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COMMUNITY-BASED COASTAL RESTORATION:  
LONG TERM IMPACTS ON HABITATS  
AND PEOPLE IN VOLUSIA COUNTY

by

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B.S. College of William & Mary, 2016

A thesis submitted in partial fulfillment of the requirements  
for the degree of Master of Science  
in the Department of Interdisciplinary Studies  
in the College of Graduate Studies  
at the University of Central Florida  
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## ABSTRACT

Coastal habitats provide invaluable economic and ecosystem services. However, coastlines are eroding at increasing rates due to anthropogenic and climate driven changes. Grey and green infrastructure solutions have been proposed to retard the decay of coastlines, with oysters serving as a popular living shoreline. Three community-based stabilizations that implemented living shorelines and engaged local communities in restoration efforts over the past decade in Volusia County were revisited to determine if they were successful and if they produced positive public perceptions of success. Chicken Island, which was restored after waves, boat wakes, tides, and adverse weather altered the natural shoreline, had significant increases in oyster size and density but an unsuccessful deployment of mangrove seedlings. The Port Orange study site installed living shoreline along existing sea wall and experienced low oyster recruitment, limited success with *S. alterniflora* propagation, and high cover of bare sediment. The Mosquito Lagoon Marine Enhancement Center had high vegetative cover and biodiversity and decreases in oyster density likely due to the development of healthy, mature oyster reefs. A survey of volunteers who participated in these three restoration projects was also conducted to determine if there is a tie in ecosystem function produced through restoration and community perceptions of restoration success. While there were not enough survey responses to draw conclusions, the responses were indicative of the future research needed to understand volunteer identities and sense of place as they relate to the human-nature system. To improve the long-term success of living shorelines, it is critical to not only select restoration methods appropriate for the specific location of the restoration, but to involve local communities to increase sense of self and investment in restoration efforts.

To my loving fiancé and family who constantly inspire me and who have supported me  
through this endeavor.

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## TABLE OF CONTENTS

LIST OF FIGURES .....	viii
LIST OF TABLES .....	ix
CHAPTER ONE: LITERATURE REVIEW .....	1
Coastal Restoration Impacts .....	2
Coastal Restoration Methodology .....	7
Restoration Identities .....	9
Area of Study .....	12
Chicken Island .....	13
Port Orange .....	14
Mosquito Lagoon Marine Enhancement Center .....	16
Hypotheses .....	18
CHAPTER TWO: BIOLOGICAL INDICATORS OF SUCCESS .....	19
Methods .....	19
Chicken Island .....	19
Port Orange .....	21
Mosquito Lagoon Marine Enhancement Center .....	23
Success Criteria .....	25
Results .....	26
Chicken Island .....	26

Port Orange .....	30
Mosquito Lagoon Marine Enhancement Center .....	36
Discussion .....	41
CHAPTER THREE: COMMUNITY RESTORATION IDENTITIES.....	47
Methods.....	47
Results.....	48
Discussion and Future Research .....	48
CHAPTER FOUR: CONCLUSIONS.....	53
APPENDIX A: SURVEY QUESTIONS.....	57
APPENDIX B: CONSENT FORM .....	59
APPENDIX C: IRB LETTER OF APPROVAL .....	62
LIST OF REFERENCES .....	64



## LIST OF FIGURES

Figure 1 Map of the Chicken Island restoration site.....	14
Figure 2 Map of the Port Orange restoration site. ....	16
Figure 3 Map of the MLMEC restoration site. ....	17
Figure 4 Chicken Island Percent Cover .....	26
Figure 5 Mean oyster density at Chicken Island (per 0.25 m <sup>2</sup> ) .....	27
Figure 6 Mean oyster shell length at Chicken Island (in mm).....	28
Figure 7 Survival of black and red mangroves on Chicken Island .....	30
Figure 8 Percent Cover at Port Orange .....	31
Figure 9 Mean oyster shell lengths at Port Orange (in mm).....	32
Figure 10 Mean oyster density at Port Orange (per 0.25 m <sup>2</sup> ) .....	32
Figure 11 Percent Cover at MLMEC .....	36
Figure 12 Mean oyster lengths at MLMEC (in mm) .....	38
Figure 13 Mean oyster density MLMEC (per 0.25 m <sup>2</sup> ).....	39

## LIST OF TABLES

Table 1 Restoration methods used at Chicken Island. ....	19
Table 2 Restoration methods used at the Port Orange restoration site. ....	21
Table 3 Restoration methods used at the MLMEC restoration site. ....	24
Table 4: Criteria for measuring restoration success. ....	25
Table 5 GLM of oyster lengths at Chicken Island ....	29
Table 6 GLM of oyster density at Chicken Island ....	29
Table 7 GLM of oyster length at Port Orange ....	33
Table 8 GLM of oyster density at Port Orange. ....	34
Table 9 Species identified at Port Orange. ....	35
Table 10 Species identified at MLEMC ....	37
Table 11 GLM of oyster lengths at MLMEC ....	40
Table 12 GLM of oyster density at MLMEC ....	41

## CHAPTER ONE: LITERATURE REVIEW

The land-sea interface is a malleable and resilient environment of great ecological importance. Coastlines both provide critical ecological services and act as important buffer zones that work to protect coastal communities from severe weather and the impacts of climate change (Beatley, 2009). In the United States, development is occurring along coastlines faster than anywhere else in the country (Daniels, 2014). At the same time, coastlines are eroding at increasing rates, threatening the safety of coastal communities. As much of this development degrades natural buffers, a critical component in coastal hazard mitigation is finding ways to develop infrastructure that protects coastal communities from sea level rise, erosion, and hurricanes. Developing effective infrastructure to promote coastal resilience is critical for protecting property, livelihoods, and critical habitats, particularly in the face of climate change (Beatley, 2009). Coastal restoration should therefore be a central focus in coastal hazard mitigation.

Coastal zones are areas of land within 50 miles of an ocean or Great Lake, including marshes, bays, estuaries, and lagoons (Daniels, 2014). These areas support a number of industries, accounting for the success of the \$2 billion commercial fishing industry and the billions of tourism dollars earned each year (Daniels, 2014). Approximately 75 percent of the largest cities are found in coastal zones, providing homes for half of the world's population (Morris et al., 2018). Consequently, development in coastal areas has contributed to the widespread destruction of ecosystems that provide natural hazard mitigation services. For example, coastal wetlands are dredged and filled to develop everything from commercial spaces to farmlands. Additionally, toxic pollutants and runoff that comes with industrial development and developments built too close to the shoreline have a major impact on vulnerable estuarine

environments and contribute to a dangerous amount of beach erosion (Daniels, 2014).

Beyond human-caused damage to the landscape, climate change is increasing the number of natural disasters that occur in coastal zones and is exacerbating the amount of damage done to lands and communities occupying these areas (NOAA, 2018). On average, 1,500 houses are lost every year to shoreline erosion. Coastal erosion also decreases property values in the U.S. by \$3 to 5 million each year (Evans, 2004). In Florida, Hurricane Matthew in 2016 caused massive amounts of damage that amounted to at least \$10 billion (NOAA, 2018). To mitigate against damages caused by natural disasters and erosion, natural and engineered structures can be constructed along shorelines. Investing in restoration and mitigation projects can provide economic sustainability and help mitigate costly damages to properties from future natural disasters.

### Coastal Restoration Impacts

The International Panel on Climate Change describes disaster risk as being a function of potential hazards, exposure, and vulnerability based on the physical conditions of a region (Hamin et al., 2018). Coastal restoration methods are ever evolving as engineers work to address the increasing impact that abiotic and anthropogenic factors have on coastlines and reduce disaster risk to coastal communities. Current methodologies can be classified in one of two ways - hard or “grey” infrastructure includes seawalls, revetments, and groins, or soft or “green” infrastructure like wetlands, reefs, and dunes (Beatley, 2009). Green infrastructure is designed to mimic natural processes while structural measures, or grey infrastructure, are man-made structures designed to minimize damage to shorelines. Each kind of infrastructure has its own benefits and disadvantages, but ultimately the type of risk reduction measures used in a particular location is dependent upon the desired level of risk reduction, the

geophysical factors of the environment, cost, and reliability of the methodology (NOAA, 2015). The spatial context of a coastal area greatly affects the determination of the effectiveness of grey or green infrastructure, influencing the condition of natural habitats and the built infrastructure, communities, and cost of property that the infrastructure is responsible for protecting (Ruckelshaus et al., 2016).

The traditional approach to armoring shorelines is the use of engineered structures like seawalls and breakwaters. Grey infrastructure has the primary goal of protecting coastal areas from exposure to risk. By nature, grey structures are physically inflexible, which is not ideal for a rapidly changing environment or for resiliency against damage (Hamin et al., 2018). It has been hypothesized that socially, grey infrastructure leads to maladaptation as it encourages a false sense of security when it is used in areas that are not suitable for development or that have not planned well for coastal resilience (Hamin et al., 2018). Grey infrastructure can only be engineered to protect an area from exposure of a hazard up to a particular grade. For example, a seawall can be constructed to protect a coastline from the damage of up to a category three hurricane. These artificial structures are unable to protect from damage incurred beyond the scale of damage it was designed to withstand (Onuma and Tsuge, 2018).

Implementing hard infrastructure to replace the protective services of coastal ecosystems in an expensive endeavor, with an estimated cost of \$4-11 billion to be spent on coastal engineering protection measures necessary to protect against the next 50 years of projected threats from climate change (Morris et al., 2018). When these structures are destroyed by storms stronger than they were designed to protect against, the tens of billions of tax dollars

that are used to subsidize coastal reconstruction are put towards recreating the same structures that were destroyed (Gillis and Barringer, 2012). For example, in Dauphin Island, AL, an area that has been battered by over a dozen severe hurricanes since 1979, over \$80 million has been spent in reconstruction costs, including \$72 million towards the subsidized federal flood insurance program for homeowners. By increasing ecosystem damage and creating new social issues in the pursuit of a mission simply to reduce damage to property and lives, grey infrastructure can be economically and environmentally unsustainable (Hamin et al., 2018). Although they have proven effectiveness up to a degree, the costs of grey infrastructure seemingly outweigh the benefits.

Green infrastructure and natural ecosystems can be an effective alternative to man-made infrastructure. One of Beatley's principles of coastal resilience involves preserving and restoring ecosystems and ecological infrastructure (2009). This is important as green infrastructure is a natural way to mitigate hazards – marshes and wetlands are able to soak up and absorb floodwaters, dunes act as natural seawalls, and reefs can aid in wave attenuation (Beatley, 2009). In a study evaluating wave energy attenuation in living shorelines in Mosquito Lagoon, researchers found that the combination of long-lived eastern oysters (*Crassostrea virginica*) and smooth cordgrass (*Spartina alterniflora*) effectively reduced 67% of the wave energy created by a single boat wake (Manis et al., 2014). Beyond providing coastal protective services, the green infrastructure supports natural capital benefits like recreation, commercial fisheries, and carbon sequestration (Ruckelshaus et al., 2016). Additionally, the effects of green infrastructure can be additive when two or more natural systems are within close proximity to each other (Morris et al., 2018). Living shorelines can consist of three complementary components depending on the spatial context of the area.

Native vegetation helps to hold soil in place to reduce erosion, buffer the coastline, dissipate wave energy, and provide ecosystem services. However, it is not effective in reducing storm surge or protecting against high water. The use of edging, like erosion control blankets, geotextile tubes, or living reefs, holds the toe of existing vegetated slopes in place. While it does not protect against high water, it can dissipate wave energy and help prevent wetland edge loss. Sills are stone, sand, or living reef breakwaters that parallel vegetated shorelines to protect against erosion and reduce wave energy (NOAA, 2015). The most effective living shorelines are those that utilize the additive benefits of multiple green infrastructure options.

Green infrastructure is usually much cheaper than engineered hard structures as it involves restoring ecosystems that already exist in a particular area and requires little to no maintenance fees (Hamin et al., 2018). Additionally, they can self-sustain and naturally adapt to changes in climate processes, minimizing the need for human intervention or upkeep (Ruckelshaus et al., 2016). Living shorelines can cost between \$45 and \$700 per linear foot to construct depending on the materials used (Restore America's Estuaries, 2015). Compared to the economic value of flood protective services of wetlands, the savings have been estimated to be \$375 per acre per year. For every dollar spent on a mitigation project, a savings of six dollars was experienced (Beatley, 2009). Green infrastructure is not only cheaper to construct and maintain, but the monetary value of the protective services they provide make it a sounder economic investment than grey infrastructure.

Eastern oysters (*Crassostrea virginica*) are important filter feeders that are common in oyster reef restoration in Florida. In the Southeast United States, *C. virginica* are most commonly found in the intertidal and play a number of critical roles in estuarine systems. These filter

feeders sequester carbon and can improve water quality through filtration and concentration of biodeposits in the water column. Additionally, they provide critical habitat for a number of juvenile and adult organisms. What makes them ideal for living shorelines is their ability to stabilize sediment and act as breakwaters in order to slow shoreline erosion (Coen, et al., 2007). Aside from water quality and erosion control services, oyster reefs are adaptive to environmental change, meaning they can recover quickly from storm events and accrete at a rate of equal to or greater than sea level rise (Morris, et al., 2019). In addition to natural erosion, boat traffic and coastal development has accelerated disturbance of oysters and of the fringing salt marsh (Coen, et al., 2007). Despite their dramatic decline in the 20<sup>th</sup> century, greater recognition of the ecosystem services oyster reefs provide has increased the appeal of oyster reef restoration and led to increasing *C. virginica* populations along the U.S. Atlantic coast (Coen, et al., 2007). Initially, oyster restoration focused on recovering the harvest of oysters and other fisheries, but more recently there has been a growing focus on maximizing other services and benefits like water quality and shoreline protection (Morris, et al., 2019). In comparison to loose shell, oyster mats or bags may prolong the integrity of the shell mound while oysters attach (Morris, et al., 2019). As the requirement for the establishment of an oyster reef is hard substratum for juvenile settlement, artificial reefs of many types have been deployed for living shorelines (Morris, et al., 2019). Oyster reef restoration can be conducted on its own or in conjunction with other restoration methodologies.

What has become more common is the combination of grey and green infrastructure strategies to utilize the strengths and benefits each has to offer. Deploying complementary grey and green infrastructure not only produces effective, sustainable hazard mitigation services, but enhance the community as a whole. Using living shorelines and other green



infrastructure for coastal protective services provides ecosystem service benefits that can boost the economy of marine resource dependent communities (Ruckelshaus et al., 2016). A number of hybrid solutions have been proposed to not only reap the benefits of both kinds of infrastructure, but to address a wider array of coastal resiliency goals. Incorporating features from both grey and green infrastructure can help planners achieve goals of hazard mitigation as well as ecological enhancement, long-term adaptation, and social benefits (Hamin et al., 2018). Combining nature based and built infrastructure, such as oyster reefs in front of seawalls, may provide maximal coastal protection benefits (Morris et al., 2018). Hard eco-engineering is a hybrid option that addresses the issue of wanting the ecological impacts of green infrastructure but needing the stability of grey infrastructure. In areas where green infrastructure is not an option, microhabitats can be retrofitted onto grey infrastructure to increase biodiversity and ecosystem services while maintaining the defensive services of the hard infrastructure (Morris et al., 2018). Though hybrid solutions would be a logical next step in developing hazard mitigation measures in coastal planning, there are still a limited number of coastal communities that implement them.

### Coastal Restoration Methodology

The key to successful community-based coastal restoration is the use of non-mutually exclusive approaches to living shorelines. Oyster restoration is popular in living shorelines as oyster reefs are capable of slowing disturbance effects on marshes and fringing reefs. Their hard structure also makes them a suitable alternative to bulkheads and other grey infrastructure, allowing them to act as natural breakwaters (Coen, et al., 2007; Brumbaugh and Coen, 2009). Oyster shell is a popular material for reef restoration as it is a biogenic substrate that provides hard substrate for oyster larvae to attach. Even in the early stages of

recruitment prior to the development of mature oysters, the shell substrate is still useful in creating a protective habitat for a diversity of species in all life stages (Brumbaugh and Coen, 2009). A scarcity of available clean shell had led to the development of viable substrate alternatives, like reef balls, that can be effective in both erosion control and spat recruitment (Brumbaugh and Coen, 2009). To supplement the benefits provided by oyster reefs, shoreline stabilization using native plants provides additional habitat and erosion control. For example, mangroves provide habitat, filter sediment, protect shorelines from erosion (Locke and Wright, 2019). However, these living shoreline solutions may work better when unnatural substrates are not present. A study in Canaveral National Seashore evaluated the effectiveness living shoreline techniques using stabilized oyster shell, *Spartina alterniflora*, and *Rhizophora mangle*. Survival of planted species was high, however, they found natural mangrove recruitment was limited and suggested that human altered substrate at shell middens may prevent natural recovery of vegetated shorelines (Donnelly et al., 2017).

Volusia County has implemented living shorelines along a number of degrading coastlines. Most living shorelines in Florida now involve oysters – whether that be in the form of loose shells, shells on mats or in bags, or the use of alternative materials like reef balls (Brumbaugh and Coen, 2009). Oyster mats utilize clean oyster shells attached to mesh mats to serve as a low-profile natural substrate to promote oyster recruitment around remnant or existing reefs (Locke and Wright, 2019). Similarly, oyster bags create stable, three-dimensional substrate to recruit oyster spat and control for erosion. These polyethylene mesh bags filled with clean oyster shells are common in small-scale reef reconstruction (Brumbaugh and Coen, 2009). Mats are used in shallow areas where a low profile is more desirable while bags can be stacked and manipulated into different shapes to fit around reefs and create breakwaters as

needed (Morris, et al., 2019). Reef balls are cement casted structures that can provide substrate for oyster spat attachment and serve as an implementation tool for mangrove seedlings. They provide the added benefits of effectively dissipating wave energy and acting as an erosion control device. Mangroves are often used in conjunction with oyster reefs and are planted in one of two ways – seedling can be planted individually or deployed in conjunction with reef balls (Locke and Wright, 2019).

### Restoration Identities

An integral component of successful community-based coastal restoration programs is the involvement of local volunteers. This study aims to understand the social psychology behind volunteer identity and place identity as they relate to coastal restoration success. Motivations and benefits of volunteering have long been a focus in behavioral research. Identity plays an important role in understanding the behavioral intent behind volunteerism. One's "self" can be shaped or categorized in different ways depending on its social relationships, forming an identity is formed through this self-categorization process. While personality can change, identity is more concrete as it is at the core of an individual (Oazimi, 2014). Volunteer role identity has been defined as a "direct and proximal cause for sustained volunteerism" and can be understood through the role identity theory which looks at the extent to which a person internalizes their role as a volunteer and incorporates the role into their self-concept (Güntert and Wehner, 2015). Self-concept deals with how an individual perceived themselves as being similar and different from other people. Through abstract social categorization, people develop perceptions of themselves that then become part of their self-concept (Oazimi, 2014). One's self-concept can be helpful in guiding future behaviors, like continued volunteer work, as the theory suggests individuals work to remain consistent with their

identity (Finkelstien, 2009). Through the lens of the theory of planned behavior, role identity can be seen as a mediator in developing strong behavioral intentions and attitudes that lead to long-term volunteer commitments (Marta et al., 2014).

Conservation volunteerism has been identified as a means to foster place identities and strengthen place relationships. Sense of place is the way people experience, know, and express a particular place that they are attached to, developing a relationship that ultimately shapes one's identity. It is indicative of the relationship humans have with the environment and the impacts each can have on the other (Oazimi, 2014). Consequently, place identity stems from the collection of interpretations, memories, perceptions and relations one feels they have with a specific setting (Oazimi, 2014). Sense of place is argued to play a significant role in identity development as aspects of one's identity stem from the images and figures of a place that have significant meaning to them. Places, however, do not have a permanent role in our identity, changing as one's sense of place evolves (Oazimi, 2014). The layers of place meaning framework dissects the human-environment relationship by evaluating sense of place, as a primary construct in developing meaning and attachment to a specific place (Bleam, 2018). This development of place identity and place meaning is critical in environmental stewardship and benefits not only the volunteer site, but the surrounding community (Bleam, 2018). It is also critical to consider perception when leveraging a community's participation in shoreline restoration. If an individual has a strong sense of place in a particular environment and they perceive as a prior restoration to be successful, they are more likely to support and participate in future restorations (Kibler et al., 2018). The identity-visualize-create framework evaluates how the goals of the restoration and the curation of a sense of place around an ecosystem play into the relationship between human

and natural systems (Kibler et al., 2018). Whether a particular restoration is successful from a biological perspective or not, positive community perceptions of success can lead to beneficial environmental feedbacks.

Volunteers have been found to have altruistic and egoistic motives for committing to long term volunteer experiences, finding that those with more years of volunteer experience reported increased involvement with conservation behavior (Bixler, Joseph, and Searles, 2013). These results support the environmental socialization framework, showing that involvement with conservation organizations that offer training and education programs and engaging with an associated social group amplifies existing interests in conservation (Bixler, Joseph, and Searles, 2013). Amongst volunteers participating in municipally sponsored volunteer events in Portland, OR, motivation for participation was identified to be connected to one of three factors: environmental identity, private pro-environment behavior, and civic engagement. Frequent volunteers were found to be more likely to feel personally attached to the local environment and feel that their efforts help solve environmental problems. The collective efforts of volunteers in working towards restoring parks may contribute to more resilient communities (Dresner et al., 2014). Further research in this area is critical in identifying positive consequences of conservation volunteerism (Dresner et al., 2014). This research seeks to apply these theories to understand the sense of place of the Indian River Lagoon community, to identify their motivations to engage in coastal restoration volunteer projects, and to understand the long-term conservation benefits that these opportunities could have for the community at large.

### Area of Study

This study evaluates the long-term success of three living shoreline restoration projects conducted in Volusia County in the past decade. The Indian River Lagoon (IRL) is a lagoon system on the east coast of Central Florida. In 1990, the IRL was designated as “an estuary of national significance” by the Environmental Protection Agency due to its role as one of the most productive estuarine systems in North America. With over 3,000 species identified in the IRL, it has high biodiversity due to its location between the temperate and sub-tropical zones (Barber, et al., 2010). The northernmost estuary in the IRL system is Mosquito Lagoon. This lagoon is dominated by soft bottom habitats, so restoration efforts focus on restoring *C. virginica*, a keystone species in the system that provides hard substrate (Barber, et al., 2010). A 2010 study evaluating dead margins of oyster reefs in Mosquito Lagoon within Canaveral National Seashore revealed that approximately 9 percent of the total aerial coverage of oyster reefs was comprised of dead margins (Garvis, et al., 2015). This study confirmed the findings of Grizzle, et al.’s 2002 study showing that the dead margins were not a result of storm activity or disease but resulted from the unnatural increase in water motion created by boat wakes. According to Grizzle, et al., the earliest appearance of dead margins was along the Intracoastal waterway. Some reefs were observed to have migrated away from the channel by as much as 50 meters (Grizzle, et al., 2002). The stabilization of shorelines using mats, bags, and other means have been effective in stabilizing shells to reduce the likelihood that they will be dislodged by boat wakes.

## Chicken Island

Chicken Island is located adjacent to the Atlantic Intracoastal Waterway in the Indian River Lagoon, directly south of the North Causeway Boat Ramp in New Smyrna Beach, Florida (29°01'47.1"N; 80°54'48.6"W) (Figure 1). The island has experienced long term impacts from waves, boat wakes, tides, and adverse weather, which has altered the natural shoreline. In a 2009 restoration project funded by The Nature Conservancy and National Oceanic and Atmospheric Administration, the researchers used oyster bags, oyster mats, and reef balls in an effort to restore the oyster beds surrounding Chicken Island. Their goal was to create a footprint of 5.5 acres of restored oyster reef habitat coverage and increase biodiversity from 0 to a target 18 species per 0.25 m<sup>2</sup>. Oyster mats were used for approximately 90 percent of the restoration acreage, while reef balls and oyster bags were placed in areas with high wave energy. Shoreline erosion was measured using stakes planted along the shore to measure shoreline deposition behind the reef ball and oyster bag plantings, and water clarity was measured using secchi disks in water samples taken under similar conditions. Finally, the researchers measured the change in vegetative cover behind fringing reefs as a metric for assessing performance by estimating the shoot density of healthy mangroves per square meter in quadrant samples of restored area. They also hoped that the involvement of volunteers would build community support for ongoing oyster reef restoration efforts and were successfully able to recruit 786 volunteers to assist in various aspect of the installation of the living shoreline.



**Figure 1 Map of the Chicken Island restoration site.**

## Port Orange

The Port Orange study site is along the Halifax River in the city of Port Orange in Volusia County, Florida (29°08'29.3"N; 80°59'04.3"W) (Figure 2). It extends approximately 0.7 miles south of the Dunlawton Causeway along the western shoreline of the river. This portion of the river runs adjacent to approximately 40 residential homes along Halifax Drive. Prior to the 1940s, much of project area was developed and a bulkhead had been constructed to provide protection. Today, the shoreline is completely developed, and shoreline sites are owned by residential landowners and the City of Port Orange. Prior to the start of this restoration, there were many unvegetated areas and some historic oyster beds with live scattered oysters along the historic bulkhead. Only one quarter of the shoreline supported emergent vegetation and the area's wind-wave potential was categorized from medium to high.



The goals of this restoration were to establish stable sloped upland shoreline edge using riprap in front of the existing bulkhead, to plant native plants to create a continuous band of intertidal vegetation, to provide structure in the lower tidal zone for wave energy attenuation and oyster recruitment, and to develop a community partnership that raises awareness and public education on living shoreline programs. On 11 shorelines belonging to private property owners, shoreline stabilization was performed, removing and reinstalling failing bulkhead or riprap systems. Oyster mats were deployed at 9 of 11 sites, deploying 720 mats total, and oyster bags used at 10 of 11 sites, deploying 650 bags total. A total of 2,200 *Spartina alterniflora* plugs were planted at the 11 sites. Following the initial installation, vegetation health, survival, recruitment, and spread was monitored 6, 12, 18, and 24 months following the restoration, as well as oyster recruitment and retention on the mats and bags. The goal was to increase acreage of healthy oyster reefs as measured by restoration areas displaying at least 22 new oysters and 2 bridges connecting deployed shells per 0.25 m<sup>2</sup> of restoration area after 12 months and to increase biodiversity from 0 to a target of 18 species per 0.25 m<sup>2</sup>. They were successfully able to recruit 57 volunteers to assist in various aspect of the installation of the living shoreline.



**Figure 2 Map of the Port Orange restoration site.**

### Mosquito Lagoon Marine Enhancement Center

Two sites were restored on the Mosquito Lagoon Marine Enhancement Center (MLMEC) property – Discovery Island, a small spoil island enhanced for educational outreach experiences, and a nearby section of marshland that aids in erosion control (29°02'05.2"N; 80°55'15.0"W) (Figure 3). The objectives of this restoration were to utilize 100% recycled oyster shell from a local oyster recycling program, sustainably harvested *Spartina alterniflora*, mangrove seedlings, and locally sourced hammock plants and shrubs to construct living shoreline to reduce impacts of erosion and wave attenuation on at least 0.5 acres of MLMEC. On the MLMEC marshland, oyster bags and mangroves were placed on the western perimeter, and shoreline and upland plants were planted in the demonstration area. On Discovery Island, oyster bags, red mangroves, salt tolerant plants and upland

hammock plants used to reduce erosion, control site access, and increase visitor safety. 882 oyster bags were created with recycled oyster shell.



**Figure 3 Map of the MLMEC restoration site.**

To measure the success of restoration, monitoring was conducted for a year following the restoration. Researchers monitored erosion and accretion rates, shoreline plant diversity and abundance, oyster recruitment and growth rates, reef thickness, abundance of fiddler crab burrows and other invertebrates, and wading bird usage of sites. Besides restoring ecosystem services and controlling erosion by using living shoreline as an alternative to hard stabilization, the goal of developing these sites was to create a way to engage the public in developing the materials necessary to carry out the living shoreline project. They were successfully able to recruit 1,706 volunteers to assist in various aspects of the installation of the living shoreline.

## Hypotheses

The goal of this study was to examine the success of three restoration projects over the past decade in Volusia County. Past restoration sites in Chicken Island, Port Orange and MLMEC were revisited to assess their long-term ‘success’ based on the projects’ original metrics. Additionally, this study explored the identities and motivations of individuals in communities adjacent to the Indian River Lagoon for participating in past coastal restoration volunteer projects. The study aims to understand these individuals’ interpretations of project success as compared to the quantitative analysis of success based on ecological and biological metrics. The goal was to understand how this information can be used to inform strategies for long-term success of living shorelines and how to market to and successfully recruit new volunteers to participate in ongoing and future restoration work in the Indian River Lagoon.

H<sub>0</sub>: Living shoreline restorations had no effect on ecosystem function.

H<sub>1</sub>: Restored and stabilized sites using multiple living shoreline components to provide erosion control services and increase biodiversity will have a positive effect on ecosystem function.

H<sub>0</sub>: Volunteer identities had no effect on their perceptions of the success of restorations.

H<sub>2</sub>: Individuals who assisted in these restoration projects will have strong identity ties with their local community and their perceptions of the success of restoration projects will be driven by this sense of self.

## CHAPTER TWO: BIOLOGICAL INDICATORS OF SUCCESS

### Methods

#### Chicken Island

Researchers restored 0.35 acres with the manpower of 2,848.5 total volunteer hours. The study site consisted of five restoration plots, each with a different combination of restoration methods implemented. The five restoration sites around the island were chosen through the identification of dead margins of existing oyster reefs. 2,600 oyster mats were deployed across four sites, 200 reef balls were deployed across four sites, and 500 oyster bags were deployed on one site. Post-deployment, monitoring was conducted six months following the initial deployment. Recruitment of oysters and number of bridges on each mat were measured on 30 randomly determined mats per restored site. The number of new plants rooted or not rooted were measured and the presence of the invasive green mussel and pink barnacle was noted. Additionally, temporal vertical profiling data was used to determine if dead margins were forming.

**Table 1 Restoration methods used at Chicken Island.**

Site	1	3	4	5	6
Restoration	500 Mats 50 Reef Balls	800 Mats	400 Mats 50 Reef Balls	900 Mats 50 Reef Balls	500 Bags 50 Reef Balls

The Chicken Island restoration site was revisited in June 2019. The six restoration sites were located and a control site, an unrestored area of healthy oyster reef, was selected to serve as a

reference point for the success of the restored areas (Table 1). At site 6, no bags or reef balls were found, so data collection was not performed at this site. Portions of oyster mats were identified but were buried too deep to conduct measurements by selecting 30 random mats. Rather, oyster count and shell length measurements were conducted in 15 randomly placed 0.25 m<sup>2</sup> quadrats at each site. Reef thickness was measured at 5 random points along 10 transects at each site. The highest point along each transect was also recorded. Using m<sup>2</sup> quadrats to conduct point intercept measurements, 100 cover points of the dominant cover were recorded in 5 randomly placed quadrats at each site. Presence of oyster clusters and other organisms were also noted. Distance from oyster mats to mangroves was recorded along 10 transects at each site to measure impact beyond footprint. Reef balls were counted and evaluated for damage. Presence or absence of mangroves in or near reef balls was also recorded.

### Statistical Analysis

Point intercept measurements were used to calculate the mean percent cover at each site. The mean distance from oyster mats to mangroves was calculated to determine the restoration impact beyond the original footprint. Means and standard error were calculated for oyster reef height, oyster shell length, oyster density, and number of oyster clusters. One Sample t-tests were then conducted to compare oyster density and number of oyster clusters to theoretical goals stated in the original study. A generalized linear model was used determine if the restoration methods used at different sites on the island had a significant effect on oyster shell length or density. All analyses were run in the program R.

## Port Orange

Researchers restored 0.21 miles of privately-owned shorelines with the assistance of 57 volunteers. 720 oyster mats were installed across 10 of 11 sites, 650 oyster bags were installed across 10 of 11 sites, and 2,200 *Spartina alterniflora* plants were installed across all 11 sites. Data on oyster mats collected from 30 randomly chosen mats and 10 randomly chosen bags at each site were collected 6, 12, 18, and 24 months following the restoration. The number of new recruits, number of bridges formed between adjacent mats were recorded. Commensal organisms on the structures were also recorded. Researchers measured the vertical reef profiles along three transect lines yearly after the initial restoration. Seagrass growth and new oyster growth from the edge of restored reefs out to 2 m were measured. Researchers also monitored for the presence of invasive species including the Asian green mussel, the charru mussel, and the pink barnacle.

**Table 2 Restoration methods used at the Port Orange restoration site.**

Site	Site 1	Site 2	Sites 3–10
Restoration	Bags <i>S. alterniflora</i>	<i>S. alterniflora</i>	Bags Mats <i>S. alterniflora</i>

Property owners of the original sites were contacted and informed of the researcher’s intention to evaluate the success of the restoration and to request permission to access their property to conduct the survey. Site 11 was excluded from the study as there was no parcel number listed and the location of the property could not be identified. Ten of the 11 original sites were revisited in June 2019 (Table 2). For efficiency purposes, adjacent properties (sites

3 and 4 and sites 7 and 8) were evaluated as one site in the 2019 survey, resulting in a total of 8 sites for analysis. Oyster count and shell length measurements were conducted in 10 randomly placed 0.25 m<sup>2</sup> quadrats at each site. Reef thickness was measured at 5 random points along 10 transects at each site. The highest point along each transect was also recorded. Using m<sup>2</sup> quadrats to conduct point intercept measurements, 100 points of the dominant cover were recorded in 5 randomly placed quadrats at each site. Presence of oyster clusters and other organisms were also noted. Number of oyster bags and mats located, as well as the distance from oyster mats and bags to the sea wall were recorded along 5 transects at 6 of the 8 sites. A plant survey was conducted, measuring number of species present, as well as the size and stem density of identified plants. Shoreline profiles were recorded along three transects perpendicular to the seawall at three sites.

### Statistical Analysis

Point intercept measurements were used to calculate the mean percent cover at each site. Means and standard error were calculated for oyster reef height, oyster shell length, oyster density, and number of oyster clusters. One Sample t-tests were then conducted to compare oyster density and number of oyster clusters to theoretical goals stated in the original study. A generalized linear model was used determine if the restoration methods used at different properties had a significant effect on oyster shell length or density. Finally, a species count was conducted to evaluate the biodiversity of the study area. All analyses were run in the program R.



## Mosquito Lagoon Marine Enhancement Center

Researchers restored 0.68 acres of marsh with the assistance of 1,706 volunteers. Shells for the oyster bags were collected through a partnership with the Shuck and Share program. 882 oyster bags were placed among the western perimeter of the MLMEC marsh and at the base of the slope of the intertidal zone around Discovery Island. Eroded shoreline along Discovery Island was regraded of existing scarp and replanted with *Spartina alterniflora*, mangroves, and upland hammock plants including sea purslane, sea oxeye daisy, sand cordgrass, blanket flower, and firebush. The terrestrial plants were placed approximately 0.5 m above mean high tide line and 0.5 m apart. 12 *R. mangle* seedlings were planted at Site 1 on Discovery Island landward of the oyster bags. A mix of *A. germinans* and *R. mangle* were then planted along the perimeter of Discovery Island except for sites 1, 2, and 3 where there were bare areas and severe erosion. 160 *A. germinans* were planted in upper intertidal zone along 181 meters of the western edge of the MLMEC marsh to help control erosion. For the first month, monitoring was conducted every week, then it was conducted quarterly after the first month. Sites 2 and 3 at Discovery Island were regraded and recycled concrete steps were installed. PVC erosion stakes were installed to measure erosion and accretion, slope and relative shoreline elevation on each transect, habitat types and percent cover along the land-water interface, and submerged and emergent vegetation, fiddler crabs, and oysters were measured using 0.25 m<sup>2</sup> quadrats along transects described above. All vegetation was identified to species and counted, and the number of crab burrows and live oysters were recorded when present.

**Table 3 Restoration methods used at the MLMEC restoration site.**

Site	Discovery Island Site 1	Discovery Island Sites 2 and 3	MLMEC Marsh
Restoration	Bags Mangroves Shoreline Plants	Bags Upland Hammock	Bags Mangroves Upland Hammock

The Discovery Island restoration site was revisited in June 2019 and accessed by kayak from the Marine Discovery Center. The 4 restoration sites and 13 transects were identified and measured (Table 3). Oyster count and shell length measurements were conducted in 6 randomly placed 0.25 m<sup>2</sup> quadrats at each site. Cover points were measured using a 0.25 m<sup>2</sup> quadrat placed 1 meter apart along each transect. Number and species of organisms present in each 0.25 m<sup>2</sup> quadrat. Scarp height and location was also noted.

### Statistical Analysis

Cover point measurements were used to calculate the mean percent cover at each site. Means and standard error were calculated for oyster shell length and oyster density. One Sample t-tests were then conducted to compare oyster density to the theoretical goal stated in the original study. A generalized linear model was used determine if the restoration methods used at different sites on the island had a significant effect on oyster shell length. Finally, a species count was conducted to evaluate the biodiversity of the study area. All analyses were run in the program R.

## Success Criteria

In order to better understand the degree to which these restoration projects were successful or not, a set of criteria had to be developed to categorize them as having high success, moderate success, or low success (Table 4). The criteria were based on ecosystem function, as determined by oyster reef health, percent cover, and biodiversity, and the percentage of the restored area where ecosystem function was shown to be significantly improved from the pre-restoration state of the location.

**Table 4: Criteria for measuring restoration success.**

High	Moderate	Low
Ecosystem function improved in more than 75% of the area.	Ecosystem function improved in between 25 and 75% of the area.	Ecosystem function improved in less than 25% of the area.

## Results

### Chicken Island

Percent cover was calculated to determine if dominant cover consisted of live oysters, oyster shells, benthos, or other (Figure 4). The mean percent cover ( $\pm$  SE) was calculated for each study site, as well as the control. Benthos, or bare sediment, was the dominant cover across sites, covering  $41.8\% \pm 0.04$  of the area. It was followed by  $36.2\% \pm 0.03$  cover of live oysters,  $21.4\% \pm 0.04$  cover of oyster shell, and  $0.52\% \pm 0.01$  other. Areas consisting of ‘other’ cover included clam shell, ribbed mussels, reef balls, and concrete. Comparing cover across sites, site 5 was largely dominated by oyster shell and site 4 had the largest percentage of benthos cover.

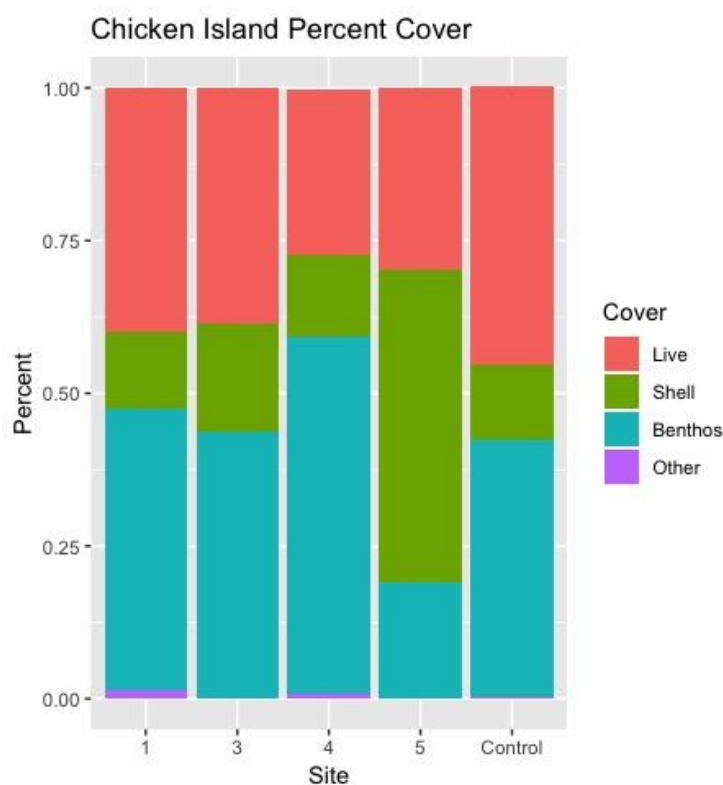
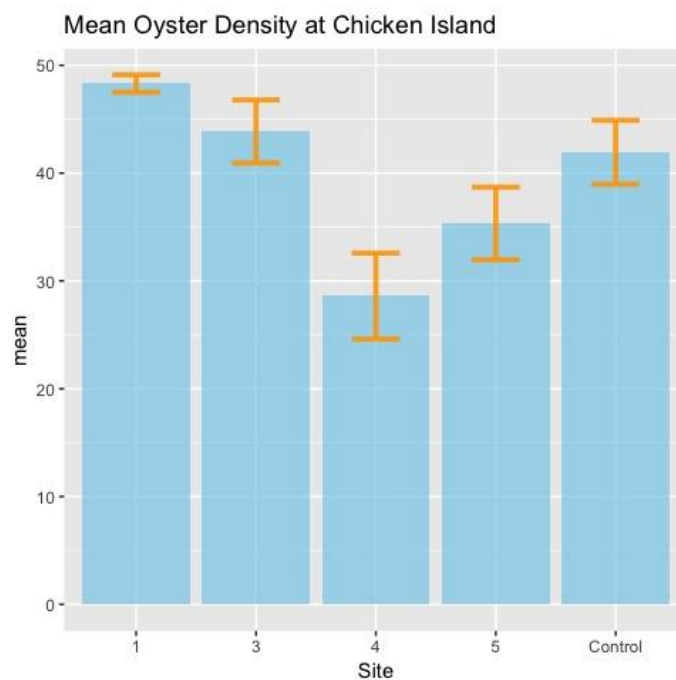
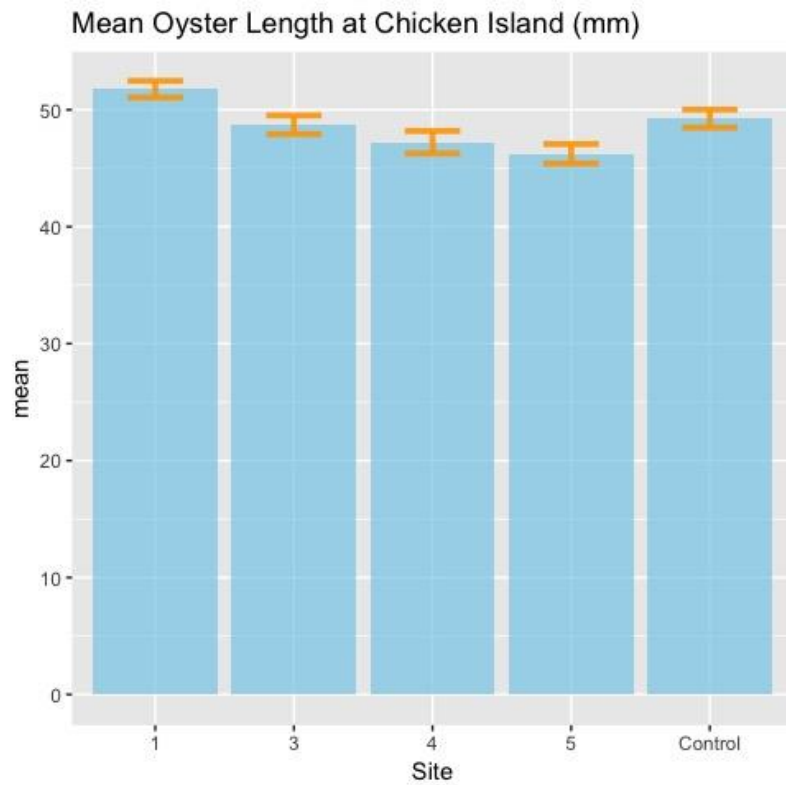


Figure 4 Chicken Island Percent Cover

The mean oyster reef height was  $43.72 \pm 3.38$  cm and the mean oyster shell length was  $4.85 \pm 0.35$  cm (Figure 5, Figure 6). Measuring the impact beyond footprint, the mean distance from the oyster mats to mangroves in the year following deployment was  $4.39 \pm 0.33$  cm and increased to  $66.52 \pm 15.8$  cm in 2019. The original restoration proposal for Chicken Island identified the goals of reaching an oyster density of 22 oysters and 6 bridges per mat, or 0.25 m<sup>2</sup>. In post-restoration surveys within a year of deployment, a mean oyster density of  $9.45 \pm 2.34$  and a mean of  $4.03 \pm 1.53$  bridges were recorded per 0.25 m<sup>2</sup>. In the 2019 survey, a mean oyster density of  $36.05 \pm 1.64$  and a mean of  $27.6 \pm 3.09$  clusters were recorded per 0.25 m<sup>2</sup>. As individual mat edges were unable to be identified due to oyster growth, for the purpose of comparison, it is assumed that mats were equivalent to 0.25 m<sup>2</sup>. In a one sided t-test comparing the 2019 mean oyster density and mean number of clusters to the theoretical values stated in the initial study, both oyster density ( $\mu = 22$ ,  $t = 8.5544$ ,  $df = 90$ ,  $p < 0.01$ ) and number of clusters ( $\mu = 6$ ,  $t = 6.9859$ ,  $df = 24$ ,  $p < 0.01$ ) were significantly higher than the goals initially stated.



**Figure 5 Mean oyster density at Chicken Island (per 0.25 m<sup>2</sup>)**



**Figure 6 Mean oyster shell length at Chicken Island (in mm)**

Generalized linear models were used to determine if the restoration methods used at different sites on the island had a significant effect on oyster shell length, density, or clusters. Shells lengths were significantly different at each site, indicating that the location and the exposure of the oysters to wave energy at different locations are appropriate predictors of oyster growth (Table 5). Sites 1, 4, and 5 had significantly different oyster densities, suggesting that location be an appropriate indicator of oyster density at these sites (Table 6). With such similar restoration methodologies used at each site, it is difficult to attribute differences between sites to restoration methods.

**Table 5 GLM of oyster lengths at Chicken Island**

	ESTIMATE	STD. ERROR	T VALUE	PR(> T )
<b>SITE 1</b>	51.7658	0.7067	73.247	< 2e-16 ***
<b>SITE 3</b>	-3.0485	1.0422	-2.925	0.003470 **
<b>SITE 4</b>	-4.5374	1.1830	-3.836	0.000128 ***
<b>SITE 5</b>	-5.5243	1.1081	-4.985	6.54e-07 ***
<b>CONTROL</b>	-2.5194	1.0551	-2.388	0.017010 *

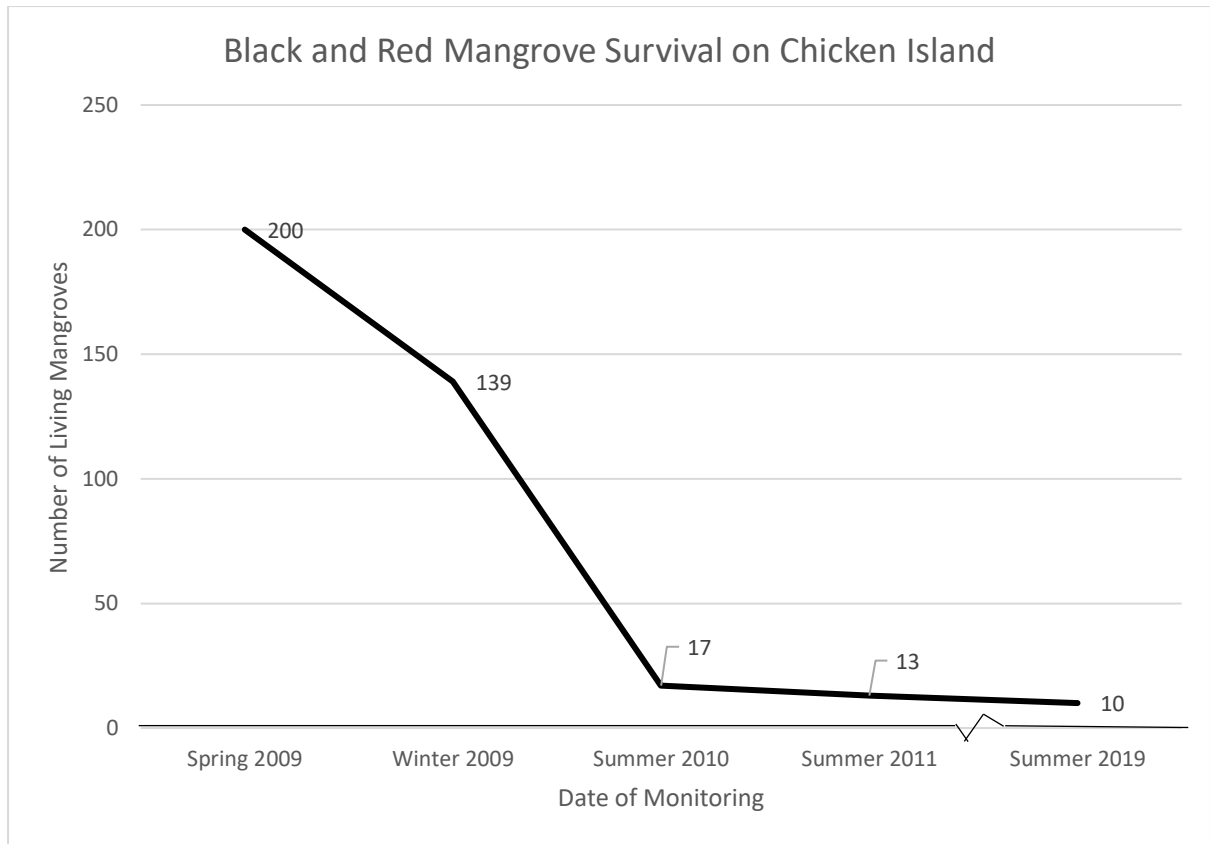
**Significance codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1**

**Table 6 GLM of oyster density at Chicken Island**

	ESTIMATE	STD. ERROR	T VALUE	PR(> T )
<b>SITE 1</b>	48.312	2.894	16.693	< 2e-16 ***
<b>SITE 3</b>	-4.446	4.161	-1.069	0.28888
<b>SITE 4</b>	-19.713	4.161	-4.738	1.08e-05 ***
<b>SITE 5</b>	-12.979	4.161	-3.120	0.00262 **
<b>CONTROL</b>	-6.379	4.161	-1.533	0.12966

**Significance codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1**

In total, 130 reef balls were found intact, 9 reef balls were found loose, and 57 were not found at all. Live oysters were observed on intact reef balls. In the 2019 survey, 9 total black mangroves were present and 1 red mangrove was found. Plotting observed mangrove survival from the time of deployment to the 2019 survey, it appears that there as a dramatic decline in mangrove survival by summer 2010 and populations did not recover between 2010 and 2019 (Figure 7).

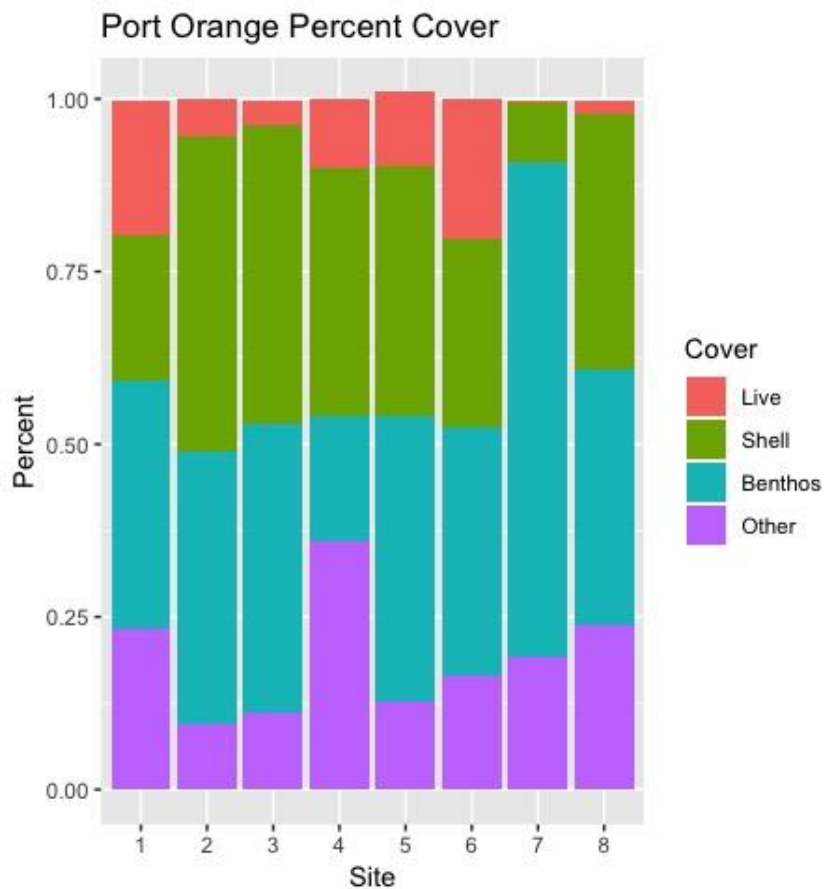


**Figure 7 Survival of black and red mangroves on Chicken Island**

### Port Orange

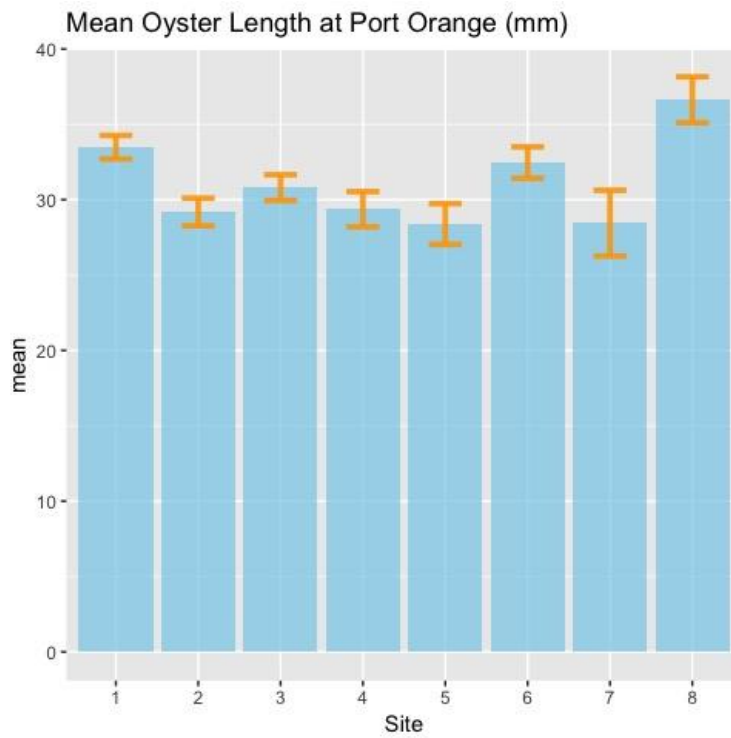
Percent cover was calculated to determine if the dominant cover consisted of live oysters, oyster shells, benthos, or other (Figure 8). The mean percent cover ( $\pm$  SE) was calculated for each study site, as well as the control. Benthos was the dominant cover across sites, covering  $40.13\% \pm 0.04$  of the area. It was followed by  $31.88\% \pm 0.03$  cover of oyster shell,  $19.05\% \pm 0.03$  other, and  $8.93\% \pm 0.02$  cover of live oyster. Shell and benthos dominated every site in Port Orange.



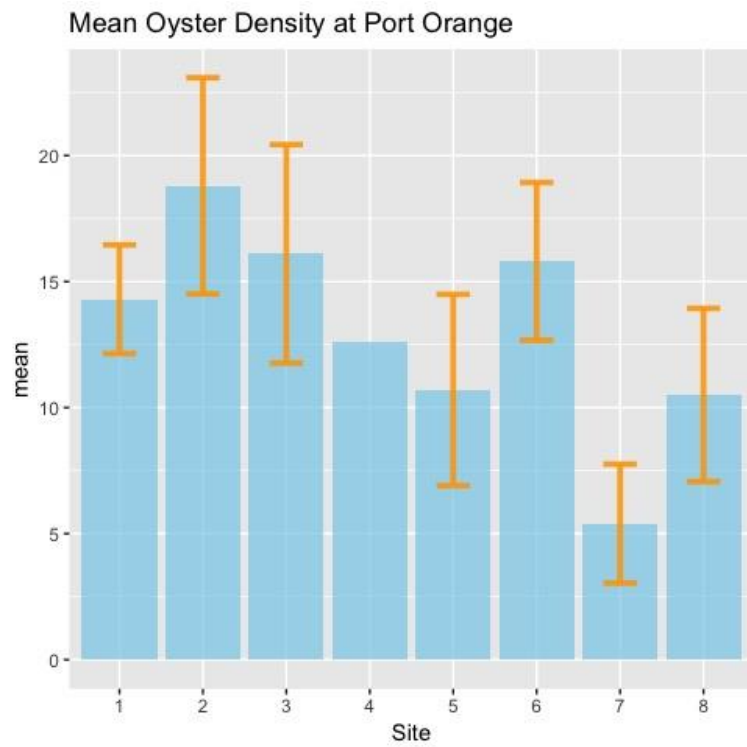


**Figure 8 Percent Cover at Port Orange**

The mean oyster reef height was  $15.85 \pm 1.38$  cm and the mean oyster shell length was  $3.18 \pm 0.40$  cm. The original proposal for the Port Orange restoration site identified the goals of reaching an oyster density of 35 oysters and 6 bridges per mat, or 0.25 m<sup>2</sup>. In the 2019 survey, a mean oyster density of  $13.03 \pm 1.27$  and a mean of  $6.73 \pm 1.49$  clusters per 0.25 m<sup>2</sup> was recorded (Figure 9, Figure 10). As no initial monitoring data was provided, the 2019 data was compared to the goals stated in the initial report. In one sided t-test comparing the 2019 mean oyster density and mean number of clusters to the theoretical values stated in the initial study, oyster density was significantly lower than the goals initially stated ( $\mu=35$ ,  $t = -17.25$ ,  $df = 79$ ,  $p < 0.01$ ), but number of clusters ( $\mu=6$ ,  $t = 0.48541$ ,  $df = 39$ ,  $p=0.6301$ ) was not significantly different.



**Figure 9 Mean oyster shell lengths at Port Orange (in mm)**



**Figure 10 Mean oyster density at Port Orange (per 0.25 m<sup>2</sup>)**

Generalized linear regressions were used to determine if the restoration methods used at different sites on the island had a significant effect on oyster shell length or density. Shells lengths were significantly different at Sites 1, 2, 4, 5, and 7, indicating that the location could be an appropriate predictor of oyster growth (Table 7). Of those sites, only Site 1 was estimated to have a positive effect on oyster length. Additionally, it should be noted that most live oysters were found on rock or the existing seawall which could have limited their survival and growth. Mean oyster densities at each site were highly variable and Site 1 was the only significant indicator of oyster density (Table 8).

**Table 7 GLM of oyster length at Port Orange**

	<b>ESTIMATE</b>	<b>STD. ERROR</b>	<b>T VALUE</b>	<b>PR(&gt; T )</b>
<b>SITE 1</b>	33.483	1.069	31.310	< 2e-16 ***
<b>SITE 2</b>	-4.302	1.419	-3.032	0.00249 **
<b>SITE 3</b>	-2.681	1.469	-1.825	0.06834
<b>SITE 4</b>	-4.117	1.563	-2.635	0.00854 **
<b>SITE 5</b>	-5.099	1.635	-3.120	0.00186 **
<b>SITE 6</b>	-1.020	1.476	-0.691	0.48948
<b>SITE 7</b>	-5.038	2.043	-2.467	0.01380 *
<b>SITE 8</b>	3.146	1.644	1.914	0.05587

**Significance codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1**

**Table 8 GLM of oyster density at Port Orange**

	<b>ESTIMATE</b>	<b>STD. ERROR</b>	<b>T VALUE</b>	<b>PR(&gt; T )</b>
<b>SITE 1</b>	14.300	3.542	4.037	0.000133 ***
<b>SITE 2</b>	4.500	5.009	0.898	0.372007
<b>SITE 3</b>	1.800	5.009	0.359	0.720400
<b>SITE 4</b>	-1.700	5.009	-0.339	0.735321
<b>SITE 5</b>	-3.600	5.009	-0.719	0.474676
<b>SITE 6</b>	1.500	5.009	0.299	0.765466
<b>SITE 7</b>	-8.900	5.009	-1.777	0.079844
<b>SITE 8</b>	-3.800	5.009	-0.759	0.450577

**Significance codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1**

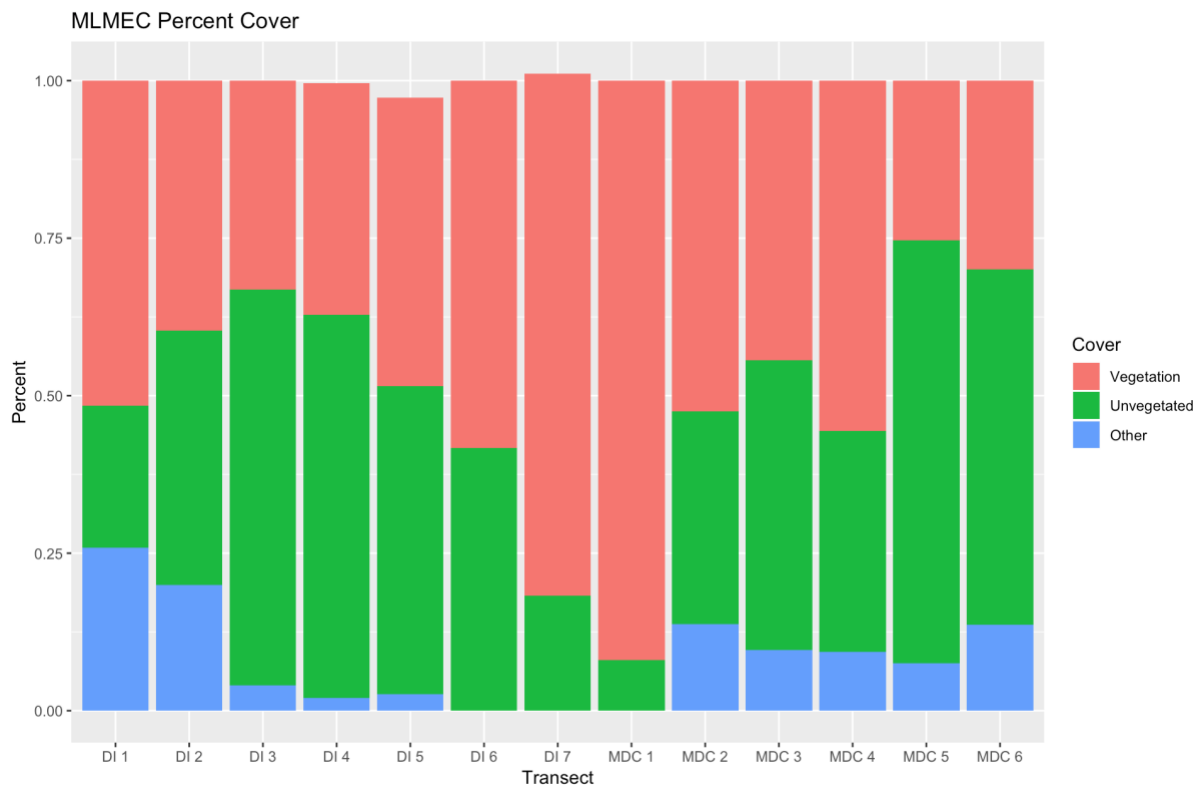
Looking at the biodiversity of the study site, 6 species were present besides oysters, the most prominent being black mangroves trees (n=20), red mangrove seedlings (n=24), and red mangroves trees (n=15) (Table 9). No invasive species were observed.

Table 9 Species identified at Port Orange

Scientific										
Name	Common Name	Total	1	2	3	4	5	6	7	8
<i>Avicennia</i>	Black Mangrove		—							
<i>germinans</i>	Tree	20	0	13	2	0	0	5	0	0
	Black Mangrove									
	Seedling	8	0	0	0	0	0	0	3	5
<i>Rhizophora</i>	Red Mangrove									
<i>mangle</i>	Tree	15	0	6	1	0	0	8	0	0
	Red Mangrove									
	Seedling	24	0	0	0	0	0	5	0	19
<i>Laguncularia</i>										
<i>racemosa</i>	White Mangrove	3	0	3	0	0	0	0	0	0
	White Mangrove									
	Seedling	6	0	0	0	0	0	5	0	1
<i>Sarcocornia</i>										
<i>ambigua</i>	Glasswort	1	1	0	0	0	0	0	0	0
<i>Spartina</i>										
<i>alterniflora</i>	Spartina	5	0	0	0	1	3	0	1	0
<i>Borrchia</i>										
<i>frutescens</i>	Sea ox-eye daisy	4	0	0	0	1	2	0	1	0

## Mosquito Lagoon Marine Enhancement Center

Percent cover was calculated to determine if dominant cover was vegetated, unvegetated, or other (Figure 11). For cover calculations, the first three quadrats from each transect were excluded as they largely were in the intertidal and not the ecotone. The mean percent cover ( $\pm$  SE) was calculated for each study site. Vegetation was the dominant cover ( $62.28\% \pm 0.05$ ) followed by unvegetated ( $34.1\% \pm 0.05$ ). There was very little else that comprised the ‘other’ category ( $3.26\% \pm 0.02$ ). Prior to enhancement, vegetation covered less than 55%, and in the post-deployment survey in summer 2016, the mean percent cover of vegetation was 71%. The 2019 data exhibits a slight decrease in vegetation across Discovery Island and the MLMEC march, but otherwise healthy vegetative cover.



**Figure 11 Percent Cover at MLMEC**

**Table 10 Species identified at MLEMC**

Scientific Name	Common Name	Total	DI 1	DI 2	DI 3	DI 4	DI 5	DI 6	DI 7	MDC 1	MDC 2	MDC 3	MDC 4	MDC 5	MDC 6
<i>Avicennia germinans</i>	Black Mangrove - Tree	104	0	2	0	11	4	0	0	13	15	47	3	0	9
	Seedling	263	34	22	28	0	18	1	5	56	11	0	35	3	50
<i>Rhizophora mangle</i>	Red Mangrove - Tree	22	10	2	0	0	0	0	0	1	1	1	2	1	4
	Seedling	10	4	2	3	0	1	0	0	0	0	0	0	0	0
<i>Laguncularia racemosa</i>	White Mangrove - Tree	34	3	2	0	9	3	0	0	0	14	0	3	0	0
	Seedling	44	9	4	11	0	18	0	0	0	0	0	2	0	0
<i>Salsola</i>	Saltwort	45	3	0	0	2	0	0	0	5	0	0	35	0	0
<i>Salicornia</i>	Glasswort	130	0	0	6	7	8	0	0	36	0	0	73	0	0
<i>Uca pugnax</i>	Fiddler Crab	25	2	3	1	0	0	0	0	0	12	0	0	7	0
	Fiddler Crab Holes	873	16	11	34	69	24	40	18	121	110	136	149	45	100
<i>Borrchia frutescens</i>	Sea Oxeye	33	6	1	0	26	0	0	0	0	0	0	0	0	0
<i>Sesuvium portulacastrum</i>	Sea Purslane	115	9	15	9	76	6	0	0	0	0	0	0	0	0
	Saltbush	3	3	0	0	0	0	0	0	0	0	0	0	0	0
<i>Atriplex</i>	Grass	56	4	6	6	13	14	8	5	0	0	0	0	0	0
	Ruderal	388	113	90	10	107	34	1	25	0	8	0	0	0	0
<i>Spartina bakeri</i>	S. bakeri	2	1	0	0	0	1	0	0	0	0	0	0	0	0
<i>Spartina alterniflora</i>	S. alterniflora	376	0	0	0	0	0	0	0	44	222	69	19	19	3
<i>Helianthus debilis</i>	Dune Sunflower	14	5	9	0	0	0	0	0	0	0	0	0	0	0
<i>Ambrosia</i>	Ragweed	2	2	0	0	0	0	0	0	0	0	0	0	0	0
<i>Gaillardia</i>	Blanket Flower	224	0	27	197	0	0	0	0	0	0	0	0	0	0
	Gastropods	3	0	0	1	0	0	0	0	0	0	2	0	0	0
<i>Portulaca grandiflora</i>	Rose Moss	4	0	0	4	0	0	0	0	0	0	0	0	0	0
<i>Opuntia</i>	Prickly Pear	8	0	0	0	3	0	5	0	0	0	0	0	0	0
<i>Juniperus virginiana</i>	Southern Cedar	1	0	0	0	0	0	1	0	0	0	0	0	0	0
<i>Sabal palmetto</i>	Cabbage Palm	1	0	0	0	0	0	1	0	0	0	0	0	0	0
<i>Geukensia demissa</i>	Ribbed Mussels	37	0	0	0	0	0	0	0	0	0	2	8	26	1
<i>Scylla serrata</i>	Mud Crab	3	0	0	0	0	0	0	0	0	0	0	3	0	0
<i>Cirripedia</i>	Barnacle	1	0	0	0	0	0	0	0	0	0	0	0	0	1

Biodiversity and plant abundance were high at the MLMEC restoration site (Table 10). 25 species were present besides oysters, the most prominent being *S. alterniflora* (n = 376), black mangrove seedlings (n = 263), and blanket flower (n = 224). No invasive species were observed.

In the winter 2017 post-deployment survey, there was a mean oyster density of  $41.5 \pm 6.7$  oysters per 0.25 m<sup>2</sup> with a mean size of  $4.7 \pm 0.5$  cm. In the 2019 survey, a mean oyster density of  $21 \pm 3.62$  and a mean size of  $5.24 \pm 0.78$  cm per 0.25 m<sup>2</sup> (Figure 12, Figure 13). In one sided t-test comparing the 2019 mean oyster density to the theoretical value stated in the initial study, oyster density was significantly lower than the post-deployment survey ( $\mu = 41.5, t = 13.907, df = 524, p < 0.001$ )

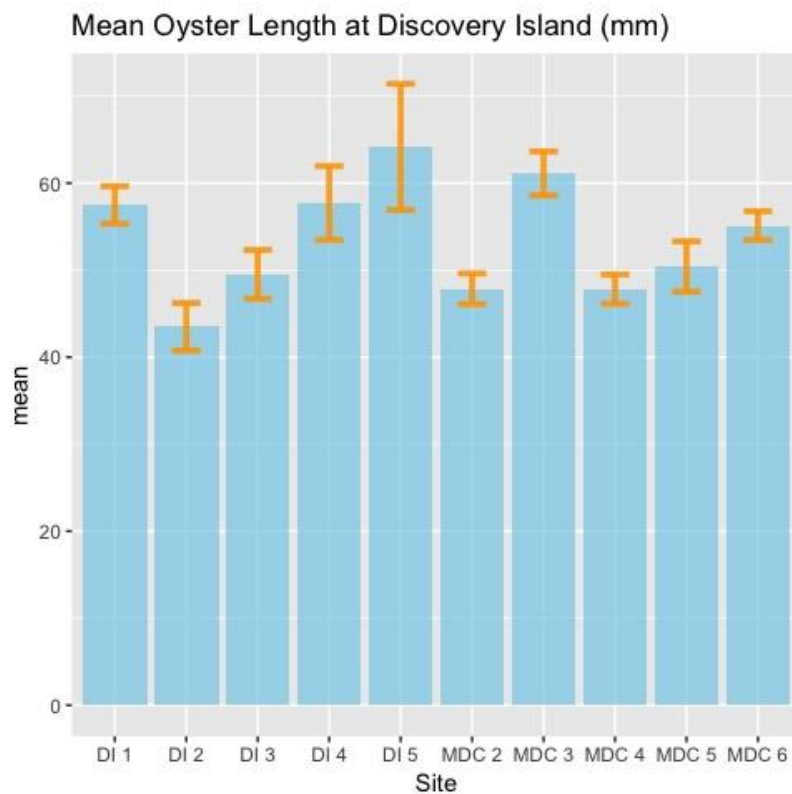
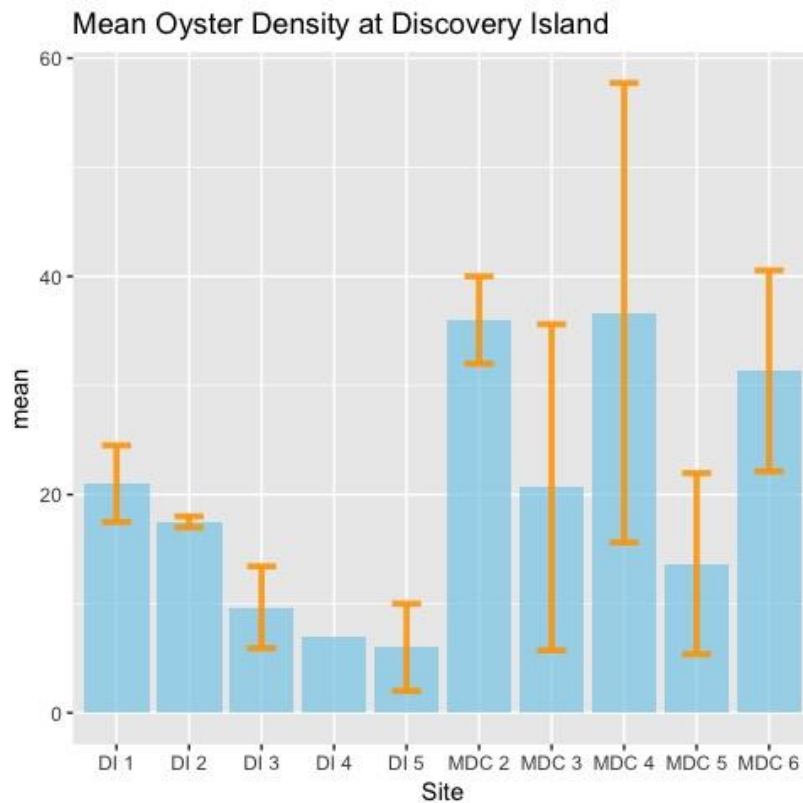


Figure 12 Mean oyster lengths at MLMEC (in mm)





**Figure 13 Mean oyster density MLMEC (per 0.25 m<sup>2</sup>)**

Generalized linear regressions were used to determine if the restoration methods used at different sites on the island had a significant effect on oyster shell length or density. Shells lengths were significantly different at Sites DI 1, DI 2, MDC 2, and MDC 4, indicating that the location is an appropriate predictor of oyster growth (Table 11). Mean oyster densities at each site were highly variable and it could not be concluded that location or restoration method were significant indicators of oyster density (Table 12).

Table 11 GLM of oyster lengths at MLMEC

	ESTIMATE	STD. ERROR	T VALUE	PR(> T )
<b>DI 1</b>	57.4921	2.1671	26.530	< 2e-16 ***
<b>DI 2</b>	-14.0063	3.6262	-3.863	0.000127 ***
<b>DI 3</b>	-7.9748	3.8598	-2.066	0.039319 *
<b>DI 4</b>	0.2222	6.8529	0.032	0.974144
<b>DI 5</b>	6.6746	5.4177	1.232	0.218512
<b>MDC 2</b>	-9.6310	2.9674	-3.246	0.001248 **
<b>MDC 3</b>	3.6208	3.0770	1.177	0.239849
<b>MDC 4</b>	-9.6739	2.7177	-3.560	0.000406 ***
<b>MDC 5</b>	-7.0774	3.4514	-2.051	0.040814 *
<b>MDC 6</b>	-2.3750	2.8007	-0.848	0.396816

Significance codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

**Table 12 GLM of oyster density at MLMEC**

	<b>ESTIMATE</b>	<b>STD. ERROR</b>	<b>T VALUE</b>	<b>PR(&gt; T )</b>
<b>DI 1</b>	21.0000	10.6935	1.964	0.0684
<b>DI 2</b>	-3.5000	16.9080	-0.207	0.8388
<b>DI 3</b>	-11.3333	15.1230	-0.749	0.4652
<b>DI 4</b>	-14.0000	21.3871	-0.655	0.5226
<b>DI 5</b>	-15.0000	16.9080	-0.887	0.3890
<b>MDC 2</b>	15.0000	16.9080	0.887	0.3890
<b>MDC 3</b>	-0.3333	15.1230	-0.022	0.9827
<b>MDC 4</b>	15.6667	15.1230	1.036	0.3166
<b>MDC 5</b>	-7.3333	15.1230	-0.485	0.6347
<b>MDC 6</b>	10.3333	15.1230	0.683	0.5048

**Significance codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1**

### Discussion

In an effort to restore and stabilize vulnerable and eroding shorelines in Volusia County, Florida, a number of living shoreline restorations have been implemented in the past decade. However, restoration projects often have limited funding that prevents the long-term maintenance and monitoring of restored areas. This is one of the first long-term evaluations of restoration success in the Indian River Lagoon system. This study revisited three sites restored between 2009 and 2016 to evaluate the long-term success of community restoration sites and if they met or surpassed the goals outlined in the initial project reports. At each location, combinations of restoration methods were used, including oyster mats, oyster bags, reef balls, mangrove and spartina plantings, and plantings of upland hammock. In evaluating

oyster recruitment and growth, percent cover of habitats, and biodiversity, this study found a range of restoration success across the three study sites. With two of the three restoration sites exhibiting significant increases in ecosystem function, the null hypothesis can be rejected.

Restored in 2009, Chicken Island is located adjacent to the Atlantic Intracoastal Waterway and was restored with the intent of addressing the long-term impacts it had experienced from waves, boat wakes, tides, and adverse weather, which had altered the natural shoreline. Combinations of oyster mats, oyster bags, and reef balls were installed to promote oyster recruitment and to assist with wave attenuation. Compared to the theoretical goals outlined in the initial project report, the 2019 survey found significantly higher mean oyster densities and oyster clusters than initially anticipated where restoration was intact. Conversely, on the south side of the island, there were no reef balls or oyster bags found. While benthos was the dominant cover ( $41.8\% \pm 0.04$ ), live oysters were a close second, covering an average of  $36.2\% \pm 0.03$  of the study area. This high live oyster percent cover, in addition to the observed mean oyster reef height of  $43.72 \pm 3.38$  cm and mean oyster shell length of  $4.85 \pm 0.35$  cm, indicate the development of healthy, mature oyster reefs. These developed reefs and the presence of the majority of the reef balls installed should assist in wave attenuation and substrate stabilization. Only 5% of deployed mangroves were located, signifying that the reef ball deployment of mangrove seedlings in this location was unsuccessful. As location was shown to be a significant indicator of oyster shell length and density, we can conclude that the smaller oyster size and lower oyster densities at sites 4 and 5 was a result of factors that affected those sites and not the other three sites. Both site 4 and 5 are on the southwest side of the island where fetch is much greater, increasing the potential for high wave energy along

that shoreline. Overall, we can categorize Chicken Island as being a moderately successful restoration.

The Port Orange study site is found along the Halifax River adjacent to approximately 40 residential homes and was restored in 2011. The shoreline is completely developed and much of the area has historic bulkhead to provide protection. Combinations of oyster mats, oyster bags, and *S. alterniflora* were installed to promote oyster recruitment and increase shoreline stabilization. Benthos was the dominant cover across sites, covering  $40.13\% \pm 0.04$  of the area and was closely followed by  $31.88\% \pm 0.03$  cover of oyster shell. Live oysters made up very little of the cover at only  $8.93\% \pm 0.02$ . With a mean oyster shell length of  $3.12 \pm 0.40$  cm and mean oyster density of  $13.03 \pm 1.27$  per  $0.25 \text{ m}^2$ , the average oyster density was significantly lower than the goal density indicated by the original study. Additionally, only 6 species were identified besides oysters, which is one-third of the goal of 18 species initially specified. Only 5 of the planted *S. alterniflora* plants deployed were still present at the time of the 2019 survey. This low oyster recruitment, low live oyster cover, and low biodiversity indicate that this living shoreline was not successful in the long-term. This could be due to the location not being an ideal candidate for this type of restoration. The area's wind-wave potential is categorized from medium to high and prior to the enhancement, only one quarter of the shoreline supported emergent vegetation. Additionally, it could be the elevation at which the plants and oysters were installed was not appropriate for growth and survival. The Port Orange site can be described as having low restoration success.

Two sites were restored at the Mosquito Lagoon Marine Enhancement Center in 2016 – Discovery Island, a small spoil island restored to provide educational outreach experiences,

and an area of marshland that aids in erosion control. Combinations of oyster bags, and *S. alterniflora* were installed to promote oyster recruitment and increase shoreline stabilization. In 2019, vegetation was the dominant cover ( $62.28\% \pm 0.05$ ) followed by unvegetated ( $34.1\% \pm 0.05$ ). Prior to enhancement, vegetation cover was 55%, and in the post-deployment survey in summer 2016, the mean percent cover of vegetation was 71%. The 2019 data exhibits a dominant vegetative cover that had significantly increased from the initial restoration but experienced a decrease in vegetation since the 2017 survey. This could be due to differences in season during which monitoring was conducted. Biodiversity and plant abundance were high at the MLMEC restoration site, with 25 species were present besides oysters. In the winter 2017 post-deployment survey, there was a mean oyster density of  $41.5 \pm 6.7$  oysters per  $0.25 \text{ m}^2$  with a mean size of  $4.7 \pm 0.5 \text{ cm}$ . In the 2019 survey, a mean oyster density of  $21 \pm 3.62$  per  $0.25 \text{ m}^2$  and a mean size of  $5.24 \pm 0.78 \text{ cm}$ . While oyster density decreased and oyster size increased, it could be hypothesized that the decrease in density could be due to oysters crowding each other out as they increase in size. Unvegetated areas and lower oyster densities appeared to occur on transects running through site 2 on Discovery Island where terracing and stabilization was conducted around the entry point to the island. In sum, the MLMEC site had moderate to high restoration success.

While this is one of the first studies providing insight into the long-term success of living shoreline restoration in the Indian River Lagoon, the differences between these sites provides insight into how site characteristics play into devising what restoration methods will be the most successful in the long run. It is critical to perform pre-restoration analyses of potential restoration sites to best understand the ecology of the area and the abiotic factors interacting with the existing ecosystems that are causing erosion. As the MLEMEC sites and Chicken

Island experienced, at the very least, moderate success, the data suggests that living shorelines are the most successful in areas with little grey infrastructure, low wind-wave potential, and limited impacts from boat wakes. Conversely, as the south side of Chicken Island and the entirety of the Port Orange site had low success rates, living shorelines may perform well in areas that are highly impacted by boat traffic and high wind-wave potential. In terms of mixing grey and green infrastructure, the Port Orange site would suggest that using oyster mats and bags, as well as *S. alterniflora* in front of existing riprap does not produce long-term restoration success. However, without further investigating other abiotic factors that may have been at play in this area, it is difficult to determine if the area's high wind-wave potential was the reason this living shoreline did not succeed. Based on these findings, it is suggested that green infrastructure and living shorelines be used where possible due to their low cost, malleability and resilience, and their long-term success as a coastal restoration methodology.

There are a number of abiotic factors that may have played a role in the long-term success or failure of these restoration sites that were not taken into consideration in this study. There could have been damage from Hurricane Matthew in 2016 that affected oyster density and plant abundance if reefs and plants were not mature enough to withstand the impacts of the hurricane and act as a buffer for the shoreline. Additionally, factors such as increased water temperature, water pollutants, or sediment suspension in the water column could have affected the development of the living shorelines, yet they were not measured or taken into account in this study or the initial studies. It is also important to consider the spatial context of the area of restoration and the methodologies used to install living shorelines. In terms of differences in ecosystem function, it is important to consider that Port Orange is along a

highly developed roadway and hardened shorelines, while Chicken Island is an uninhabited island with a dense vegetative fringe. Additionally, the elevations for installation of oyster mats, oyster bags, and reef balls may not have been ideal for plant and spat recruitment. Challenges were also introduced through the limited amount of initial monitoring data and trying to translate the initial methods used into best practices used today. In further analyses of the long-term success rates of living shorelines, abiotic factors, spatial context, and restoration methodologies should be taken into consideration to give a more complete picture of the ecosystem function of living shorelines.



## **CHAPTER THREE: COMMUNITY RESTORATION IDENTITIES**

### Methods

An online survey through the Survey Monkey platform was distributed to volunteers who participated in the restoration projects studied and who are 18 years old or older at the time of the current study through email. The questions used in the survey were based on personal and community identity, volunteer duration, access to volunteer opportunities, and likelihood for participation in similar opportunities in the future (Appendix A). The survey was sent out by email to those who previously volunteered with the restoration projects in question and provided their email addresses at the time of the project. This was selected as the best means of contact for distributing an online survey specifically to individuals previously involved in the restoration. Researcher contact information was provided for any individuals who may have had questions regarding the research, or the information provided on the informed consent form. Consent forms were distributed with each survey and each participant was requested to submit acknowledgement of their consent (Appendix B). At the end of the survey, participants were asked if they are willing to be contacted for participation in a one-on-one interview. If they consented, they were asked to provide contact information. The contact information was removed from the survey results and the survey was assigned a participant number. The contact information was stored in an excel file separate from the survey results and from any other data besides the participant number. This information was stored on a secured computer that only the researchers involved in the study had access to. At the conclusion of the study, this information was destroyed. The consent explained the purpose of the study and requested their potential participation in a one-on-one interview. All IRB guidelines were followed for this study (Appendix C).

## Results

Of the 2,549 volunteers who participated in these three living shoreline restoration projects, 103 emails were obtained from volunteer records. Given that many of the emails provided were from 10 years ago, at least 33 email accounts were no longer active, and the email bounced back to the sender. From the emails that did go through, the number of survey responses was  $n = 3$ . Due to such a low survey response rate, further interviews were not conducted.

## Discussion and Future Research

Due to the small sample size, conclusions cannot be drawn from the survey results and the findings cannot inform theory. However, the results can be indicative of the future research necessary to understand the connection between human and natural systems in Volusia County. According Kibler et al. (2018), it is difficult to quantify the full impact of coastal restoration because critical relationships between human and natural systems are poorly understood. When shoreline and ecosystem restoration are viewed through the lens of coupled human-nature systems, there are a number of positive and negative feedbacks that can occur. However, incorporating community engagement in restoration projects can utilize sense of place to create a chain of positive feedback (Kibler, et al., 2018). The small sample size of  $n = 3$  can offer suggestions for future research based on the identity-visualize-create framework and understandings of public perceptions of restoration success.

The first part of the identity-visualize-create framework is to identify and leverage existing attachments to the ecosystem. The Indian River Lagoon is a major tourist draw and economy

driver for Volusia County. Survey participants lived in Volusia County for an average of 21 years. Additionally, all participants indicated that they enjoy spending their time outdoors. Sense of place builds on the long-term relationship individuals have with a location. This relationship can be strengthened through increased interactions with one's surroundings such as through economic and ecosystem benefits and the recreation and natural beauty an area provides. These survey results are indicative of a strong sense of place within the IRL and provide ample support for the need for future research in the area. All survey participants also indicated that they volunteer with other local organizations, one of which indicated that they regularly volunteer with other environmental and restoration organizations. Future research would be beneficial in understanding if there are connections between volunteer identity and sense of place. As this place identity plays into an individual's decision to support or participate in restoration initiatives, it is critical to understand the intrinsic motivations that individuals have to volunteer and restore local coastlines.

The second component of identity-visualize-create framework is providing visualizations of the dynamic systems in the human-nature space to support the existing understanding of the benefits and implications of restorations. All participants in this study have previously participated in Volusia County restoration projects. Additionally, all participants held either a bachelor or advanced degree. It is critical to conduct future research to understand the knowledge community members have regarding coastal restoration. While participants in this survey had at minimum a college degree, it is important for researchers to have an understanding of the preexisting knowledge their audience has in order to improve community restoration programs. As levels of knowledge can vary throughout communities and research indicate that identity is largely formed during childhood, it may be of benefit for

restoration programs to assume low levels of knowledge in order to reach a broader audience in terms of age and education. Knowing the extent of sense of place and preexisting knowledge a community has regarding coastal restoration can give researchers a better idea of the actions, whether positive or negative, community members may make that can affect the human-nature system.

The final part of the identity-visualize-create framework is the creation of opportunities where sense of place can be realized through restoration work by explaining how particular projects are related to individuals' attachment to the area. The majority of percent indicated that they discovered the restoration opportunity through the Marine Discovery Center, where they likely were receiving education on the benefits of coastal restoration. After participating in these restoration projects all participants indicated that they had a positive experience participating in the project and that they were likely to recommend similar experiences to friends. It is important to understand why community member not only participate in restoration projects but continue to volunteer with the same programs as it can provide insight on how community members fulfill their place identity and their volunteer identity. Additional research needs to be done to understand if the Marine Discovery Center largely has return volunteers or if they regularly reach new areas of the community. Finally, further studies should investigate if the educational opportunities the Marine Discovery Center offers the community motivates them to participate as a volunteer in restoration projects. Not only is it important to provide restoration volunteer opportunities, but it is important to understand why volunteers participate in these projects and if the opportunity fulfilled their place identity.

It is important to understand community perceptions of restoration compared with the ecosystem function of the restored sites. Volunteer identity and sense of place, when coupled with ecosystem function, can be used to predict future attitudes and behaviors towards restoration efforts. Using the likelihood of ecosystem improvement with restoration in coupled human-natural space as modelled by Kibler et al. (2018), it can be predicted that there is a high likelihood for ecosystem improvement through restoration when existing restorations have high ecosystem function and when communities have a strong sense of place and individuals consider their volunteerism as part of their identity. Depending on the level of ecosystem function, stakeholders may be emotionally invested in the functional ecological system and dedicated to long-term monitoring of degrading areas or stakeholders may require some leveraging for continued ecological improvement. One of the results that stood out in this survey was that 100% of participants ranked the restorations as being very successful. In terms of ecological indicators of restoration success, Chicken Island and MLMEC were found to have moderate to high ecosystem success following restoration and Port Orange had low restoration success. If further research supports the sense that IRL community members perceive the restoration projects they participate in to be successful, their perception can drive increased community action as characterized by a strong sense of place. It is important to conduct additional research in this area to understand if these attitudes and perceptions are limited to past volunteers or if they extend further into the community. Despite varying biological evaluations of success of the three observed living shoreline restorations, public perceptions of success of these projects may drive the development of future restoration projects in Volusia County.

Without the data to provide enough insight into the behavioral motives of the volunteers in the restoration projects being researched, the null hypothesis cannot be rejected. This research in volunteer role identity, sense of place, and conservation is critical as human and natural systems do not operate independently. Conservation and restoration projects cannot be successful without community buy-in and support. However, this leveraging of community members is not possible without understanding the relationship people have with their local environment and how this relationship help shapes their identity. Often, identity is defined through culture, social interactions, and environment. However, research into volunteer identity as it relates to conservation emphasizes the identities developed through the natural systems they interact with. Using this understanding of identity, conservation researchers can better predict behaviors of individuals that will either be of benefit or detriment to natural systems and restoration efforts. While this research resulted in no significant findings, it did provide valuable insight into the need for future research on the relationships between identity, sense of place, and restoration efforts.

## CHAPTER FOUR: CONCLUSIONS

Anthropogenic actions and climate driven changes have led to the destruction of coastal habitat that provide critical ecosystem services and act as important buffer zones. Both grey and green infrastructure solutions have been proposed to retard the decay of coastlines. In Volusia County, living shorelines have becoming an increasingly popular choice in shoreline restoration and stabilization. Three community-based restorations that implemented living shorelines and engaged local community members in restoration efforts and education were observed in this study. Living shorelines were implemented at Chicken Island, Port Orange, and MLMEC in 2009, 2011, and 2016 respectively. This study was conducted to determine if these restorations were successful in the long-term and if they produced positive public perceptions of success of coastal restoration.

The three study sites experienced varying levels of biological success as determined by oyster size and density, biodiversity, and percent cover. Chicken Island, which was restored after waves, boat wakes, tides, and adverse weather altered the natural shoreline, had significant increases in oyster size and density on the north side of the island but had an unsuccessful deployment of mangrove seedlings in reef balls. The Port Orange study site installed living shoreline along an existing sea wall and experienced low oyster recruitment, unsuccessful *S. alterniflora* propagation, and high cover of benthos and loose shell likely due to the fact that the site was identified as having medium-high wind wave potential. MLMEC, the latest of the three sites, showed promising increases in vegetative cover and biodiversity from the initial restoration, as well as decreased oyster density coupled with increased oyster size, indicating the development of large, healthy oysters.

A survey of volunteers who participated in these three restoration projects was conducted to determine if there is a tie in ecosystem function produced through restoration and community perceptions of restoration success. Due to a small sample size, conclusions were unable to be drawn from the survey results, but they were indicative of future research critical to volunteer identity, sense of place, and restoration success. The survey indicated a need to better understand the degree to which Volusia County residents incorporate the IRL into their sense of place and how place identity and volunteer identity play a role in their decisions to participate in coastal restoration efforts. Additional research is necessary to understand the full impact coastal restoration has on the coupled human-natural system in the IRL system. Participants had strong perception of restoration success which suggests a need for further research into how the alignment of perceptions of restoration success and ecological measures of restoration success can drive future development of restoration projects. While a number of abiotic factors may play a role in the success of specific living shoreline projects, community involvement in such projects can boost sense of self and lead to the support of more restoration projects and investment in the long-term success of existing restorations.

This study is one of the first to not only evaluate the long-term success of living shorelines, but to attempt to understand the role volunteers play in restoration success. As a preliminary investigation into this research, there were a number of takeaways and lessons learned that can be used to better inform future studies. As the initial restorations took place 3-10 years ago, there were difficulties in finding information regarding methods used and the preliminary data that was collected before the restoration and in the initial months following the restoration. Much of the information and reports found were written to satisfy grant or partnership requirements, providing limited insight into what work was intended to be



performed versus what work was actually performed, as well as limited data provided from the short-term observation performed following the restoration. In terms of comparing success across restoration sites, there was little consistency in the data collected at each site that was indicative of success. This research suggests that indicators of coastal restoration success should be standardized in order to guide data collection when restoration projects are initially conducted and when they are evaluated in the future. In terms of gathering better data from restoration volunteers, there was difficulty in the long-term tracking and engagement of volunteers who participated in the projects in question. It may be of benefit to either regularly engage with volunteers following their participation in a restoration project or broaden the inclusion criteria to include volunteers from any restoration project in Volusia County rather than only including those who participated in a particular project. While further insights will arise as this area of research expands, the results from this study provide a useful starting point for further research.

Based on the results of this study, it is recommended that green infrastructure and living shorelines be used where possible due to their low cost, malleability and resilience, and their long-term success as a coastal restoration methodology. Further research is needed to understand the roles of abiotic factors in the long-term success or failure of coastal restorations as well as when it is appropriate to combine both grey and green infrastructure. In terms of volunteer engagement, restoration programs should seek ways to improve long-term engagement of volunteers. Green infrastructure is beneficial for this as volunteers can be involved in the installation and maintenance of living shorelines. This continuous involvement of volunteers not only benefits the long-term success of living shorelines but can potentially strengthen the place identity of community members who volunteer with

restoration projects. To improve the long-term success of living shorelines, it is critical to not only select restoration methods appropriate for the specific location of the restoration, but to involve local communities to increase sense of self and investment in restoration efforts.

## **APPENDIX A: SURVEY QUESTIONS**

## Survey Questions

1. What is your age?
2. What is your sex?
3. What is your education level?
4. How did you hear about this volunteer experience?
5. What did you do as a volunteer?
6. How would you rate your volunteer experience with this project?
7. How likely are you to participate in a similar volunteer experience?
8. How likely are you to recommend a similar volunteer experience to a friend?
9. How would you rate the success of this project in terms of its overarching goals?
10. Do you have internet access at home?
11. Do you enjoy spending time outdoors?
12. Do you use email?
13. Do you use social media?
14. How long have you lived in Volusia County?
15. How many times have you volunteered with coastal restoration projects in Volusia County?
16. Do you participate as a volunteer with organizations?
17. What other kinds of organizations do you volunteer with?
18. Are you willing to participate in a phone interview regarding this study? If yes, please provide your contact information below.

## **APPENDIX B: CONSENT FORM**

## **Explanation of Research**

**Title of Project:** Restoration Identities: Motivations for Participation in Coastal Restoration Volunteer Projects

**Principal Investigator:** Rachel Wimmer

**Co-Principle Investigators:** Linda Walters, Ph.D., Amanda Anthony, Ph.D.

You are being invited to take part in a research study. Whether you take part is up to you, so that participation is completely voluntary. You can withdraw from the study at any point without any repercussions by telling the researcher you would no longer like to participate. You must be 18 years of age or older and have participated in coastal restoration volunteer projects in Volusia County.

**Purpose of the research study:** The purpose of this research is to explore the identities and motivations individuals in communities adjacent to the Indian River Lagoon had to participate in past coastal restoration volunteer projects. The secondary goal of this research is to understand these individuals' interpretations of the projects' success as compared to the quantitative analysis of the success of the restoration projects from an ecological and restorative biology standpoint. The third goal is to understand how this information can be used to market to and successfully recruit new volunteers to participate in ongoing and future restoration work in the Indian River Lagoon and similar restoration projects.

The intent for this study is to understand the motivations for engagement in local coastal restoration projects in order to gain better insight into how to best engage future volunteers in similar projects.

### **What you will be asked to do in the study:**

- Complete an online survey. Participants will be given a survey related to topics volunteer identity and motivations to volunteer. Each survey should take participants no more than 10 minutes to complete.
- One-on-one interview. At the end of the survey, participants will be asked if there are willing to participate in a one-on-one interview over the phone, at the time of their choosing. They do not have to participate in the phone interview if they complete the survey, but they cannot participate in the interview unless they have first completed the survey. Transcriptions of audio recordings will occur after the completion of the interview and recordings will be erased or destroyed once the research has been completed. Each interview should take no more than 20 minutes to complete.

You can withdrawal from the study at any point in time. Your participation in the study will not affect your ability to volunteer in the future.

**Study contact for questions about the study or to report a problem:** If you have questions, concerns, or complaints: Rachel Wimmer, Graduate Student, Dr. Amanda Anthony, Assistant Professor, Sociology, College of Sciences,

Amanda.anthony@ucf.edu or Dr. Linda Walters, Professor, Biology, College of Sciences, Linda.walters@ucf.edu.

**IRB contact about your rights in the study or to report a complaint:** Research at the University of Central Florida involving human participants is carried out under the oversight of the Institutional Review Board (UCF IRB). This research has been reviewed and approved by the IRB. For information about the rights of people who take part in research, please contact: Institutional Review Board, University of Central Florida, Office of Research & Commercialization, 12201 Research Parkway, Suite 501, Orlando, FL 32826-3246 or by telephone at (407) 823-2901.

## **APPENDIX C: IRB LETTER OF APPROVAL**





UNIVERSITY OF CENTRAL FLORIDA

**Institutional Review Board**  
FWA00000351  
IRB00001138  
Office of Research  
12201 Research Parkway  
Orlando, FL 32826-3246

EXEMPTION DETERMINATION

February 28, 2019

Dear Rachel Wimmer:

On 2/28/2019, the IRB determined the following submission to be human subjects research that is exempt from regulation:

Type of Review:	Initial Study
Title:	Restoration Identities: Motivations for Participation in Coastal Restoration Volunteer Projects
Investigator:	Rachel Wimmer
IRB ID:	STUDY00000146
Funding:	None
Grant ID:	None

This determination applies only to the activities described in the IRB submission and does not apply should any changes be made. If changes are made, and there are questions about whether these changes affect the exempt status of the human research, please contact the IRB. When you have completed your research, please submit a Study Closure request so that IRB records will be accurate.

If you have any questions, please contact the UCF IRB at 407-823-2901 or [irb@ucf.edu](mailto:irb@ucf.edu). Please include your project title and IRB number in all correspondence with this office.

Sincerely,

Gillian Morien  
Designated Reviewer

## LIST OF REFERENCES

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