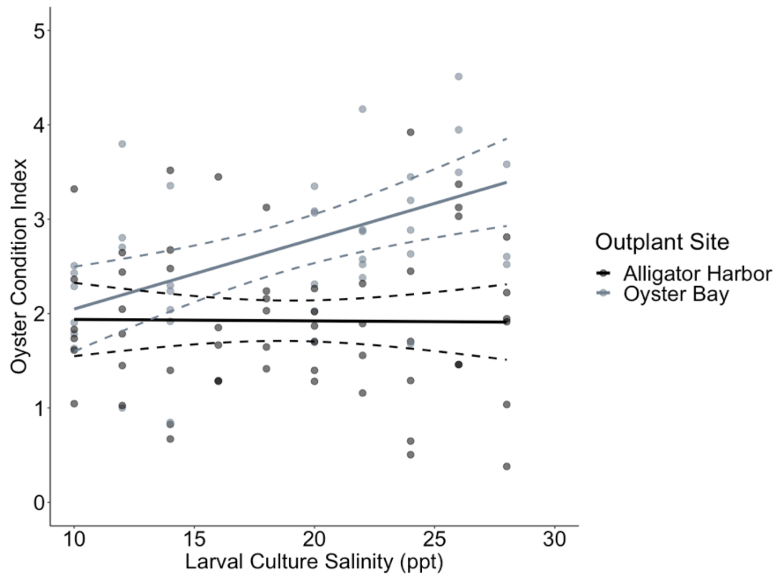

Figure 29: Effect of larval culture salinity (ppt) and field site on condition index of oysters. Colors indicate different field sites (Alligator Harbor in black, and Oyster Bay in gray). Points represent condition index of individual oysters in each treatment. Solid line represents best fit glm, and dashed lines are the calculated 95% confidence interval of the model.

Future work. During the 2025-2026 period, work on carry-over effects will continue, including work on parental effects and how matching or mismatching culture to field environment affects oyster physiological performance.

3.3 Improving restoration success in the bay scallop (Morgan Hawkins, Ph.D Candidate, FSU)

Introduction

Bay scallops (*Argopecten irradians*) are commercially and ecologically important bivalves that are equipped with 40+ light detecting eyes, swim freely, and grow to reach market size in 10-12 months. In the 1950s, the bay scallop fishery was popular, as fishermen in Florida harvested an average of 250,000 pounds of *adductor muscle* per year (NOAA Commercial Fisheries Landings). Over time, populations began to decline due to poor water quality, loss of seagrass habitat, and overharvesting. In 1996, Florida legislators banned commercial harvest of bay scallops indefinitely. Since then, bay scallops have only been available for recreational harvest, which increased the popularity of "scalloping", the practice of collecting scallops by hand while snorkeling in seagrass meadows. In 2018, revenue from this sport exceeded 1.8 million dollars in Steinhatchee, with both locals and tourists from 16 states participating (Granneman et al. 2021). Take limits and shortened scalloping seasons have been imposed to limit overharvesting. However, even with management, the fishery has been suggested to be unsustainable in Steinhatchee, a site known to be the source population of larval recruitment and genetic diversity for the Florida population (Granneman et al. 2021). The continuous decline of bay scallops suggests there are insufficient numbers of reproductive adults to replenish depleted populations. As density dependent broadcast spawners, their reproductive success depends on a close proximity to a conspecific. Challenged with years of suboptimal recruitment, and lack of ongoing population surveys, bay scallop restoration and management optimizations are essential in delaying the loss of this unique bivalve in Florida's seagrass meadows. Restoration aquaculture is a technique used by conservations to increase spawner densities in recruitment limited areas and aid population recovery efforts. Bay scallops are collected from the wild, spawned in a hatchery, and raised until a certain growth milestone is reached. One of the biggest challenges in restoration aquaculture is the release of cultured animals into the wild. Since these animals are raised in controlled environments, they develop plastic responses suited to stable conditions, which may not translate well to the unpredictability of natural habitats. These physiological, morphological, and behavioral differences can cause long lasting effects to cultured animals, leading up to 90% mortality of hatchery-raised scallops before reaching their reproductive stage (Arnold et al. 2005, Bell et al. 2005, Seyoum et al. 2003). With an immense investment in time and funding to produce offspring in the hatchery, more importance should be placed on enhancing survival upon release. Surprisingly, there is relatively little information regarding the physiological and morphological differences between wild and hatchery raised bay scallops. Understanding these differences will give scientists and conservationists insight into explaining hatchery bay scallops' high mortality rates. This information can then be used to optimize restoration aquaculture for example, by changing culturing techniques or implementing acclimation periods.

Objectives

1. Identify any morphological differences in hatchery compared to wild spat.
2. Identify differences in survivability and growth rate of hatchery raised bay scallops compared to wild bay scallops overtime.
3. Investigate the differences/similarities in condition index, gonadal index and shell breaking strength between wild and hatchery raised bay scallops (See previous 2023-2024 Annual report)

Methods

To complete the above objectives, wild bay scallop spat were captured from spat traps deployed on Nov. 21st, 2022, and Dec. 9th, 2024 in Turkey point shoal. Conducting this experiment twice over two different years helps account for culture variability, ensuring more reliable results. The 2025 component of this study is still ongoing. 34 spat traps were removed and processed on Feb. 14th. 2023, yielding 235 wild spat ranging from 3mm-14mm. In 2025, 35 spat traps were removed on Feb. 17th., yielding 28 wild spat ranging from 1mm-9mm. These juveniles were housed at the FSUCML hatchery for 48hrs while being measured and paired with hatchery spat. Hatchery spat resulted from 30 wild bay scallop parents during a spawn on Nov. 2nd 2023 and the culture set on Nov. 17th, 2023. In 2025, hatchery spat were from 28 wild bay scallop parents spawned on Dec. 6th and set on Dec. 12th. Their husbandry consisted of daily water changes, live algal feed ranging from 150K- 250K depending on age and were weaned off the live algae diet a few weeks before deployment. Each individual was measured for length, width, depth, and weighed with a microbalance. Hatchery spat and wild spat were placed in separate 1.5mm spat bags and then placed in a 18mm mesh aquaculture bag placed inside a bottom cage in Turkey point shoal (SAL- 23 2415-SR), a seagrass meadow known to house native bay scallops. In 2025, the site is now located on Dog Island Shoal, in hopes to avoid wild oysters set during the study. The Turkey Point shoal site was visited monthly for sampling and cleaning. The sampling consisted of pouring the contents of the bags onto a white tray with a ruler placed in the middle. Images of the scallops were taken with an iPhone 13 Pro Max and processed on Image J. Shell areas were measured to calculate gross growth rates, and survival was scored over time. Undesirable contents (dead shell, crabs, snails) were removed during the cleaning process. These methods are the same for the 2025 Dog Island site. Once the paired scallops reached reproductive maturity in October 2023, they were returned to the lab on 10/09/2023 for condition indexing, gonadal indexing, adductor indexing, and shell breaking strength comparisons. Wet weights of shell, total tissue, gonad, and adductor muscle were recorded using a microbalance. Prior to breaking the shells of the scallops, pictures were taken with an iPhone 13 ProMax 32 with a nearby ruler to measure final shell area using the image processing software, ImageJ. Using a tensile strength testing device, shell breaking strength was recorded for each individual. Then, samples were placed in a drying oven for 1 week, and all measurements were recorded for a dry weight.

Results and Discussion

Initial length, width, depth, and weight measurements have been completed for the 2023 and 2025 component of this study, completing objective 1. Hatchery scallops initially weighed significantly less than their wild counterparts in both years (2023: n=126, F=8.383, P=0.00412) (2025: n=28, F=7.695, P=0.00759) (Fig. 30). This is a key finding that may help explain why releasing juvenile hatchery bay scallop spat into the wild is widely unsuccessful. Less weight may be correlated to a thinner shell, or less tissue mass, indicating a plastic response from artificial culturing conditions that impacts success in the wild. Hatchery-raised juveniles may be more vulnerable to predation due to thinner shells or fewer internal reserves, making it harder to withstand environmental variability. This result suggests allowing hatchery juveniles to acclimate to the wild environment by placing them in grow-out cages prior to release could be a strategy to increase survival.

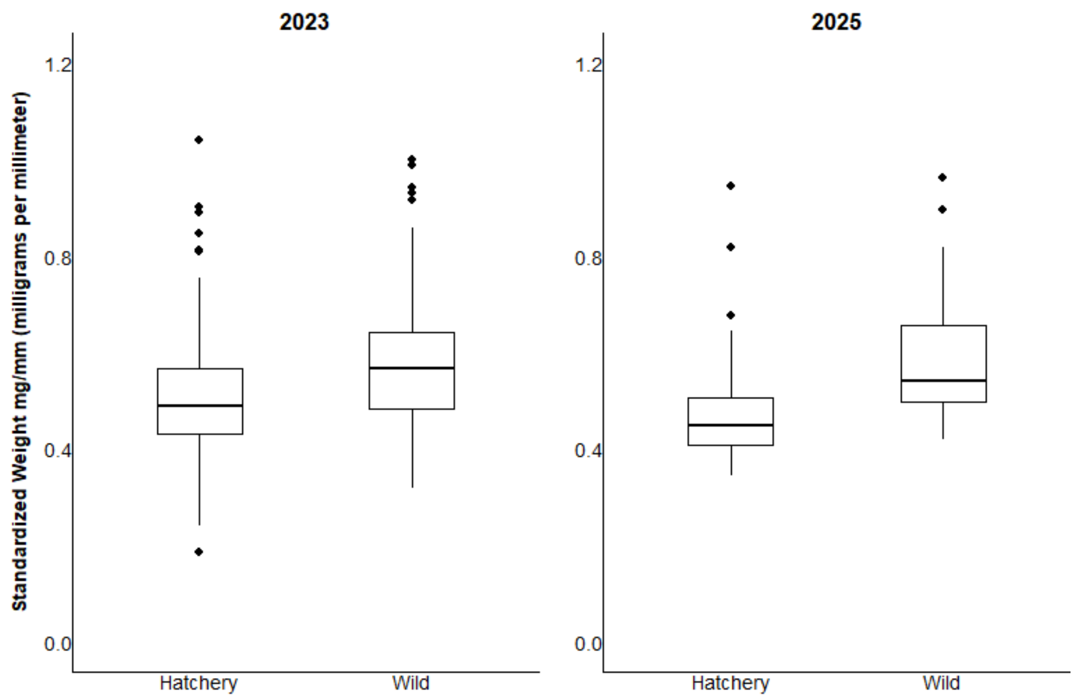

Figure 30. Standardized weight of juvenile bay scallop spat sourced from the FSUCML Research Hatchery and locally wild captured spat from deployed spat traps in both 2023 (left) and 2025 (right) years.

Survival graphs for the 2023 study have been completed to address objective 2. ImageJ analysis is still underway for the growth aspect of the study. The current study in 2025 is still being monitored. Survival was consistent between hatchery and wild bay scallops for a few months, until hatchery scallops underwent a large drop in survival as water temperatures peaked in August and September (Fig. 31). Further statistical analysis will be performed in 2025 to infer if these differences were significant.

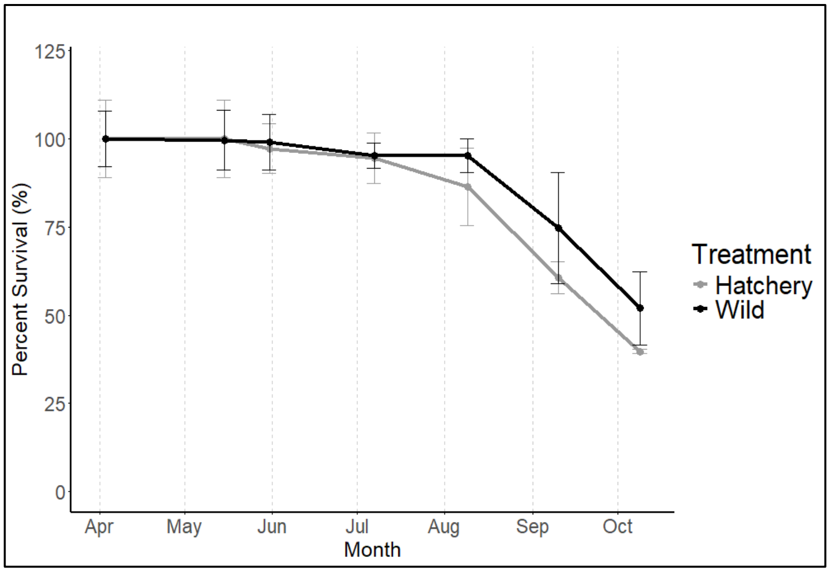

Figure 31. Percent survival of hatchery and wild scallops through time in 2024. Each treatment consisted of two replicates. Error bars represent standard deviation.

Results addressing objective 3 were reported in ABSI annual report 2023-24. In summary, there were no statistical differences among condition index, gonadal index, adductor index, shell weight, or shell breaking strength between hatchery and wild bay scallops. This evidence further suggests hatchery bay scallops can perform equally to wild bay scallops, if given proper acclimation time to the environment. Initially, juveniles seemed less adapted to life outside controlled hatchery conditions. However, after a grow-out period in predator exclusion cages, hatchery-raised scallops adjusted to natural conditions and began resembling their wild counterparts.

Future Directions

The insights gained from this experiment will drive continued advancements in bay scallop restoration aquaculture, optimizing techniques for long-term success in this region. In 2024 a bay scallop production spawn produced 100,000 bay scallop spat to be used in a subsequent investigation of hatchery bay scallop dispersal, growth, and survival when free planted into restoration plots on Dog Island Shoal. This novel research study has built upon this work by ensuring a shortened nursery grow-out phase that works to promote less plastic responses to artificial environments. This study also releases scallops at a predator refuge size of 30mm, before the stage where large die-offs were present in the 2023 grow-out process. Bay scallops during August and September were heavily covered in oyster spat, ascidians, and barnacles. These hitchhikers as well as the increased stress due to increased summer water temperatures could have led to high mortalities in both wild and hatchery cages. Therefore, as a free-swimming bivalve, bay scallops should be released from cages to limit stress influenced mortalities. The 2025 study will monitor the release of scallops immediately upon release, allowing scientists to better understand their behavior and causes of mortality at this stage.

3.4 Apalachicola Bay System Report Card (Dr. Josh Breithaupt, FSUCML Faculty)

Introduction

Ecosystem health" is a seemingly simple idea that masks the fact that ecosystems are dynamic and variable in time and space, and assigning degrees of health can be influenced by subjective assessments that give undue weight to a single indicator, lack of objective targets related to regulatory or consensus, spatially or temporally biased data collection, a mismatch in data availability for all indicators, as well as other challenges. However, the concept is useful insofar as it suggests the notion of a holistic, multi-disciplinary, multi-interest approach to observing ecosystems and evaluating their dynamic processes (Lancaster 2000). Creation of local ecological report cards is one approach that has been applied in numerous restored estuaries recovering from compromised ecological function. Dr. Breithaupt at FSU's CML is conducting a review of coastal water body report cards throughout Florida, the US, and the world to identify: 1) the variables that are tracked, 2) the stakeholders and process involved in deciding on a manageable number of variables that are meaningful to each ecosystem, 3) the data collection entities, 4) the frequency of report card production, 5) the spatial and temporal resolution of the reporting units, and 6) the logistical processes of collecting, standardizing, and evaluating the data in a way that can be understood by all stakeholders.

Work conducted thus far has focused on reviewing existing report card efforts for other coastal regions to understand their creation process and intended purposes. In the last decade, the use of Report Cards has increased substantially all around the world. Table 1 provides several examples potentially most relevant to the Apalachicola Bay system from the US. Each system is unique in terms of the size of the monitored area, the purpose of the effort, and the indicators that are used for reporting. Some report cards are developed and coordinated by an outside consulting group like the University of Maryland's Center for Environmental Studies Integration and Application Network (e.g., the Chesapeake Bay & Watershed Report Card) but others are developed and coordinated by local stakeholders (e.g., the Indian River Lagoon's Marine Resources Council).

Table 1. Examples of report cards for coastal systems in the United States, their size, and stated purpose.

Location	Watershed + Bay Area (Sq. miles)	Purpose/Objectives
Indian River Lagoon, FL https://lovetheirl.org/2024-report/	2,637	"an annual health assessment of the Indian River Lagoon (IRL)"
Sarasota Bay Estuary Program, FL https://sarasotabay.org/our-estuaries/report-card/	202	"Every year, we create an Ecosystem Health Report Card to track conditions in each of our five bay segments. This report card is intended to guide and prioritize monitoring and management actions; it is not a regulatory tool."
Chesepeake Bay , USA https://ian.umces.edu/publications/2023-2024-chesapeake-bay-watershed-report-card/	64,000	"Socio-environmental report cards are co-developed in collaboration with local stakeholders. They are proven tools for measuring social, environmental, and economic health, and create social capital through the collaborative process used to create them."
Maryland Coastal Bays, USA https://mdcoastalbays.org/the-programs/science/report-cards/	175	"Coastal Bays health is defined as the progress of four water quality indicators (nitrogen, phosphorus, chlorophyll a, dissolved oxygen) and two biotic indicators (seagrass, hard clam) toward scientifically derived ecological thresholds or goals."

Tampa Bay Estuary Program, FL, USA https://tbep.org/water-quality-report-card/	2600	"an evaluation method was developed to assess whether load reduction strategies are achieving desired water quality results. Tracking the attainment of bay segment specific targets for these indicators provides the framework for developing and initiating bay management actions."

An important common lesson stated in many of the development documents for report card projects around the world, is the importance of having input from stakeholders in the selection of the ecosystem indicators that will be used for evaluation and scoring. This process frequently identifies a mismatch between indicators that are unanimous important but that lack a critical element that will allow them to be used; examples of the problems include lack of proper spatial or temporal coverage of data collection, lack of known actionable responses that can meaningfully change the outcomes either because of lack of knowledge or scale of the problem, and lack of informed thresholds either via regulatory or recognized science values. Table 2 provides an example of the wide range of indicators that can be used for evaluating water quality; it should be noted that many report cards recognize that a water body cannot be graded in isolation from its watershed, so there are several report cards that have separate reporting products for the water and the watershed. Tampa Bay provides a particularly interesting report card process – they collect a very wide variety of data types, but ultimately their report card is most focused only on two key indicators (chlorophyll-a and light penetration) as indicative of nutrient loading and seagrass health. This seems like a particularly important lesson for Apalachicola Bay to consider – there are likely to be many stakeholders with different indicators that they would like to see tracked and reported, but without strong consensus and clear goals, such widespread efforts can lead to an unwieldy and costly effort that may not be effective.

Table 2. Examples of coastal report cards, their size, and stated purpose.

Location	Indicators
Indian River Lagoon	harmful algae, seagrass coverage, sediment health, wastewater spills, and water quality
Sarasota Bay Estuary Program	Total nitrogen, Chlorophyll-a (phytoplankton), Seagrass meadows, Macroalgae
Chesapeake Bay	Total phosphorus, total nitrogen, dissolved oxygen, benthic community, water clarity, chlorophyll-a, aquatic grasses, fisheries index
Maryland Coastal Bays	Water Quality: dissolved oxygen, nitrogen, phosphorus, chlorophyll-a Biotic: seagrass, hard clams
Tampa Bay Estuary Program	Many measurements, but two indicators: Chlorophyll-a and Light penetration

A secondary part of the report that is being prepared will evaluate how many of these data types are already collected for Apalachicola Bay and where there may be data gaps. Deliverables at the end of the project will be a review of report card creation processes and a road-map for implementing an ecological report card for the Apalachicola Bay region. The review document will make suggestions, but ultimately will only be a guide to help the Partners for a Resilient Apalachicola Bay start the processes of implementing something like a report card product as a long-term regional tool for evaluating ecological, economic, and cultural well-being of the ABS region.

4. Coupled life history modeling

4.1 Larval Dispersal and Predictive Habitat Suitability modeling - Adam Alfasso, Ph. D Student

Introduction:

Habitat Suitability models (HSM's; also known as Indices , HSI's) are spatially explicit representations of the effects of these environmental factors on the survivability of an individual species, expressed as quality of habitat(Cake 1983, Roloff & Kernohan 1999, Linhoss et al. 2016). When properly constructed and validated, HSM's have been shown to be robust, flexible decision support tools, and can be used to guide habitat restoration efforts to maximize the probability of restoration success(Theuerkauf & Lipcius 2016, Silva & MacDonald 2017, Theuerkauf et al. 2021). The goal of this research is to construct a series of spatially explicit models that describe and evaluate the effects of changing environmental conditions on habitat suitability in Apalachicola Bay for the eastern oyster (*Crassostrea virginica*).

Certain applications of HSM's are capable of incorporating biological datasets, and project future distributions under hypothetical climate change scenarios (Thuiller et al. 2016, Hao et al. 2019, Khan & Verma 2022). The spatial distribution of most benthic populations of marine systems is connected through the dispersal of its early life stages (Cecino & Treml 2021). Population connectivity can drive both ecological and evolutionary processes (Cowen & Sponaugle 2009), and the dispersal pathways that link populations drive recruitment dynamics which can affect the ability of populations to recover (Balbar & Metaxas 2019). A growing number of studies have successfully linked the outcome of biophysical modelling with empirical data (Lett et al. 2010, Arnold et al. 2017). We will therefore be using the outcomes of such a model to incorporate the impact of the mobile life stage of the oyster and the impacts of larval connectivity into our habitat suitability modelling efforts.

Objectives

From March 2023–March 2024, our work addressed three objectives:

1. To incorporate of experimentally derived larval growth and mortality functions for salinity and temperature tolerances of locally adapted oysters into the bio-physical model of Apalachicola Bay.
2. Analyze reef source-sink dynamics and connectivity under the three derived climate scenarios.
3. Generate larval biology datasets for inclusion into a habitat suitability model.

Methods

The individual based model constructed by Dr.'s Morey and Chen was further refined to include updated salinity growth/mortality curves, as well as temperature-based growth and mortality (Fuqua and Brooke in review). The model assumes a 20-day larval duration, with an additional 20% daily mortality. The agents were allowed to grow from larvae (0.04m) to competent settlement size (0.225mm), at which point they fell from the water column. If a larvae landed within a reef area, they were considered to have survived; otherwise, they were considered 'dead'.

The surviving individuals were used to calculate larval survival, larval retention, source/sink designation, source/sink diversity, and connectivity matrices. Current analyses were conducted using a 1km grid. Survival in each cell is calculated as the total larvae that survived to settle from the original larvae that were released from the cell. Larval retention is calculated as the total ratio of larvae that settle within its originating cell. Designation of source and sink is calculated as the difference in each cell between total surviving larvae supplied to the system and total larvae that settled within the individual cell. Source Diversity is calculated as the percent of unique sites that a cell contributes particles to, while Sink Diversity is calculated as the percent of unique sites from which the site receives particles. Connectivity between each cell was calculated the sum of all unique reefs each cell supplied to and was supplied by, standardized over all possible reefs. This was evaluated both between individual cells via a connectivity matrix, and as an overall measure between local retention and total larval immigration. For the matrices, individual cells were further combined into larger cohesive reefs that exhibit both spatial proximity and similar connectivity measurements, such that inferences of connectivity between 'reef connectivity' can be made.

Preliminary Results and Discussion

From initial releases of 1.225 million larval agents, Spring and Fall of 2019 had 58% and 62% survival, Spring and Fall of 2012 had 63% and 56% survival, and Spring and Fall of 1998 had 55% and 52% survival. Spatial patterns suggest that under 'normal' climate conditions larval survival in the eastern portion of Apalachicola Bay is generally high in both seasons, with the western portion of the Bay showing a decrease in survival in the Fall season (Fig. 32). Figure 33 suggests that both Spring climate scenarios show a net decrease in survival in immediate adjacency to the river mouth, with slight increases as you move outwards towards the Gulf. The southern end of St. Vincent Bar particularly shows marked decreases under the 'wet' scenario. Figure 34 indicates that the Fall season in a 'dry 'scenario shows marked decreases in survivability throughout the Bay, while the wet scenario shows decreases in direct line of flow from the river and increases in the farther eastern and western portion of the bay. The connectivity matrices for the Spring season show a general trend of mixing within reef complexes with some connectivity to adjacent reefs, while the Fall season shows a general shift of increased larval settlement westward (Fig. 35).

The incorporation of temperature growth and mortality metrics altered the survival patterns in the Bay from the salinity-only model, suggesting that while salinity is likely the most influential environmental variable, it is important to include other variables to fully understand the impacts of local conditions on survival. The impact of drought conditions on larval survival has been hypothesized to have been one of the factors repressing the recovery of the oyster population's following the crash in 2011. It is interesting to observe that an anomalously wet year can be as detrimental to larval survival as a drought, yet in the Fall season there are reefs that seem to perform better than the climatological norm. The connectivity matrices also suggest there are regimes in connectivity patterns between seasons. In the Spring, the larvae from the east and west tend to remain in their locales, with larva from the middle of the Bay spreading in both directions as well as south with the river outflow. In the Fall however, the prevailing winds and currents advect larvae to the west, leading both to lower survival rates of larvae from the west-most reefs and to greater connectivity from the west to the east (Fig. 36).

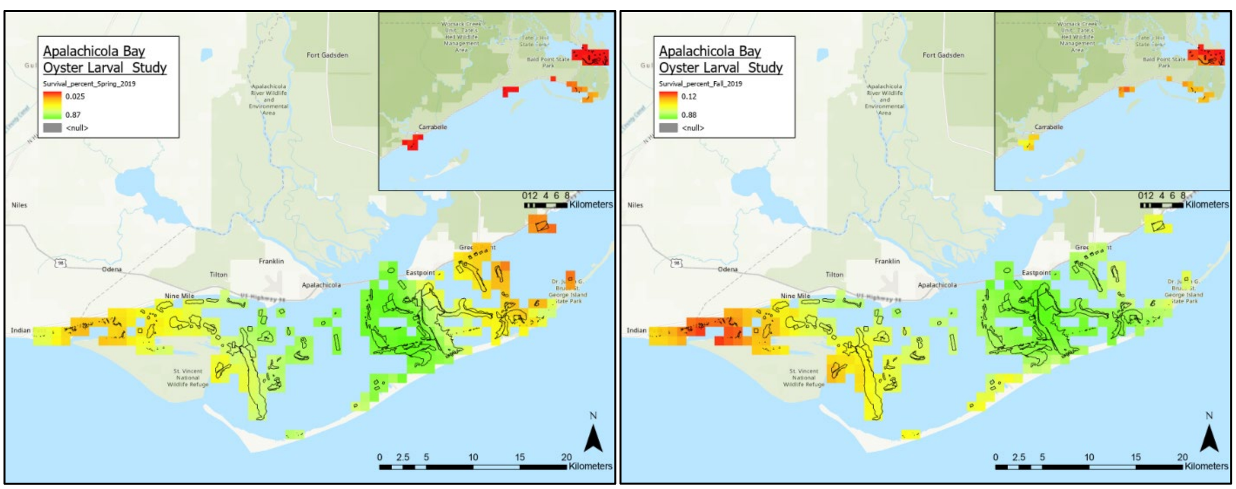

Figure 32. Oyster larval survival percentage in Apalachicola Bay for Spring (left panel) and Fall (right panel) of 2019 ('normal' river flow). Green indicates high survival, red indicates low survival.

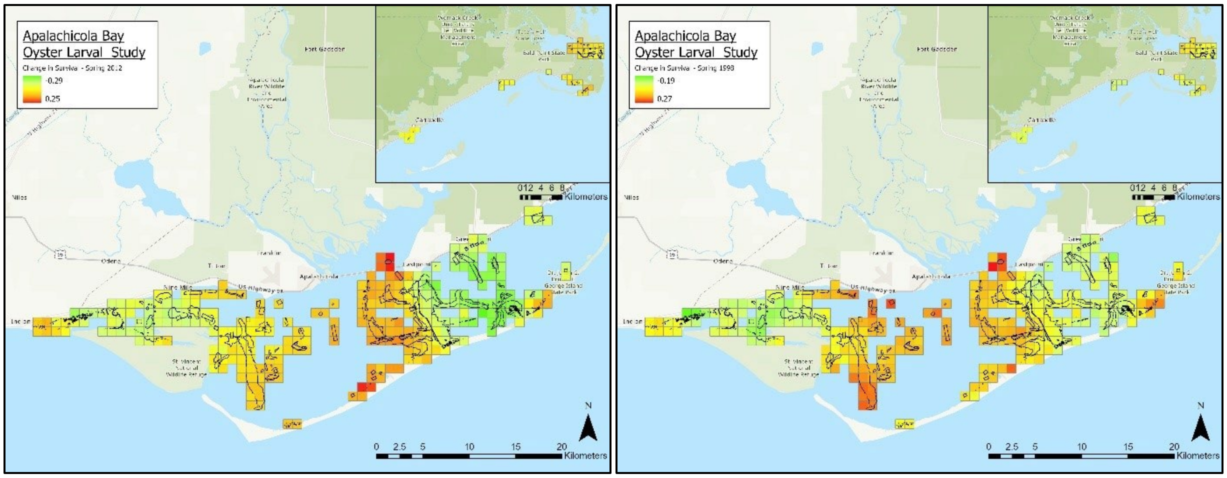

Figure 33. Visualized percent change in Spring larval survival between climates scenarios. The left panel is the difference between Spring 2019 and Spring 2012 (normal vs. dry), and the right panel is the difference between Spring 2019and Spring 1998 (normal vs. wet). Green indicates a net increase, red indicates a net decrease.

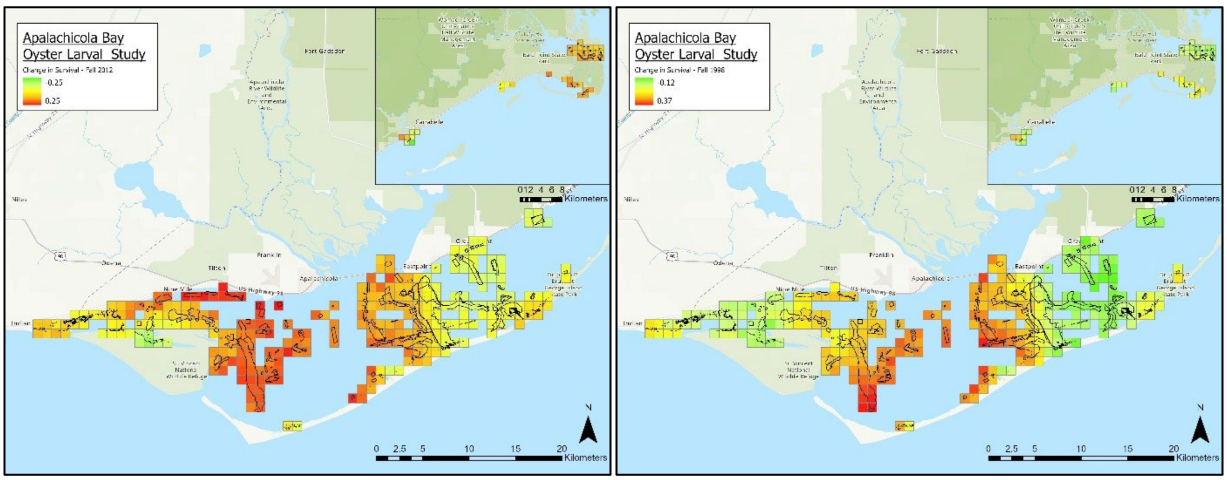

Figure 34. Visualized percent change in Fall larval survival between climates scenarios. The left panel is the difference between Fall 2019 and Fall 2012 (normal vs. dry), and the right panel is the difference between Fall 2019and Fall 1998 (normal vs. wet). Green indicates a net increase, red a net decrease.

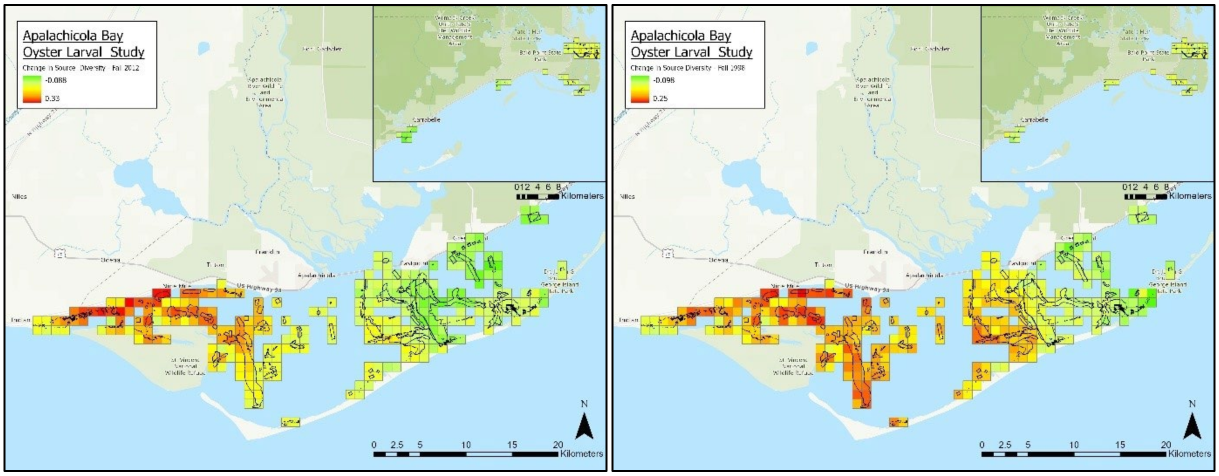

Figure 35. Visualized percent change in Fall Source Diversity between climates scenarios. The left panel is the difference between Fall 2019 and Fall 2012 (normal vs. dry), and the right panel is the difference between Fall 2019and Fall 1998 (normal vs. wet). Green indicates a net increase, red a net decrease.

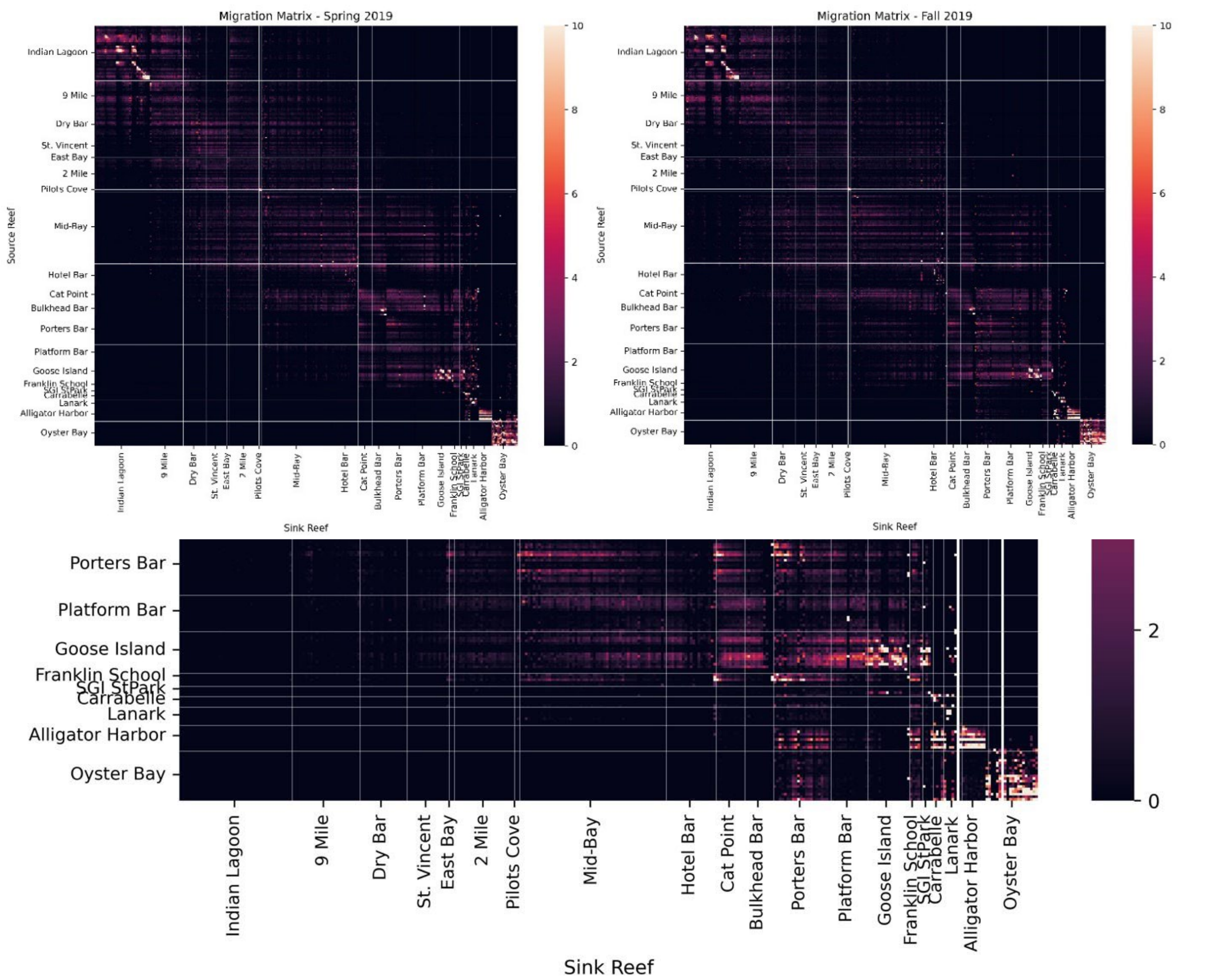

Figure 36. Connectivity matrix of modelled successful larval exchange among conglomerated analysis sites

for eastern oysters in Apalachicola Bay and neighboring environments. Each element in the matrix shows the proportion of total settlement in each destination reef (columns) from each source reef (rows). Reefs are ordered from west to east, beginning in Indian Lagoon and ending in Oyster Bay. Local retention can be seen on the diagonal, with light colors representing higher percentage, and darker colors lower. Bottom inset highlights Fall 1998, showing larval settlement from Oyster Bay reaching Porters Bar, a pattern not replicated under other climate scenarios.

Future Work

In 2025-2026, datasets of larval survival, larval supply, and reef connectivity will be used as biological predictor variables in the construction of the habitat suitability models. The changes between the seasonal can will be evaluated to examine how adult oyster distributions may be influenced under extreme climate scenarios.

5. ABSI Research and Restoration Hatchery (ABSI Hatchery Team)

5.1 Hatchery accomplishments

Construction of the permanent facility concluded in 2022 and since then efforts to optimize cultures of algae, larvae, spat, and maintenance of broodstock has been initiated to improve yields. The most important additions outlined in previous reports include 1) Insulation of the facility with HVAC additions in 2023, allowing for the maintenance of temperature which was impacting success in the early establishment of the hatchery. 2) Installation of a heat pump semi-recirculating system in 2023, which also works to maintain flow-through nursery system water temperatures in grow-out periods. 3) The establishment of the algal production facility in 2023, allowing for the cultivation of live algal ratios instead of previously used algal paste. 4) Installation of 15 replicated 170L conical tanks (sloped bottom) in 2023 for proper replication when conducting larval experiments.

In 2024, the hatchery continued completing additional projects to advance production. To increase larval rearing success, the hatchery replaced the original larval rearing tanks.

Anecdotal evidence suggested a negative reaction to the original plastic tanks, influencing the purchase of four large fiberglass tanks with conical bottoms to facilitate faster drain downs and limit the accumulation of debris on the tank bottom. Additionally, the addition of nursery seed bottles, which act as elongated up-wellers, were installed to increase capacity for the grow-out of oyster seed. This addition allows for the production of individual oyster seed, which is vital for ongoing research projects. To address issues experienced with water quality and the removal of fine sediments, the hatchery removed old mechanical filtration filters using bag filtration and exchanged them with a large sand filter. The sand filter enables for a faster, more efficient removal of waste entering the facility, saving technicians time.

In the algae facility the hatchery has created new protocols to limit foreign contaminants in live algal cultures. During work investigating the use of probiotics by M. Hawkins, the algae production system was exposed to predatory ciliates, which antagonized algae and larval and early spat stages of animals, causing algal cultures to crash and increased animal mortality. This contamination proved to be a widespread and common problem in hatcheries in general, and the hatchery sought advice about contamination problems with multiple algae specialists. The hatchery focused much of the 2024 year refining algal facility methods to ensure the highest quality feed was being used for production. The hatchery now uses sub-micron filtered seawater that has been sterilized with chlorine before entering the production system. The water delivery system and flooring are sterilized daily to prohibit intrusion of ciliates. The algae facility also has optimized algae counting by purchasing a cell counter in lieu of hand counting. This product saves employee time and produces accurate cell counts for calculating algal densities for feeding shellfish. This improves not only the efficacy of the hatchery but also allows for accuracy when reporting results in scientific publications.

Production of larvae during the 2024-2025 year was variable. Spring 2024 larval production was marked by highly variable development and survival rates of larvae, spurring detailed sampling and partnership with the Bivalve Hatchery Heath Consortium (BHHC), to investigate causes of larval culture failure. In the fall of 2024, the fall oyster larval season ended early due to the frequency and severity of the hurricanes that made landfall on Florida's west coast. Below, table 1 describes the cultures attempted and completed during 2024.

Date	Species	Initial larval count (Millions)	% Survival (Final larvae/ Initial larvae)	Culture Note
3/31/2024	Hard Clam, *Mercenaria Mercenaria*	11.2	35.6%	Probiotic experiment - Did not complete metamorphosis due to ciliates
4/1/2024	Eastern Oyster, *Crassostrea virginica*	3.4	0	High larval mortality
4/3/2024	Eastern Oyster, *C. virginica*	15.5	0	High larval mortality
4/21/2024	Eastern Oyster, *C. virginica*	9.8	23.2%	Probiotic experiment - Completed metamorphosis
4/21/2024	Eastern Oyster, *C. virginica*	11.2	0	High larval mortality
4/30/2024	Eastern Oyster, *C. virginica*	44.3	7%	Production - Completed metamorphosis. High larval mortality
5/9/2024	Hard Clam, *M. Mercenaria*	2.8	76%	Probiotic experiment - Completed metamorphosis
5/20/2024	Eastern Oyster, *C. virginica*	27.0	0	Experienced developmental delays
5/27/2024	Eastern Oyster, *C. virginica*	16.3	0	Experienced developmental delays
5/30/2024	Eastern Oyster, *C. virginica*	5.0	0	Experienced developmental delays
6/13/2024	Eastern Oyster, *C. virginica*	7.7	0	BHHC sampling - experienced developmental delays
6/20/2024	Eastern Oyster, *C. virginica*	3.5	0	BHHC sampling - experienced developmental delays
9/9/2024	Eastern Oyster, *C. virginica*	7.7	0	High larval mortality

9/12/2024	Eastern Oyster, *C. virginica*	14.9	0	High larval mortality
12/04/2024	Bay Scallop, *Argopecten irradians*	5.05	72%	Hawkins experiment - Completed metamorphosis
12/16/2024	Bay Scallop, *A. irradians*	9.96	60%	Hawkins experiment - Completed metamorphosis

Bivalve Hatchery Health Consortium Collaboration

Due to the severity of larval culture crashes in the spring, the hatchery collaborated with the BHHC to investigate potential causes. The BHHC is a free health diagnostic program run by the University of Rhode Island (URI) who is gathering samples around the globe from shellfish hatcheries to identify potential culprits of larval crashes. The hatchery sent samples of water, larvae, and algal feed from two oyster cultures and one bay scallop culture (see table 1) through the larval lifespan. These samples undergo sequencing, histology, bacterial assessments, and mass spectrometry to determine what parameters may have led to the larval crashes. Preliminary results indicate some of these crashes may have been associated with transient heavy metal contamination in water. Additionally, initial bacterial tests indicate larval crashes were not caused by harmful bacteria–specifically *Vibrios* spp. or *Pseudoalteromonas* spp.--during this time. The remaining samples provided to URI are being analysed presently, therefore, the results of these assessments are not complete. Further tests include mass spectrometry, which will indicate if cultures were ongoing during any harmful algal blooms. These results will be particularly relevant to this area of Florida as during fall spawns, high concentrations of *Pseudo-nitzschia* sp. were seen in the hatchery. This algae is a known harmful algae and can produce domoic acid, which negatively affects development of shellfish larvae.

Most likely, broodstock condition, water quality, and the ambient bacterial and algae composition interacted to produce variable larval production success. The collaboration with BHHC will continue through the program's final year in 2025, where the hatchery will send at minimum two full sampling kits for diagnostics. The data will be compiled and analyzed, and all results from public research hatcheries will be published in the future.

Broodstock conditioning

To support research projects and production, the hatchery attempted conditioning for the three species of bivalves–hard clams, bay scallops, and eastern oysters. Conditioning was successful with hard clams and bay scallops, leading to the clam spawns in March and May 2024 and scallop spawns in November and December 2024. However, results of all eastern oyster out-of-season conditioning attempts were highly variable. The hatchery continues to be restricted by season for eastern oyster spawns and will need to use wild-conditioned oysters for this coming year.

Research Support

During the 2024–2025 year, the hatchery was able to provide research support to multiple projects. Hatchery facilities were used in multiple research projects outlined in the current report including work from M. Hawkins and E. Fuqua. Additionally, the research hatchery provided oyster seed for experiments focused on oyster physiology and field restoration experiments, and the algae facility produced quality live feed that supported many research projects for faculty, staff, and students.

Future work

The hatchery plans to accomplish oyster spawns for restoration experiments in Apalachicola Bay, will continue to support other ABSI research and will continue collaborating with BHHC. The hatchery will continue to optimize algal and animal culture primarily for oysters but also other species relevant to ABSI

6. Outreach and stakeholder engagement

6.1 Social-ecological exploration into the impact of oyster population collapse and fishery closure of the Apalachicola Bay (Dr. Betsy Mansfield, Post-doctoral Scholar, FSU)

Introduction

In parallel to the research conducted by ABSI, Dr. Mansfield worked to interview community members within the Apalachicola Bay region to understand the social, cultural and economic impacts of oyster population decline and fishery closure. The goal of this work was two-fold, 1) record the social and cultural impacts of foundation species loss of oysters within the human dimension of the region and 2) understand community members priorities for oyster restoration and how participating community members defined restoration success.

Methods and outcomes

To address objective 1, semi-structured interviews were conducted with 28 community members with various relationships to the historical oyster fishery. These participants included oyster fishers, seafood dealers, local business owners, guide fishing captains, and local community members with little to no direct relationship with the fishery. Questions were asked about the importance of oysters to both the individual participant, and the community as a whole, along with questions about individual and community impacts from oysters loss. From thematic analysis of the responses, we found that oysters had individual impacts within the social, economic, ecological and nutritional realms, with the greatest number of individual factors being from economic impacts. Community impacts were analyzed utilizing an ecosystem services approach, and respondents did mention noting changes in provisioning, regulating and supporting services, such as changed in water quality or reef-associated species, with varying levels of commonality. However, every participant mentioned at least one cultural ecosystem service that was negatively impacted by the oyster fishery closure and population collapse. Most common was responses regarding changes in community identity within the region, as many participants noted that the region has shifted from seafood industry reliance to tourism. Additional changes in social well-being, individual identity, and community brand were commonly noted. Results from this work highlight not only the ecological importance of oysters to this region, but also the cultural importance of the species. The full details of the results of this work can be found in Mansfield et al. (2025) in Ecology and Society.

To address objective 2, questions were asked to community members about their priorities and expectations of ongoing restoration efforts within the Bay during the previously mentioned semi-structured interviews. In conjunction with this work, a review of all restoration efforts for oysters in the state of Florida since 2000 was conducted to understand common goals, approaches, and success thresholds for these projects. The goal of this work aims to understand how restoration has been approached in the past, in terms of defining success and setting thresholds to measure it, and understand how these definitions may align, or misalign with community stakeholder's expectations. Work on this project is ongoing, with the goal of both publication of the results and the formulation of recommendations for setting restoration success metrics and thresholds in future endeavors.

6.2 Targeted outreach to the Community

With the conclusion of the ABSI Community Advisory Board in November of 2023, ABSI's targeted outreach to the community has decreased slightly. However, Dr. Sandra Brooke and Dr. Joel Trexler joined The Partnership for a Resilient Apalachicola Bay as advisory board members and continue to provide research updates to the committee members. ABSI was represented at the FSUCML Open House in April 2024, at various events throughout the Tallahassee and Florida panhandle region, and at Aquaculture 2025 – the largest aquaculture conference in the world. Finally, a new shell recycling program has been initiated and is in the early planning stages.

The Partnership for a Resilient Apalachicola Bay

The Partnership for a Resilient Apalachicola Bay (hereafter referred to as The Partnership) is the public-led successor group of the ABSI Community Advisory Board. Its mission statement and purpose are listed below.

Mission Statement: To engage state agencies responsible for the restoration and management of the Apalachicola Bay System to ensure long-term effective management and restoration strategies are implemented, monitored, and adaptively managed toward restoring and enhancing oyster reefs, fisheries management, and the health of the Bay. The Partnership is the group that will bring together management, the community, and science to ensure the long-term health of Apalachicola Bay.

Purpose: To provide a forum for agencies and stakeholders to work collaboratively to develop consensus recommendations informed by the best available science, data, and stakeholders' experiences for the restoration and management of the oyster resource and health of the Apalachicola Bay System, and to ensure there is a reliable mechanism and process for the monitoring, funding, and implementation of the ABSI CAB's Recommendations for the Apalachicola Bay System Ecosystem-Based Adaptive Restoration and Management Plan. Dr. Sandra Brooke and Dr. Joel Trexler have joined The Partnership as non-voting advisory members. Their roles are to provide background on ABSI's Community Advisory Board and the Apalachicola Bay System Ecosystem-Based Adaptive Restoration and Management Plan, and oyster research updates.

The Partnership first met on March 26, 2024, and has held nine meetings since then. Their tenth meeting will be held on March 19, 2025. A comprehensive list of the meetings, minutes, and presentations can be found here (https://www.partnershipforapalachbay.org/meetings/).

Shell Recycling – Shuck 'N Release

FSUCML and ABSI staff have partnered with the Panacea waterfront community to collect shells during their festivals. We have collected shell through participation in multiple festivals. The next step in this burgeoning program is to partner with local businesses and distributors to collect their waste shell.

Left: A festival guest empties their shell into the "Shuck 'n Release" basket.
Above: The pile of collected shells continues to grow

Public Outreach and Engagement
Last year, our outreach and engagement hit a record high! 2024 was flush with school groups, tours, field trips, and festivals. As a result, over the last year, we have engaged with over 31,560 individuals through a variety of events, which is a 37.6% increase in engagement since 2023.

FSUCML Open House
On April 20th, the FSUCML celebrated its 75th Anniversary with the return of our Open House. We welcomed over 1,500 to explore our lab's research facilities, as well as learn about our projects, as well as those from local, state, and federal environmental agencies. ABSI was prominently featured as our staff spoke with guests about the shellfish research and restoration hatchery, current intertidal and subtidal sampling data sets, reef balls and more.

Right: ABSI Technician Jazzy Jones showcases artificial reef balls

Below: ABSI Technician Haley Crawford teaches guests about the algae feeding system in the shellfish research and restoration hatchery.

Aquaculture 2025
On March 6 – 10, 2025, four FSUCML graduate students, including three who work on ABSI initiatives (M.S Student Morgan Hawkins, Ph.D. Candidate Emily Fuqua, and Ph.D. Candidate Donaven Baughman) represented FSUCML and ABSI at the Aquaculture 2025 conference. Morgan gave a presented her work on the use of commercial probiotics to increase survival and growth in hatchery shellfish larval cultures. Emily gave a talk on her research into how anthropogenic changes to the environment, such as increasing ocean temperature and increasing anoxic zones, affect an organism's physiology, and in turn, how physiological changes affect an organism's behavior and ecology. Her Ph.D. focus is on Eastern oyster health in the Apalachicola Bay system. Donaven Baughman also presented on his research in which he focuses on the impacts of predators and environmental factors on the physiological processes and allocation of energy to various important life history characteristics (e.g., growth, predation defense, and reproduction) of eastern oysters. Aquaculture 2025 is the largest aquaculture conference in the world with close to 4,000 attendees from over 90 countries.

L-R: Morgan Hawkins, Emily Fuqua, and Donaven Baughman.

School Groups
ABSI continues to be an education opportunity within public schools and homeschool collectives in Franklin, Wakulla, and Leon Counties, as well as out-of-state groups from Ohio, Georgia, and South Carolina. This year, we were also happy to welcome the Florida Indian Youth Program, the Boys and Girls Club, 4H Club, and students from several main campus departments. These programs are tailored to best

fit the age of the children participating. We have created inclusive cross-curriculum educational resources and experiences for students of all ages to help address some of the environmental issues that Apalachicola Bay faces. We hope to promote the science of the Bay and the importance of a healthy ecosystem through fun and engaging programs.

Festivals

These events are of a larger scale in which the goal is to reach as many people as possible. We brought a variety of materials (posters, lab equipment, oysters, and more) to showcase the full breadth of ABSI. The events were held throughout the Big Bend area.

Guests stop by the FSUCML tent at the Panacea Beer and Oyster Festival to learn about ABSI's research.

- 02/01/2024: FSU Day at the Capitol (Tallahassee, FL)
- 02/06/2024: FIO's Florida Oceans Day at the Capitol (Tallahassee, FL)
- 03/30/2024: Panacea Beer and Oyster Fest (Panacea, FL)
- 04/13/2024: Sopchoppy Worm Gruntin' Festival (Sopchoppy, FL)
- 04/27/2024: Carrabelle Riverfront Festival (Carrabelle, FL)
- 05/03/2024: ANERR's Estuaries Day (Eastpoint, FL)
- 05/04/2024: 12th Annual Autism OdysSea (Navarre Beach, FL)
- 08/23/2024: Involvement Fair (Tallahassee, FL)
- 10/19/2024: Tallahassee Science Festival (Tallahassee, FL)
- 11/01/2024 – 11/02/2024: Florida Seafood Festival (Apalachicola, FL)
- 11/09/2024: Sopchoppy Shells and Tails Festival (Sopchoppy, FL)
- 11/16/2024: Panacea's Blue Crab Festival (Panacea, FL)
- 02/22/2025: MagLab's Open House (Tallahassee, FL)

Free Friday FSUCML tours

These tours have continued to flourish at the FSUCML. Every Friday from 11 am – 4 pm, guests are welcome to attend a guided tour of the FSUCML. During these tours, individuals receive a detailed look at the current research being conducted by our staff, a large part of which is ABSI. This includes an overview of the Bay area and the issues that it faces. As part of the tour, individuals also get the chance to walk through our shellfish research hatchery and see oysters up close. These tours provide the perfect setting for individuals to get a glimpse of what the ABSI team does daily while providing them an opportunity to ask any questions they may have about the Bay or our role in its recovery. Since March 2024, we have had over 750 people join our tours, a 25% increase from 2023.

Hatchery Technician Louis Lockhart speaks with a group in the shellfish research and restoration hatchery.

ABSI Website (https://marinelab.fsu.edu/absi/)

The ABSI team continues to update the ABSI website with research information and ABSI leadership and staff.

Local News Coverage

The ABSI project continues to be featured in local news, however, as news is more commonly shared across social media pages, rather than formal blogs and paper mediums. Below is a list of articles and news segments from March 2024 – March 2025, but it is not exhaustive.

- The Oyster "Plan" – WFSU Public Media (April 2024)
- Community Effort Aims to Restore Apalachicola Bay Oyster Harvests, Livelihoods – Public News Service (May 2024)
- Documentary on collapse of Florida's oyster reefs will debut on PBS stations – Tallahassee Democrat (January 2025)
    - Unfiltered Documentary Website
- PBS Stations to show documentary on decline of Florida's oyster reefs – Florida Politics (January 2025)
- Student Star: Erin Tilly – Florida State News (February 2025)
- How AI is Changing Oyster Farming – Garden and Gun (February 2025)
- Shuck It: Gov. DeSantis budget shells out $30M for oyster reefs – Florida Politics (February 2025)
- Apalachicola Bay set to reopen for oyster harvesting after five years of closure – WTXL Tallahassee (March 2025)

7. Economic revitalization for Franklin County

7.1 Economic Revitalization Programs for Franklin County (Dr. Matthew Carter, Dr. Susana Santos, Marina Lickson, Jim Moran College of Entrepreneurship)

Summary to date

The Jim Moran College (JMC) of Entrepreneurship / Jim Moran Institute (JMI) began executing the entrepreneurship-based programming described in Appendix 2 of the ABSI Grant Amendment to Project 69. The first of four planned entrepreneurship leadership education cohorts begins its programming in April 2025 with a four-session classroom module. The JMC/JMI team presented the program roadmap to the December board meeting of the Partnership for a Resilient Apalachicola Bay. The team procured the classroom venue at ANERR, established marketing channels through local media and chambers of commerce, and enrolled to date its lower-end target cohort size with three weeks of marketing remaining.

Background and key achievements to date

The Franklin County entrepreneurship capacity building includes two programs, Accelerate Franklin and the Forgotten Coast Small Business Program. Accelerate Franklin focuses on nascent entrepreneurs looking to take existing idea-stage, micro-, and small-ventures and build them into sustainable ventures. An Accelerate Franklin cohort is 9 months in length and accomplishes these goals through a pre-defined set of more than 80 proven entrepreneurial action steps, bringing boot camp training, 1:1 mentorship, and small-group learning opportunities directly into the community. Forgotten Coast Small Business Program is targeted at CEOs, founders, entrepreneurs, and presidents of established small businesses (typically those 3+ years in business with 3+ employees). It includes four 4-hour classroom sessions followed by peer-to-peer mentoring opportunities.

The project, when executed to all four cohorts (two for each program), represents up to 1,180 hours of total business-contact time. The first cohort (Forgotten Coast Small Business Program) launches in April. Each cohort of the two programs will be 5-15 businesses in size. We are tailoring both programs to the Franklin County audience, reflecting both the contemporary make-up of the local economy and capacity building for fishing-related businesses entering/re-entering the market.

Enrollment demand is difficult to gauge given the small market size and uncertainty of the Franklin County entrepreneurship ecosystem four years into Apalachicola Bay closure. The enrollment pace in the April sessions of the Forgotten Coast Small Business Program will be a helpful data points

Key achievements to date:

- Presented the two programs to the December board meeting of the Partnership for a Resilient Apalachicola Bay
- Announced first cohort of the Forgotten Coast Small Business Program at this meeting
- Networked with local business leaders to stimulate enrollment interest.
- Established relationships with the Apalachicola Bay and Carrabelle Chambers of Commerce, joining the former.
- Booked the classroom venue for the first cohort of Forgotten Coast Small Business Program (ANERR facility).
- Developed and implemented marketing strategy for the two programs.
- Advertised first cohort on local radio and through the Apalachicola Bay Chamber of Commerce events calendar.
- Enrolled the threshold size for the April cohort of the Forgotten Coast Small Business Program. With three weeks to go before the first classroom session, we will continue to market the program to increase cohort size.

Future work:

- Pursue additional marketing channels and networking to enroll more business leaders in the April cohort.
- Plan and market subsequent cohorts through established channels.
- The JMC/JMI Team supports an unfunded extension of the Economic Revitalization of Franklin County components of the ABSI grant. An extension into 2026 would allow us to space out the cohort start dates while also avoiding the tourism high season that would suppress participant enrollment (Memorial Day to July 31).

Future cohort schedule:

- Future cohort schedule:
  - Accelerate Franklin cohort 1: Q3 2024
  - Forgotten Coast Small Business Program cohort 2: Q4 2024
  - Accelerate Franklin cohort 2: Q4 2024