A Strategic Marine Area Plan for Hernando County

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Executive Summary

Marine resources are a major driver of the economy and tourism in Hernando County, and the County has identified a need to clearly identify goals objectives, and strategies for sustaining and improving marine resources in the region. This Strategic Marine Area Plan (S-MAP) summarizes a year-long collaboration between the authors and representatives from Hernando County to develop a strategic plan for the sustainable management of marine resources in the County, based on the best available science. The plan was developed with guidance from the Hernando County Port Authority, which included input from the public and other County officials in the course of five noticed public meetings. As agreed from the outset, the Plan addresses only the shoreline interface and marine waters within the political jurisdiction of Hernando County, which extends seaward to the state line, a distance of 9 nautical miles. The Plan addresses six goals that will sustain and improve the marine environment, tourism, access, and the ecological health of Hernando County's marine and coastal resources. These include: 1) shoreline stabilization, 2) oyster reef restoration, 3) artificial reefs, 4) recreational and commercial fisheries, 5) vessel navigation and water access, and 6) hardbottom and seagrass habitat. For each goal, we have outlined a specific set of objectives and strategies that reflect the County's input, as well as federal and state management and regulatory authority in marine waters. Each of these Goals is informed by a corresponding Science Plan, which includes specified action items that, if undertaken, will allow the county to sustainably manage its marine resources in the manner described in the Plan. The Science Plan for each goal also includes a flow chart that provides a conceptual pathway for achieving these goals. Further, the Plan includes a scientific literature review related to each goal, and where uncertainties exist we have specified research objectives that would allow data collection to reduce those uncertainties and improve the ability of the county to manage its marine resources.

Goal 1: To ensure that all estuarine shoreline interfaces in Hernando County contribute to the ecological health and resiliency of the County's coastal and estuarine ecosystems.

Objective 1.1: Promote the use of "living shorelines" as the preferred method of shoreline stabilization.

Strategy 1.1.1: Inventory the linear extent of all private residential and commercial shoreline parcels and publicly owned shoreline parcels to identify those parcels that can take full advantage of regulatory streamlining for living shorelines.

Strategy 1.1.2: Based on the inventory from Strategy 1.1.1, identify those parcels whose biophysical characteristics make them suitable for living shorelines.

Strategy 1.1.3: For those parcels that exhibit features suitable for living shorelines, develop an outreach/stakeholder engagement program and permitting/regulatory strategy to maximize their use.

Strategy 1.1.4: Develop a living shoreline monitoring program that tracks the success of living shorelines over time.

Objective: 1.2: Promote the use of "oyster gardens" by waterfront homeowners who have suitable habitats and available waterfront infrastructure.

Strategy 1.2.1: Inventory shoreline properties to determine those properties that have suitable habitat and waterfront infrastructure to install oyster gardens (e.g. docks, sea walls).

Strategy 1.2.2: Create a residential oyster gardening program.

Objective 1.3: Explore the potential for "living seawalls" to serve as a method for enhancing the ability of existing hardened shorelines to provide ecological benefits and to promote coastal resiliency.

Strategy 1.3.1: Research the ecological efficacy and cost effectiveness of living seawalls.

Strategy 1.3.2: Inventory existing seawalls that would benefit from the presence of a living seawall when a more sustainable option cannot be achieved.

Strategy 1.3.3: Establish a living seawall demonstration project.

Objective 1.4: Develop incentives to encourage riparian landowners to install living shorelines, oyster gardens, living seawalls and other shoreline-friendly techniques.

Strategy 1.4.1: Explore opportunities to create a small grants program that gives home and business owners access to raw materials needed to install living shorelines, oyster gardens, living seawalls and other shoreline-friendly practices.

Strategy 1.4.2: Provide technical assistance to home and business owners to install living shorelines, oyster gardens, living seawalls and other shoreline-friendly practices.

Objective 1.5: Promote community involvement and K-12 education related to shoreline management.

Strategy 1.5.1: Encourage programs such as “Grasses in Classes” in public and private schools.

Strategy 1.5.2: Explore opportunities to create a small grant program for curriculum development and field-based education, including marsh grass nurseries.

Shoreline Stabilization Key Policy Resources

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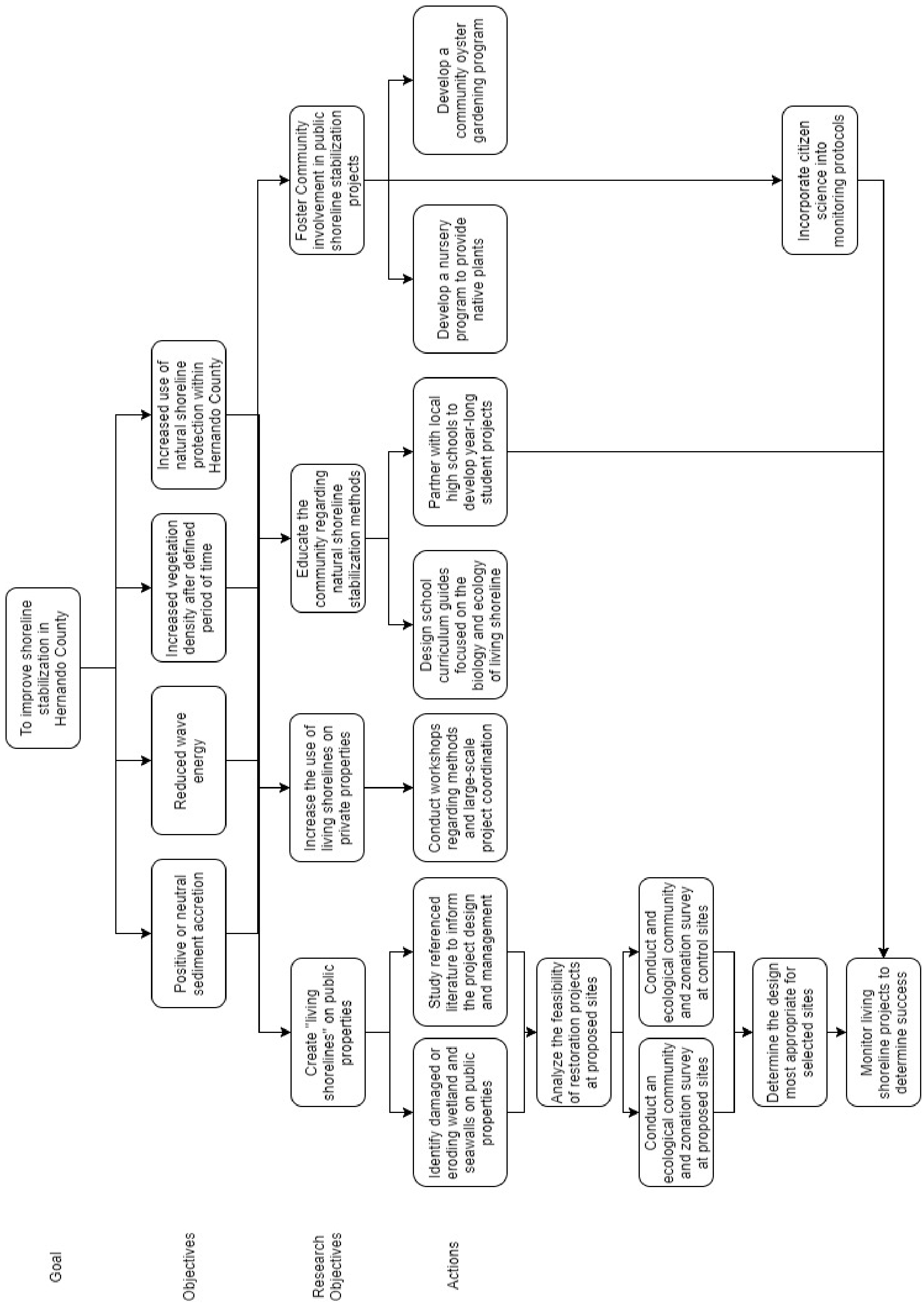
US Army Corps of Engineers (2017), Nationwide Permit Reissuance, http://www.usace.army.mil/Media/Fact-Sheets/Fact-Sheet-Article-View/Article/1043655/nationwide-permit-reissuance/.

US Army Corps of Engineers (2017) Nationwide Permit Bank Stabilization. http://www.nao.usace.army.mil/Portals/31/docs/regulatory/nationwidepermits/Nationwide_Permit_13.pdf?ver=2017-07-13-114446-990.


Goal
Objectives
Research Objectives
Actions
To improve shoreline stabilization in Hernando County
Positive or neutral sediment accretion
Reduced wave energy
Increased vegetation density after defined period of time
Increased use of natural shoreline protection within Hernando County
Create "living shorelines" on public properties
Increase the use of living shorelines on private properties
Educate the community regarding natural shoreline stabilization methods
Foster Community involvement in public shoreline stabilization projects
Identify damaged or eroding wetland and seawalls on public properties
Study referenced literature to inform the project design and management
Conduct workshops regarding methods and large-scale project coordination
Design school curriculum guides focused on the biology and ecology of living shoreline
Partner with local high schools to develop year-long student projects
Develop a nursery program to provide native plants
Develop a community oyster gardening program
Analyze the feasibility of restoration projects at proposed sites
Conduct an ecological community and zonation survey at proposed sites
Conduct and ecological community and zonation survey at control sites
Determine the design most appropriate for selected sites
Incorporate citizen science into monitoring protocols
Monitor living shoreline projects to determine success

Literature Review and Research Objectives

Goal 1. Shoreline Stabilization

Background:

Salt marshes are a type of coastal wetland that are flooded and drained by saltwater brought in by the tides. Dominated by salt-tolerant plants such as smooth cordgrass (*Spartina alterniflora*) and needle rush (*Juncus roemerianus*), these marshes cover many acres in northern Florida (Main and Creswell 2017). Coastal wetlands, such as salt marshes, are some of the most productive ecosystems on Earth. They support fisheries, act as nursery grounds to many different types of organisms and provide shelter and food for many finfish, shellfish, birds and other wildlife (Barbier et al. 2011). Indeed, these services have led salt marshes to be valued at $981 to $6,471 per acre (Barbier et al. 2011). This places the value of Hernando County's salt marshes conservatively at $12 million.

Although vulnerability varies by location, coastal communities can be highly susceptible to various hazards, including erosion, sea level rise, and storm surge. While erosion is a natural process, it becomes an area of concern when human infrastructure is present. Storm surge can cause extensive beach erosion and damage to infrastructure as high energy waves pummel the coastline. When compounded over time, the extent and severity of damage to infrastructure and coastal habitats can increase and potentially travel further inland as sea levels rise. Furthermore, the intensity and frequency of storm events are expected to increase which may also increase the risk of damages (Bender et al. 2010, Pachauri et al. 2015, Sutton-Grier et al. 2015).

Despite the extensive use of hardened structure to stabilize shorelines, it is not the most effective method for all conditions. In areas of high wave energy, hardened structures are a necessity to stabilize the coast and reduce the impacts of erosion (NOAA 2015). However, once they are built, hardened structures are unable to adapt to changing environmental conditions and can disrupt natural ecological processes that the system relies on. The vertical surface of seawalls deflects wave energy in such a way that sediment erodes underneath. This can compromise sea wall integrity and can eventually lead to the need for costly repairs. Furthermore, traditional hardened shoreline stabilization structures support less biodiversity and alter the natural slope of intertidal zones over time (Seitz et al. 2006, Bilkovic and Mitchell 2013, Sutton-Grier et al. 2015). This can ultimately lead to a loss of the salt marsh habitat.

The impact shoreline hardening incurs on these ecosystem services has led to an increased interest in more natural, ecosystem-based shoreline stabilization approaches. A wide variety of options are available ranging from hybrid to natural shoreline stabilization structures (NOAA 2015, Sutton-Grier et al. 2015). Natural infrastructures, often termed living shorelines, can incorporate many elements such as salt marsh, mangroves, oysters, and coral reefs depending on site conditions (Sutton-Grier et al. 2015). While research on these natural stabilization methods is ongoing, results do indicate that natural approaches can provide some key benefits such as storm protection, decreased erosion, and many ecosystem services (Barbier et al. 2011, Gedan et al. 2011, Shepard et al. 2011). Furthermore, living shorelines incorporating salt marsh grasses and oysters have the potential to keep up with sea level rise (Sutton-Grier et al. 2015).

Hernando County has extensive canal systems throughout the Hernando Beach community. Many properties around the Weeki Wachee Gardens, Bayport, and Pine Island rely on sea walls as a form of shoreline protection. Unfortunately, some of these structures are failing and need repair. In addition, coastal areas along Jenkins Creek and Linda Pedersen County Park have historically experienced erosion. Hernando County seeks to address these erosion issues using natural shoreline stabilization methods whenever possible. This move towards natural shoreline stabilization could provide a unique opportunity to assess the effects of these methods on a regional scale.

Goal: To improve shoreline stabilization in Hernando County through more natural methods. In addition, we aim to promote these best management practices through community participation, education, and outreach.

Project Success Criteria:

- Positive or neutral sediment accretion at selected sites
- Reduction in wave energy at selected sites
- Increase vegetation density at selected sites after a defined period
- Increase use of natural shoreline protection within Hernando County

Research Objective: Create living shorelines on public properties with a history of erosion issues

Action: Study important background information to inform planning, design, and management of natural shoreline stabilization projects.

- Visit NOAA's Habitat blueprint site for living shoreline training and information (https://www.habitatblueprint.noaa.gov/)
- Reference *Living Shorelines Engineering Guidelines* before baseline monitoring begins for guidance on designing sites based on measured parameters (Miller et al. 2015)

Action: Identify damaged or eroding wetland and seawalls on public properties

- Use aerial imagery over time and local knowledge to determine eroding wetland areas
- Inventory damaged seawalls which may be candidates for natural shoreline stabilization methods

Action: Analyze the feasibility of restoration projects at proposed sites

- Reference NOAA's *Conceptual Guidance for Considering the Use of Living Shorelines* in determining the feasibility of restoration at proposed sites (NOAA 2015)
- Determine the probable cause for erosion issues at identified sites

Action: Conduct an ecological community and zonation survey at proposed sites to determine their current condition (Currin et al. 2008, Miller et al. 2015)

- Measure baseline data for any parameters included in ongoing monitoring protocols
  - *See Neckles et al. (2002) for a thorough description of local and regional living shoreline assessment*
    - Standardizing monitoring protocols between sites will allow for a regional (within county) assessment of stated objectives
    - This resource also includes recommended monitoring frequencies
- Living shoreline design is often based on the following parameters (Miller et al. 2015)
  - Currents
  - Elevation
  - Prevailing wind and wave direction
  - Sediment erosion rate
  - Soil composition
  - Vegetation type and density
  - Water salinity
  - Wave energy

Action: Conduct an ecological community and zonation survey at nearby healthy (control) sites

- For surrounding healthy (control) sites, measure the same variables (*see above)*
  - This is needed to determine necessary design elements, possible elevation changes, and to quantify goal targets

Action: Determine the most suitable design for each proposed site to meet the stated project objectives while also fulfilling permitting and exemption requirements

- Utilize the *Living Shorelines Engineering Guidelines* handbook prepared for the New Jersey Department of Environmental Protection for guidance on site planning and design (Miller et al. 2015)
- Consider Table 1 in (Sutton-Grier et al. 2015) which discusses the strengths and weaknesses of a wide range of shore stabilization techniques
- Consider NOAA's *Living Shoreline Planning an Implementation* website for a description of design elements that can be incorporated into living shoreline designs (http://www.habitat.noaa.gov/restoration/techniques/lsimplementation.html)
- Use NOAA's MAPTITE ArcGIS tool to plan appropriate plant species for living shoreline projects based on elevation and tides

Action: Monitor living shoreline sites regularly to determine if stated objectives have been met

- *See Neckles et al. (2002) for detailed monitoring protocols designed for the assessment of objectives both on the local and regional scale*

Research Objective: Increase the use of living shorelines as a shoreline stabilization method on private properties

Action: Conduct workshops with stakeholders; these can be designed for many purposes

- To educate stakeholders regarding the use of natural shoreline stabilization methods
- To coordinate large scale projects which require the cooperation of multiple landowners

Research Objective: Educate the community regarding natural shoreline stabilization methods

Action: Design school curriculum guides which incorporate relevant living shoreline elements, biology, and ecology

Action: Partner with local high schools to develop year-long student projects

Research Objective: Foster community involvement in public shoreline stabilization projects

Action: Develop a nursery program to provide native plants for shoreline stabilization projects

Action: Develop a community oyster gardening program within Hernando County to provide oyster seed for shoreline stabilization projects

- Coordinate planning efforts with other organizations, such as Brevard Zoo, which have successful oyster gardening programs (https://restoreourshores.org/living-shoreline/oyster-mats-gardening/#oystergardeningtab)

Action: Incorporate citizen science into monitoring protocols to reduce cost and encourage public participation

- *See Currin et al. (2008) for insight regarding incorporating citizen scientists into monitoring protocols*

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Goal 2: To maintain, restore and create a robust system of nearshore oyster reefs that contributes to estuarine health, productive fisheries and coastal resiliency.

Objective 2.1: Ensure the health of existing oyster reefs in Hernando County.

Strategy 2.1.1: Inventory and map existing oyster reefs and systematically assess their relative health.

Strategy 2.1.2: Identify factors which contribute to the relative health of existing oyster reefs and any threats that have resulted or could result in degradation.

Strategy 2.1.3: Manage existing reefs to retain neutral oyster reef height and/or promote positive reef growth.

Strategy 2.1.4: Monitor existing oyster reefs to provide baseline data for future oyster projects.

Objective 2.2: Restore historic oyster reefs where current and foreseeable future conditions warrant their growth and sustainability.

Strategy 2.2.1: Inventory and map the historic maximum extent of oyster reef coverage in the nearshore waters of Hernando County.

Strategy 2.2.2: Identify the causes for the decline in historic oyster reef coverage and assess the ability to restore historic reefs, taking into consideration natural and anthropogenic coastal change.

Strategy 2.2.3: Prioritize restoration of larger-scale historic oyster reefs, taking into account changed conditions.

Objective 2.3: Create new oyster reefs in viable habitats that will contribute to estuarine health, productive fisheries and coastal resiliency.

Strategy 2.3.1: Identify and map suitable habitat for new oyster reef development where conditions warrant it.

Strategy 2.3.2: Encourage community-based programs to create small scale, low profile oyster reefs.

Objective 2.4: Ensure that Hernando County has a consistent source of cultch for use in restoration and creation of oyster reefs.

Strategy 2.4.1: Develop a shell recycling program and provide incentives to local restaurants to contribute discarded oyster shells.

Strategy 2.4.2: Consider a recycling program for discarded scallop shells such as collection at public boat ramps and marinas where scallop shells are discarded during scallop harvest season.

Strategy 2.4.3: Identify local and regional sources of non-shell based cultch from appropriate native materials (i.e. limerock).

Strategy 2.4.4: Consider the use of experimental materials and techniques such as cured concrete, precast reef modules such as reefballs and oyster shell gabions, and oyster catcher products.

Objective 2.5: By ____, create a comprehensive spatially-explicit Hernando County Oyster Reef Restoration and Management Plan that addresses existing, restored and created oyster reefs and their associated habitats.

Strategy 2.5.1: Delineate potential management areas including spawning reserves, experimental reef development sites, regulated harvest areas, and suitable but un-colonized habitat.

Strategy 2.5.2: Create and support a community-based oyster habitat management and restoration program that includes oyster gardening, living shorelines, shell recycling, and small-scale reef development coupled with education and outreach.

Strategy 2.5.3: Create a comprehensive monitoring program that monitors water quality, salinity, freshwater inputs, benthic habitat, navigation impacts, spat recruitment, fisheries enhancement, and bird foraging.

Strategy 2.5.4: Ensure plan consistency with existing federal, state, regional and non-governmental oyster reef restoration plans, programs and initiatives.

Strategy 2.5.5: Seek conceptual approval from regulatory agencies for oyster reef restoration and enhancement oyster reef projects identified by the Plan.

Oyster Reef Restoration Key Policy Resources

Charlotte Harbor National Estuary Program. (December 2012). Charlotte Harbor National Estuary Program Oyster Habitat Restoration Plan.

Deep Water Horizon Oil Spill Natural Resources Damage Assessment: Strategic Framework for Oyster Restoration Activities. (June 2017).

Dunn, R. and Ankersen, T. (June 2016). Thinking Big and Going Long: Adapting Florida's Conceptual Permitting Approach to Large-Scale Long-Term Restoration. Environmental and Land Use Law Section Reporter XXXVII:5.

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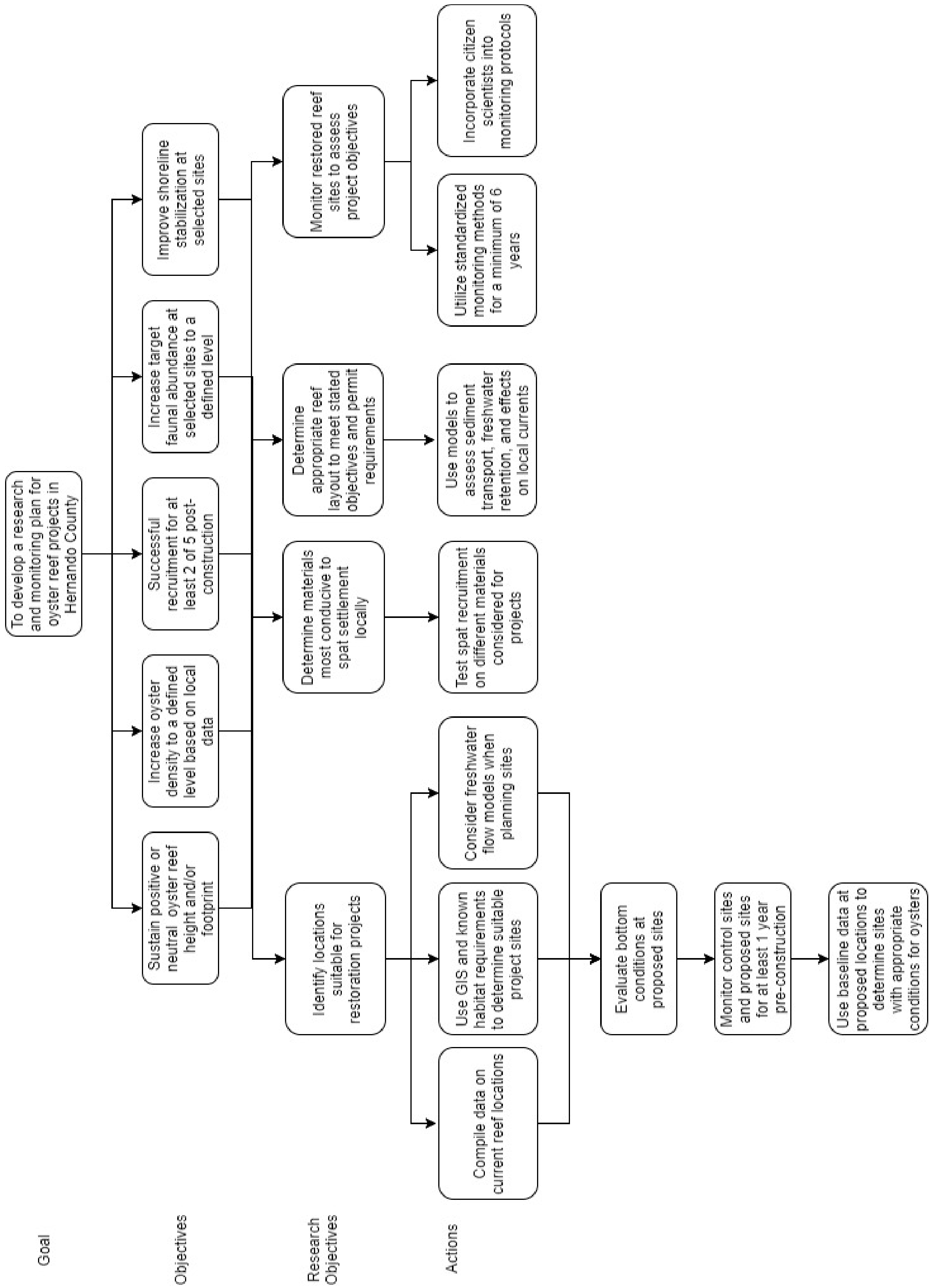
The Suitability of Concrete for Oyster Reef Restoration.


Goal
To develop a research and monitoring plan for oyster reef projects in Hernando County
Objectives
Sustain positive or neutral oyster reef height and/or footprint
Increase oyster density to a defined level based on local data
Successful recruitment for at least 2 of 5 post-construction
Increase target faunal abundance at selected sites to a defined level
Improve shoreline stabilization at selected sites
Research Objectives
Identify locations suitable for restoration projects
Determine materials most conducive to spat settlement locally
Determine appropriate reef layout to meet stated objectives and permit requirements
Monitor restored reef sites to assess project objectives
Actions
Compile data on current reef locations
Use GIS and known habitat requirements to determine suitable project sites
Consider freshwater flow models when planning sites
Evaluate bottom conditions at proposed sites
Monitor control sites and proposed sites for at least 1 year pre-construction
Use baseline data at proposed locations to determine sites with appropriate conditions for oysters
Test spat recruitment on different materials considered for projects
Use models to assess sediment transport, freshwater retention, and effects on local currents
Utilize standardized monitoring methods for a minimum of 6 years
Incorporate citizen scientists into monitoring protocols

Literature Review and Research Objectives

Goal 2. Oyster Reef Restoration

Background:

Oyster reefs throughout the Big Bend Region of Florida, mainly composed of the Eastern Oyster (*Crassostrea virginica*), are an integral part of estuarine habitats. These filter-feeding bivalves engineer complex reefs and bars in subtidal and intertidal zones that provide vital ecosystem services. Some of these ecosystem services include shoreline stabilization, water filtration, decreased turbidity, and nutrient cycling (Coen et al. 2007, Scyphers et al. 2011, Kellogg et al. 2013). Oyster reefs play a significant role in supporting many economically valuable finfish and crustaceans by providing habitat, food, and shelter (Lowery et al. 2007). Oysters are quite adaptable to changes in temperature and salinity. However, both natural and anthropogenic stressors over extended periods of time can negatively impact oyster recruitment, survival, and resistance to disease (Seavey et al. 2011, Petes et al. 2012). Therefore, it is important to consider both biotic and abiotic factors when selecting sites for successful oyster restoration or enhancement in Hernando County.

Since the 1970's, the overall extent of oyster reefs within the Gulf of Mexico has declined. This decline may be attributable to various factors, e.g., overharvest, shifting hydrology, and disease (Jackson et al. 2001, Carranza et al. 2009). Seavey et al. (2011) noted a 66 to 88% net loss of oyster reefs spanning from Cedar Key, Florida, to Horseshoe Beach, Florida, between 1982 and 2010. This loss was likely due to the human use and reduction of freshwater outflow from local rivers. Reductions in freshwater flow effectively shrink the amount of available habitat at optimal salinities for Eastern Oysters.

Minimal historical data regarding oyster reefs in Hernando County is available. However, the reefs for which information is available generally corroborate the results of previous work. Large oyster reefs offshore and adjacent to Weeki Wachee River were present in 1886. In addition, NOAA charts from 1977 document oyster reefs adjacent to the Chassahowitzka River. However, these reefs have since subsided (Raabe et al. 2004). This may be, in part, due to the reduced freshwater flows from the Chassahowitzka and Weeki Wachee rivers into the surrounding estuaries which was implemented in 1988 (Guvanasen et al. 2000).

Oyster reef restoration is a high priority for Hernando County due to the associated ecosystem services such as shoreline stabilization and fisheries benefits. However, careful design, collection of baseline data, and continued post-deployment monitoring are all pertinent to success at the selected sites. In addition, alteration of the environmental conditions responsible for reef degradation may be necessary to restore oyster habitats (Gregalis et al. 2009).

Goal: To develop a research and monitoring plan for the construction and ongoing management of eight oyster reef restoration projects over the course of seven years. The overarching goal of these reef restorations will be to increase shoreline stabilization and enhance local fisheries.

Project Success Criteria:

- Sustain positive or neutral oyster reef height and/or footprint
- Increase oyster density to a defined level based on local data (use baseline data from control sites to determine the success standard)
- Successful recruitment (use baseline data from control sites to determine the success standard) for at least two of five years following reef construction
- Increase target faunal abundance at selected sites to a defined level
- Improve shoreline stabilization at selected sites (*see also Shoreline Stabilization)*

Research Objective: Identify locations suitable for restoration projects

Action: Compile data in a similar manner to Seavey et al. (2011) regarding historic and current reef locations using aerial photos from the Land Boundary Information System or some other source

Action: Use GIS in conjunction with known habitat requirements to determine suitable locations for oyster reefs designed to meet project objectives

- Consider using a Habitat Suitability Index similarly to Barnes et al. (2007)
- Consider wave energy and slope
- Consider access to fishing when determining site locations
- Consider sources of threats in the area that could negatively impact reefs:
    - Sedimentation
    - Storm water runoff
    - Point sources of pollution
    - Poorly flushed areas
    - Locations that would be navigational hazards
    - Locations of future coastal development

Action: Consider freshwater flow models to determine the effect of water use projections on oyster reef restoration projects and plan sites accordingly (Parker et al. 2013, Buzzelli et al. 2015)

Action: Evaluate bottom conditions at to determine if the selected site will support the materials used for habitat restoration

Action: Monitor current oyster reefs (as control sites) and proposed restoration sites for a minimum of one year to determine realistic project success benchmarks, specialized habitat requirements, and site suitability (Baggett et al. 2015)

- Physical Measurements:
    - Reef footprint (m^2)
    - Reef area (m^2)
    - Reef height (m)
- Environmental variables
    - Water temperature (°C)

    - Salinity (ppt or psu)
    - Dissolved oxygen (subtidal only, mg/L)
- Test oyster recruitment at proposed and natural control sites using spat collectors

Action: Use baseline data at proposed sites to determine areas with high spat recruitment, low spat mortality, and the lowest frequency of hypoxic and anoxic conditions (Gregalis et al. 2009).

- Oyster recruitment and abundance varies by location based on natural spat settlement
- The study's most successful reef was 2-3 km away from the nearest natural reef

Research Objective: Determine materials most conducive to spat settlement locally

Action: Test recruitment potential of limestone rock, oyster shell, mixed materials, or biodegradable alternatives

- Consider scientific literature such as La Peyre et al. (2014) which found that spat density was higher on rock reefs than shell reefs in the Gulf of Mexico

Research Objective: Determine appropriate reef layout to meet stated objectives and permit requirements

Action: Use models to assess sediment transport, freshwater retention, and effects on local currents

Research Objective: Monitor restored reef sites to assess project objectives

Action: Utilize recommendations by Baggett et al. (2015) to monitor and assess project objectives for a minimum of six years

Action: Incorporate citizen scientists into monitoring protocols to engage the community and decrease monitoring costs

- Pre- and post- reef site monitoring conducted by citizen science groups
- Volunteer SCUBAdivers

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Goal 3: To enhance Hernando County's fisheries by maximizing available structure for recreationally important fish species at all life history stages through artificial reef deployment.

Objective 3.1: Create a robust complex of nearshore artificial reefs that enhances existing hard bottom habitat, supports nature-based tourism and contributes to sustainable fisheries management.

Strategy 3.1.1: Inventory and map Hernando's County's nearshore submerged lands and identify suitable locations for nearshore artificial reefs.

Strategy 3.1.2: Prioritize habitat structure gaps where nearshore artificial reefs can serve as life history stepping stones for recreationally important juvenile fish moving to deeper water.

Strategy 3.1.3: Identify one or more nearshore artificial reef sites to serve as interpretive snorkeling trails to promote non-consumptive recreational reef use and research.

Objective 3.2: Create a robust complex of offshore artificial reefs that enhances available structure, supports recreational fisheries and contributes to sustainable fisheries management.

Strategy 3.2.1: Inventory and map Hernando County's offshore submerged lands and identify suitable locations for offshore artificial reefs.

Strategy 3.2.2: Prioritize reef design and placement to maximize potential for recruitment of recreationally important fish species and localized ecological benefits.

Strategy 3.2.3: Identify one or more offshore artificial reef sites to serve as sites for non-consumptive use by recreational divers and research.

Objective 3.3: By ____, create a comprehensive spatially and temporally explicit Hernando County Artificial Reef Construction and Management Plan.

Strategy 3.3.1: Promote innovation in artificial reef management and design, including the use of experimental materials, designs and recreational use policies.

Strategy 3.3.2: Ensure plan consistency with existing federal, state, regional and non-governmental plans, programs and initiatives, including the Hernando County Restore Act Multiyear Implementation Plan.

Strategy 3.3.3: Use the Hernando County Artificial Reef Management Plan as the basis to seek conceptual approval from regulatory agencies for artificial reef projects identified by the Plan.

Strategy 3.3.4: Create a stakeholder engagement plan for all phases of artificial reef system design, deployment and monitoring.

Artificial Reefs Key Policy Resources

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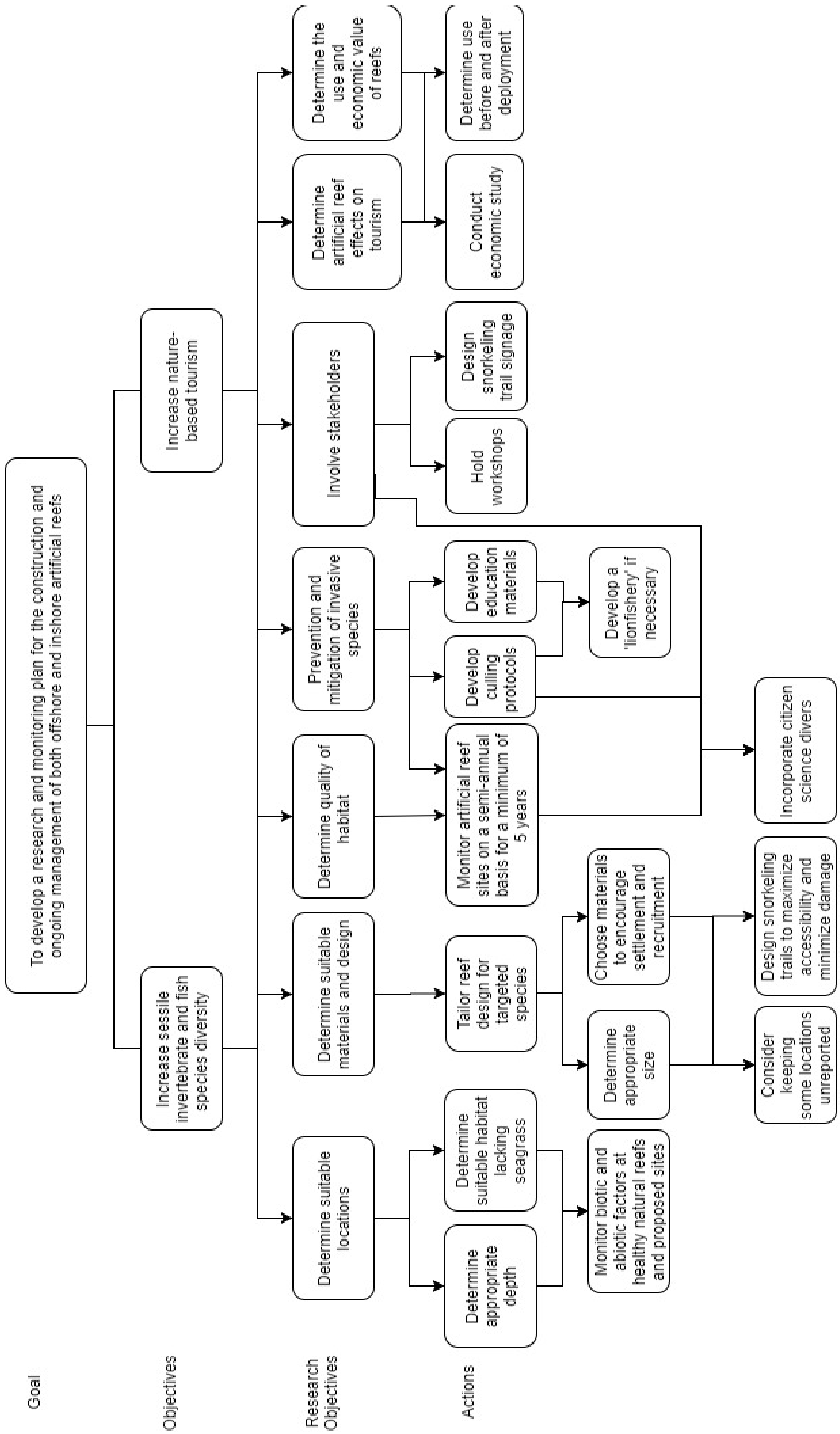

Goal
Objectives
Research Objectives
Actions
To develop a research and monitoring plan for the construction and ongoing management of both offshore and inshore artificial reefs
Increase sessile invertebrate and fish species diversity
Increase nature-based tourism
Determine suitable locations
Determine suitable materials and design
Determine quality of habitat
Prevention and mitigation of invasive species
Involve stakeholders
Determine artificial reef effects on tourism
Determine the use and economic value of reefs
Determine appropriate depth
Determine suitable habitat lacking seagrass
Monitor biotic and abiotic factors at healthy natural reefs and proposed sites
Tailor reef design for targeted species
Determine appropriate size
Choose materials to encourage settlement and recruitment
Consider keeping some locations unreported
Design snorkeling trails to maximize accessibility and minimize damage
Monitor artificial reef sites on a semi-annual basis for a minimum of 5 years
Develop culling protocols
Develop education materials
Develop a 'lionfishery' if necessary
Incorporate citizen science divers
Hold workshops
Design snorkeling trail signage
Conduct economic study
Determine use before and after deployment

Literature Review and Research Objectives

Goal 3. Artificial Reefs

Background:

Artificial reefs are one tool which can be utilized by managers for both the restoration and enhancement of marine ecosystems. They are defined as structures of natural or human origin that are submerged on the seafloor to mimic characteristics of a natural reef (Baine 2001, Dupont 2008). Historically, artificial reefs were deployed for various purposes including the replenishment and increase of vertebrate and invertebrate populations, recreational and sport diving, trawling prevention, shoreline protection, and increasing available habitat (Davis 1985, Brock and Norris 1989, Polovina and Sakai 1989, Cheney et al. 1994, Baine 2001). However, within Florida the focus of artificial reefs has been mainly to enhance recreational fisheries and diving opportunities.

Artificial reefs play a vital role in the economy of Florida and Hernando County specifically. Florida has over 3,000 reef deployments in 34 of its coastal counties (FWC 2003, Adams et al. 2006). Economic analysis has shown that, generally, benefits associated with artificial reefs exceed costs and that they increase local economic activity (Adams et al. 2006). Hernando County supports a large nature-based recreation and tourism industry centered around diving, snorkeling, and fishing on both artificial and natural reefs. Thus, artificial reefs are a vital component of Hernando County's economy. This necessitates the appropriate implementation and management of these resources.

Hernando County seeks to design, deploy, and monitor both inshore snorkeling trails and offshore reefs in order increase nature-based tourism within the county. Despite Hernando County's long history of artificial reef deployment, no consistent monitoring program has been established (Seaman 2004). Therefore, a major focus of future artificial reef projects will be to create a comprehensive reef development and monitoring program that incorporates scientific research, collaboration, and community engagement. For both reef types, baseline data collection will play a key role in determining if projects have met their objectives (Dupont 2008). It is essential that future artificial reef projects within Hernando County include a period of pre-deployment monitoring. This pre-deployment monitoring could be an ongoing part of hardbottom assessments (*see Seagrass and Hardbottom*) provided the monitored sites are similar to proposed artificial reef sites.

A key debate in scientific literature, which should be considered in artificial reef planning, is whether reefs increase the production of a fishery or simply aggregate individuals. Arguments for a production increase include the fact that they augment available food resources, improve feeding efficiency, provide shelter from predation, and provide vacant habitat (Baine 2001). It is clear that reefs attract fish and thus can change the distribution of biomass susceptible to catch. This change in distribution can occur either with or without increasing the size of the stock (Polovina 1991). Artificial reefs can also aggregate fish that were previously unexploitable without increasing total stock. As a result, it is important to manage fish stocks after artificial reef deployment to prevent overfishing (Pickering and Whitmarsh 1997).

While this is a contentious debate, research indicates that the structural complexity of reef design plays an important role in determining species composition, colonization patterns, and productivity (Luckhurst and Luckhurst 1978, Pickering and Whitmarsh 1997, Dupont 2008). These factors are important for determining appropriate reef design to benefit stakeholders. One study found that, out of many reef attributes, divers most valued (willingness to pay) the reef's site biodiversity (Polak and Shashar 2013). This result highlights the underlying benefit of maintaining high biodiversity at artificial reefs to encourage use by stakeholders. However, increased use by divers can also cause an increase in the amount of damage reefs sustain (Medio et al. 1997). Therefore, the biodiversity and relative abundance of sessile invertebrate and reef fish species should be monitored over time at artificial reef sites in Hernando County.

Inshore artificial reefs, including snorkeling trails, are growing in popularity and provide key recreational benefits. These trails can be used to concentrate reef use and limit damage to vulnerable habitats (Hawkins and Roberts 1993). Additionally, they can be utilized to service more users when interpretive staff are limited (Plathong et al. 2000). Like terrestrial trails, trampling of organisms can be a problem and is associated with user behavior (Medio et al. 1997, Rouphael and Inglis 1997). Plathong et al. (2000) indicated that a significant amount of coral damage can occur with limited trail use (average of 15 people per week). This damage was most concentrated at interpretive signs. Therefore, careful planning regarding the design and management of snorkeling trails is needed to balance use and habitat protection. Plathong et al. (2000) recommends periodic closures and/or rotation of snorkeling trail use by the public to mitigate damage.

Regardless of reef type, planning, permitting, and monitoring to ensure project success are important for successful artificial reef projects. The major obstacles in meeting stated project objectives are inadequately addressing reef siting, size, stability, cost, monitoring protocols, management of local use, and external climatic factors (Baine 2001). Of these, all but one can be planned for in advance. These issues need to be addressed fully to ensure project success. Permits from United States Army Corps of Engineers & Florida Department of Environmental Protection are required to deploy an artificial reef (Adams et al. 2006). There are also established guidelines from the Florida Fish and Wildlife Conservation Commission (FWC) in the *State of Florida Artificial Reef Strategic Plan* (FWC 2003, Adams et al. 2006).

Goal: To develop a research and monitoring plan for the construction and ongoing management of both offshore and inshore artificial reefs. The overarching goal of these projects will be to enhance and increase nature-based tourism within the county. Whenever possible, projects should aim to support high sessile invertebrate and fish species diversity.

Project Success Criteria:

- Increase nature-based tourism to a defined level based on current trends and county goals
- Increase sessile invertebrate and fish species diversity on new reefs within Hernando County's jurisdiction to a defined level (which is intermediate to natural reefs and current artificial reefs)

Research Objective: Determine suitable locations for additional artificial reefs to meet stated goals

Action: Determine suitable habitat lacking seagrass and hardbottom using collected data in Geographic Information Systems (GIS)

- Conduct side scan surveys, diver surveys, magnetometers surveys, and sediment surveys to document suitability
- Potential sites should have less than 0.6 m of unconsolidated substrate with dolomitic or calcitic limestone underneath to decrease sinking (Obrochta et al. 2003).
- Proximity to other existing and proposed reefs provides a source of adult fish, juvenile fish, and larvae for colonization

Action: Determine appropriate depth to achieve stated objectives

- Inshore innovative reefs should be placed at depths greater than two meters to reduce damage to biota by snorkelers (Plathong et al. 2000)

Action: Monitor biotic and abiotic factors at healthy natural reefs, established offshore artificial reefs (control sites), and candidate sites to determine suitability requirements

- Environmental variables
    - Water depth (m)
    - Current direction (degrees) and magnitude (cm/sec) at surface and near bottom depth
    - Salinity (ppt) at surface and at near bottom depth
    - Water temperature (°C)
    - Turbidity (Secchi disk depth)
- *See monitoring section below on recommendations related to fish and invertebrate biota pre-deployment and post-deployment monitoring*
- Use larvae collectors or settlement tiles to determine coral recruitment dynamics at proposed sites
    - This step can be excluded in reef expansion projects

Action: Consider keeping the location of some offshore artificial reef sites unreported

- This can provide greater refuge to resident species, but is not effective in providing refuge for transient species (Ingram Jr and Patterson III 2001)
- This technique is most effective in marine protected areas, and may not be appropriate for reefs placed in permitted artificial reef zones which are unprotected from fishing efforts (Ingram Jr and Patterson III 2001, Addis et al. 2013, Addis et al. 2016)
- Consider seeking unreported reef sites in conjunction with zones for alternative management options (*See Recreational and Commercial Fishing)*

Action: For inshore snorkeling trails, follow baseline monitoring recommendations by Plathong et al. (2000) to determine the effects of use

- Conduct transect or quadrant assessments 6 months before deployment and/or signage installation and 6 months after deployment, but before public use
    - Measure percent coverage of sessile invertebrate species
- Monitroing of coral and invertebrates at artificial reefs could mirror methods used in natural hardbottom assesments (Sullivan and Chiappone 1992, Holt et al. 2013)
- Monitoring efforts could incorporate citizen scientists to reduce costs (Holt et al. 2013)

Research Objective: Determine suitable materials and design to meet stated objectives

Action: Tailor reef design elements to specifically targeted fish species that will encourage increased use by recreational divers and snorkelers

Action: Choose appropriate reef materials to encourage settlement of sessile invertebrates and recruitment of targeted fish species

- Concrete structures have historically been most favored in artificial reef construction followed by natural rock.
- There are some instances where natural rock may be more appropriate:
    - Limestone boulders are correlated with higher species richness than reef modules due in part to increased habitat heterogeneity (Dupont 2008)
        - Habitat heterogeneity leads to increased biodiversity and higher biomass (Bohnsack et al. 1994)
        - Increased species richness is associated with higher resilience to environmental changes
    - Limestone may also be favored when there is an associated dredging project (Yozzo et al. 2004)
    - *See Thanner et al. (2006) and Dupont (2008) for innovative reef modules that incorporate natural limestone into their design*
        - This design increases habitat complexity and is often used in conjunction with mitigation projects
    - Incorporating small holes, a few cm in diameter, into reef module designs have been shown to reduce fish recruit mortality (Shulman 1984, 1985, Shulman and Ogden 1987, Hixon and Beets 1989)
    - Structural complexity plays an important role in determining fish species composition, patterns of colonization, and artificial reef productivity (Luckhurst and Luckhurst 1978, Anderson et al. 1989, Bohnsack et al. 1994)

Action: Assess if mooring bouys effectively reduce the amount of damage to artificial reefs caused by users

Action: Determine the appropriate reef size to meet stated objectives

  - Multiple small reefs supported higher fish densities than one large reef of equivalent size (Bohnsack et al. 1994)

Action: Design snorkeling trails to maximize accessibility and education potential while minimizing damage to reef sites

  - Establish snorkeling trails along the edge of a reef
  - Create a path of use approximately six meters wide
  - Place numbered stainless-steel signs (21 x 15 cm) at important landmarks
    - Signs should be placed at a 45-degree angle to the substrate and face the trailhead
    - Signs should be marked with a number corresponding to a laminated trail guide
    - Numbered signs with a corresponding interpretive guide reduce coral and substrate damage by eliminating the need for snorkelers to dive below the surface to read interpretive information
  - Consider rest stations over sandy bottoms to reduce damage to benthic biota by users who need to rest or fix equipment (Plathong et al. 2000)

Research Objective: Involve stakeholders in artificial reef projects through public education, engagement, and citizen science

Action: Design signage for inshore snorkeling trails to maximize accessibility and education while minimizing damage to reef site

- *See Plathong et al. (2000) and Medio et al. (1997) for further recommendations regarding educating trail users on equipment use, safety, and reduction of habitat damage*

Action: Hold workshops regarding Hernando County's artificial reef program to engage and educate stakeholders

- Involve stakeholder input in the of artificial reef planning process
- Workshops can be used as an opportunity to involve stakeholders in the development of an artificial reef management plan specific to Hernando County

Action: Incorporate citizen scientists into monitoring protocols

- Consider a reef adoption program for ongoing monitoring

Research Objective: Determine if artificial reef projects have augmented recreational tourism within Hernando County

Research Objective: Determine the quality of habitat available to reef users

Action: Collaborate with other Florida counties who are currently monitoring artificial reefs, such as Miami-Dade County, to create a feasible, appropriate, and meaningful management plan to determine project success (Thanner et al. 2006)

Action: Assess reef fish relative abundance at offshore artificial reefs with multiple methods if possible (Seaman 2000)

- Monitor sites at artificial reefs and control reefs on a semi-annual basis for a minimum of five years
    - o Consider remote video systems referenced in Lowry et al. (2012) and Pelletier et al. (2012) for monitoring reefs; these systems may overlap with sea turtle and hardbottom monitoring protocols (*See Seagrass and Hardbottom*)
    - o Consider a modified Bohnsack and Bannerot 1986 visual census technique utilized by Miami-Dade County in ongoing monitoring efforts
        - ▪ Visual underwater fish censuses can have large errors and biases introduced by over and under estimation of fish distances regardless of diver experience (Harvey et al. 2004).
        - ▪ Errors and biases can be improved by employing distance calibration between divers (Bell et al. 1985)

Action: For offshore reefs, assess sessile invertebrate recruitment and assemblage using photo quadrants

- o *See the following resources for methods (Sullivan and Chiappone 1992, Thanner et al. 2006, Holt et al. 2013)*

Action: For both reef types, collect data on environmental parameters at regular intervals

- o *See pre-deployment environmental parameters*

Action: For inshore snorkeling trails, conduct transect or quadrant assessments 6 months post deployment and annually

- o Measure percent coverage of sessile invertebrate species (Plathong et al. 2000)

Research Objective: Prevention and mitigation of invasive species

Action: Monitor the presence of invasive species during regular monitoring activities

Action: Develop educational materials to inform divers and snorkelers regarding citizen reporting opportunities (https://nas.er.usgs.gov/sightingreport.aspx)

Action: If invasive species such as red lionfish *Pterois volitans* are present, develop a sufficient culling protocol to control local populations (Dahl et al. 2016, Chagaris et al. 2017, Usseglio et al. 2017)

- Incorporate citizen scientist divers in culling protocols
- The development of a 'lionfishery' could be used to increase demand and culling efforts if red lionfish were to invade local reefs (Chapman et al. 2016)

Research Objective: Determine the use and economic value of inshore innovative reefs and offshore reefs

Action: Conduct an economic study similar to those described in Adams et al. (2006) to determine the economic value of artificial reefs in Hernando County

Action: Determine artificial reef use, before and after reef deployment, to estimate increases in nature based tourism and overall recreational usage

- Use pre-deployment analysis to set quantifiable project success goals related to ecotourism
- *See Smallwood et al. (2011) and (Simard et al. 2016) regarding recommended methods for conducting recreational surveys*

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Goal 4: To maintain a robust economically and ecologically sustainable recreational and commercial fishery.

Objective 4.1: Determine the relative health and economic value of the recreational fisheries in Hernando County and better understand angler attitudes and the relationship between the fishery and the marine resources on which it depends (e.g. seagrasses, hardbottom, artificial reefs, etc.).

Strategy 4.1.1: Conduct a stock assessment to determine stock status (age composition, fishing mortality, and relative abundance) for major recreational fisheries in Hernando County (e.g. Red Drum, Spotted Seatrout, Snook, Grouper).

Strategy 4.1.2: Develop a creel survey to quantify catch, fishing effort, economic activity and angler attitudes associated with Hernando County's recreational fisheries.

Objective 4.2: Determine the relative health and economic value of the commercial fisheries in Hernando County, and the relationship of the fishery to the marine resources on which it depends (e.g. seagrasses, hardbottom, etc.).

Strategy 4.2.1: Quantify the economic value of commercial fisheries and fisher needs and attitudes associated with the County's commercial fisheries.

Strategy 4.2.2: Explore the feasibility of developing an aquaculture industry in Hernando County (e.g. baitfish, shellfish, sponges, etc.).

Objective 4.3: Develop and implement a holistic approach to recreational and commercial fisheries management in Hernando County based on principles of adaptive management and new and integrated approaches to fisheries management.

Strategy 4.3.1: Conduct workshops with user groups and FWC personnel to summarize results of surveys, economic analyses, and fish stock status assessments.

Strategy 4.3.2: Quantify angler preferences for recreational fishery management (e.g., use of trophy regulations, attitudes regarding harvest, etc.).

Strategy 4.3.3: Collaborate with FWC and neighboring counties to implement improved management of recreational and commercial fisheries, including experimental approaches that promote Hernando County as a leader in sustainable fisheries management.

Recreational and Commercial Fisheries Key Policy Resources

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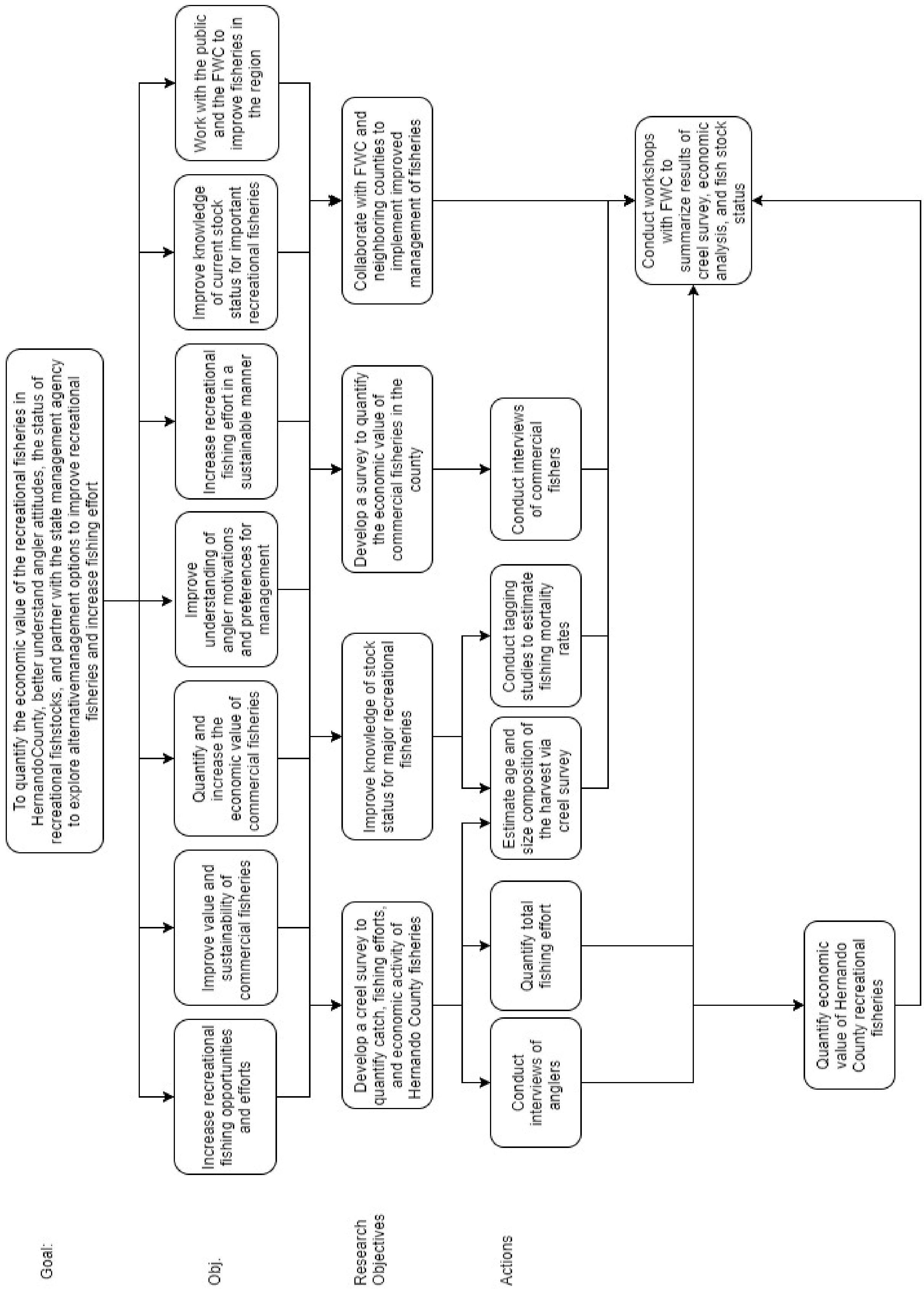
Goal:
To quantify the economic value of the recreational fisheries in HernandoCounty, better understand angler attitudes, the status of recreational fishstocks, and partner with the state management agency to explore alternativemanagement options to improve recreational fisheries and increase fishing effort
Obj.
Increase recreational fishing opportunities and efforts
Improve value and sustainability of commercial fisheries
Quantify and increase the economic value of commercial fisheries
Improve understanding of angler motivations and preferences for management
Increase recreational fishing effort in a sustainable manner
Improve knowledge of current stock status for important recreational fisheries
Work with the public and the FWC to improve fisheries in the region
Research Objectives
Develop a creel survey to quantify catch, fishing efforts, and economic activity of Hernando County fisheries
Improve knowledge of stock status for major recreational fisheries
Develop a survey to quantify the economic value of commercial fisheries in the county
Collaborate with FWC and neighboring counties to implement improved management of fisheries
Actions
Conduct interviews of anglers
Quantify total fishing effort
Estimate age and size composition of the harvest via creel survey
Conduct tagging studies to estimate fishing mortality rates
Conduct interviews of commercial fishers
Quantify economic value of Hernando County recreational fisheries
Conduct workshops with FWC to summarize results of creel survey, economic analysis, and fish stock status

Literature Review and Research Objectives

Goal 4. Recreational and Commercial Fisheries

Background:

Recreational and commercial fisheries are of vital economic importance to the Florida economy, and particularly the economies of coastal counties within which those fisheries are primarily located. Florida has 3.1 million recreational anglers, who spend 58 million days on the water fishing (US Department of the Interior 2012). Of those total number of anglers, 1.2 million fish freshwater and 2.4 million fish saltwater. The recreational fishing industry in Florida is driven by $4.9 billion in expenditures by all anglers, of which 80% is associated with saltwater fishing. Florida leads the nation in the numbers of recreational anglers and their associated expenditures. In addition, saltwater anglers on the West Coast of Florida generate almost two-thirds of the total saltwater angling-related sales in Florida (US Department of Commerce 2015). Thus, recreational saltwater fishing is a big business in Florida, with the majority of that business occurring on the Florida Gulf Coast.

The commercial seafood industry is also an important contributor to the Florida economy. Sales of all seafood (all market sectors) in Florida totals $18 billion, of which approximately $1 billion of the total sales are associated with Florida-harvested seafood. And of the total dockside value of all Florida-harvested seafood, approximately 80% originates from the Florida Gulf Coast (Florida Wildlife Conservation Commission 2017.

Commercial and recreational fishing are important drivers for the Hernando County economy. For example, there are 50 commercial seafood harvesters located in the county. In addition, 12 wholesale seafood dealers and 18 retail seafood dealers are located in Hernando County. Commercial seafood harvesters take over 7,000 trips per year and land 2.1 million pounds of seafood, valued at $7 million dockside. In terms of recreational fishing activity, there are approximately 10,000 freshwater and 34,000 saltwater anglers located within Hernando County. Each of these sectors generate diverse types of economic activity, which creates considerable benefits to the local economy. There is a clear need to quantify the economic impact of commercial fisheries in the county, and to explore options to better manage and enhance the value of commercial fisheries.

The coastal recreational fisheries in Hernando County are extremely diverse and productive. Fisheries include inshore game fish such as spotted seatrout *Cynoscion nebulosus,* Red Drum *Sciaenops ocellatus,* Atlantic Tarpon *Megalops atlanticus* and Common Snook *Centropomus undecimalis*, all of which attract anglers to the region. These species are common in the creek, mangrove and seagrass habitats that are found inshore throughout Hernando County. The recreational fishery is for Bay Scallop *Argopecten irradians* is extremely popular, with fishing effort increasing through time. Scallops are collected by snorkelers over seagrass habitats, and very limited information exists on stock status for Bay Scallop. Offshore fish species include a wide range of reef fish (groupers and snappers) and pelagic predators (e.g., mackerels), and offshore fisheries include both hook and line and spearfishing participants.

Monitoring data and stock assessments for recreational fisheries are conducted at broad spatial scales (e.g., Gulf coast), and there is a need for location-specific status data on recreational fisheries. Existing surveys that quantify total expenditures, angler catch rates, and fishing effort lack the resolution to identify metrics at the county level. For example, the Marine Recreational Information Program (http://www.st.nmfs.noaa.gov/recreational-fisheries/index) estimates recreational fishing effort, harvest, and catch and release of fish for the Gulf and Atlantic coasts of Florida. However, this program does not produce reliable metrics at the county level due to sparse spatial and temporal sampling coverage, and there is a need to quantify the value and participation in recreational fishing at smaller spatial scales (e.g., county level). Further, data to quantify fish stock status such as age composition, growth rates, fishing mortality rates and size at maturity are lacking at local scales, and such data could be used to improve management of recreational fisheries locally.

Recreational anglers are extremely diverse in their preferences from fisheries. Anglers range from those who seek to harvest fish for consumption to those that prefer catch and release fishing for trophy fish. Termed 'angler specialization' (Bryan 1977; Chipman and Helfrich 1988; Ditton et al. 1992), angler attitudes about fish harvest range widely among angler typologies, with some anglers preferring to keep all their catch and others seeking unique fishing opportunities (e.g., catch of trophy fish) and practice catch and release as a conservation practice.

Despite heterogeneity in angler preferences, fisheries management is often applied across broad spatial scales. Harvest regulations like length limits and bag limits are typically applied either statewide or across broad regions within states (e.g., Gulf coast). However, in some cases regulations can be tailored to provide unique fishing experiences for certain angler types, with the potential to attract anglers to unique opportunities. For example, catch and release regulations for largemouth bass have created trophy fisheries in Florida (Dutterer et al. 2014) and Texas (Chen et al. 2011), with anglers being attracted to water bodies that have increased potential to produce large fish due to low harvest rates. Thus, recognizing the diversity among anglers could create opportunities for improved fishery management, and possibly higher overall participation by anglers.

Goal: To quantify the economic value of the recreational and commercial fisheries in Hernando County, better understand angler attitudes, the status of recreational fish stocks, and partner with the state management agency to explore alternative management options to improve recreational and commercial fisheries.

Project Success Criteria

- Create enhanced recreational fishing opportunities in the county
- Improve the value and sustainability of commercial fisheries
- Quantify the economic value of recreational and commercial fisheries and increase this value through time
- Improve understanding of angler motivations and preferences for management in the county

- Increase recreational fishing effort overall, while maintaining sustainability of fish stocks
- Improve knowledge of current stock status for fish that support important recreational fisheries
- Work with the public and the FWC to improve fisheries in the region

Research Objective: Develop a creel survey to quantify catch, fishing effort, and economic activity associated with Hernando County's recreational fisheries over time.

Action: Conduct interviews of anglers (periodic intervals)

- Collaborate with Florida Sea Grant on survey design and creel survey
- 12 sampling days per month stratified between weekend and weekdays with a higher proportion of weekend days sampled
- Conduct interviews of inshore anglers on the water using a stratified random roving design
- Conduct interviews of offshore anglers at access points and marinas
- Quantify angler preferences for fishery management (e.g., use of trophy regulations, attitudes regarding harvest, etc.)

Action: Quantify total fishing effort using boat or boat trailer counts

- This information to be gathered using boat counts from an airplane or camera counts at random access points

Action: Use IMPLAN economic analysis to quantify the economic value of Hernando County's recreational fisheries

- Creel survey (*see above)* should include questions that can be utilized for the economic analysis

Estimated Cost: $150,000-175,000 per year for two years (2018 and 2019)

Research Objective: Improve knowledge of stock status (age composition, fishing mortality, and relative abundance) for major recreational fisheries in Hernando County (Red Drum, Spotted Seatrout, Snook, Groupers)

Action: Conduct tagging studies to estimate fishing mortality rates, which can be directly used in stock assessments

- Work with local fishing guides and Florida Sea Grant to tag fish
- Use of high reward passive tagging for estimation of harvest rates
- Focus on inshore species (Common Snook, Spotted Seatrout, Red Drum)

Action: Estimate age and size composition of the harvest via creel survey (see *above*)

- Fishery-dependent sampling of age/size composition during creel survey

Estimated Cost: $180,000 per year for two years (2019 and 2020)

Research Objective: Develop a survey to quantify the economic value of commercial fisheries in the county.

Action: Conduct interviews of commercial fishers (periodic intervals)

- Collaborate with Florida Sea Grant on survey design and creel survey
- Conduct interviews of commercial fishers
- Quantify angler preferences for fishery management (e.g., use of trophy regulations, attitudes regarding harvest, etc.)

Research Objective: Collaborate with FWC and neighboring counties to implement improved management of recreational and commercial fisheries

Action: Conduct workshops with FWC personnel to summarize results of creel survey, economic analysis, and fish stock status

- Identify management actions to consider
- Develop implementation strategies with FWC and neighboring counties (Citrus, Marion, Sumter, Pasco)
- Host public workshops to outline management options

Estimated Cost: $10,000 in 2021

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Goal 5: To develop, maintain and enhance a resilient program of land-based and in-water maritime access infrastructure to support the sustainable commercial and recreational use of the marine and estuarine waters of Hernando County.

Objective 5.1: Maintain and improve motorized and motor-assisted vessel navigation in and through the waters of Hernando County.

Strategy 5.1.1: Inventory, assess and map (bathymetry & surficial charting) all formal and informal navigation channels and mooring/anchoring areas in Hernando County based on vessel draft, vessel use and channel carrying capacity.

Strategy 5.1.2: Develop a schedule of channel improvements and routine maintenance based on the navigation channel inventory and assessment in Strategy 5.1.1.

Strategy 5.1.3: Coordinate inventory and maintenance schedules with permitting agencies and explore a countywide framework for channel maintenance and improvements.

Strategy 5.1.4: Develop and implement a dredged material management system that prioritizes opportunities for the beneficial use of dredge spoil for restoration and enhancement.

Strategy 5.1.5: Inventory, assess and map all public (regulatory and informational) and private aids to navigation to ensure that they conform to federal and state public safety and environmental protection requirements (particularly seagrasses and manatees), and improve boater compliance.

Strategy 5.1.6: Develop a schedule of improvements and routine maintenance based on the aids to navigation inventory and assessment in Strategy 5.1.5.

Strategy 5.1.7: Maintain existing seagrass protection zones and identify areas where additional protection zones may be needed to reduce scarring.

Strategy 5.1.8: Prepare an Emergency Management Plan for waterways and associated infrastructure that is consistent with federal and state frameworks, and work with the U.S. Coast Guard, the Florida Fish and Wildlife Conservation Commission, the Florida Division of Emergency Management and other federal and state agencies to regularly update oil spill response plans as they relate to Hernando County.

Objective 5.2: Maintain and improve non-motorized vessel navigation opportunities in and through the waters of Hernando County.

Strategy 5.2.1: Develop and maintain a robust network of nearshore saltwater paddling trails and associated land-based and in-water infrastructure that maximizes access to marine resource amenities and minimizes vessel-user conflicts.

Strategy 5.2.2: Promote the Florida Saltwater Circumnavigation Trail through Hernando County and coordinate with adjacent counties to ensure continuity, compatibility and joint marketing opportunities.

Objective 5.3: Create robust education, compliance and financing programs to ensure the sustainable use of waterways in Hernando County.

Strategy 5.3.1: Review all County ordinances for consistency with federal and state laws governing management of waterways, and revise as necessary.

Strategy 5.3.2: Provide continuing maritime and waterway law education for Hernando County law enforcement officials with boating and waterways jurisdiction.

Strategy 5.3.3: Develop and enhance boater education programming in Hernando County, drawing upon resources provided by Florida Sea Grant and the UF IFAS extension program.

Strategy 5.3.4: Pursue Florida Boating Improvement Program (FBIP) funds and other federal and state grant programs for the improvement and maintenance of maritime infrastructure, including waterways, signage, derelict vessel removal and education. Priorities and future expenditures of those monies in this Plan will be based on recommendations from the Hernando County Port Authority.

Objective 5.4: To maintain and improve land-based motorized and non-motorized boating access infrastructure based upon expected growth through the year 2040 at adequate levels of service.

Strategy 5.4.1: Conduct a comprehensive boating access inventory and carrying-capacity study that takes into account current and projected demographic trends, identifies user preferences, and considers new access sites if warranted.

Strategy 5.4.2: Develop a schedule for implementation of recommendations for repairs, maintenance and improvements to coastal boat ramps provided in the 2017 Boat Ramp Master Plan prepared by the Hernando County Department of Public Works.

Vessel Navigation and Water Access Key Policy Resources

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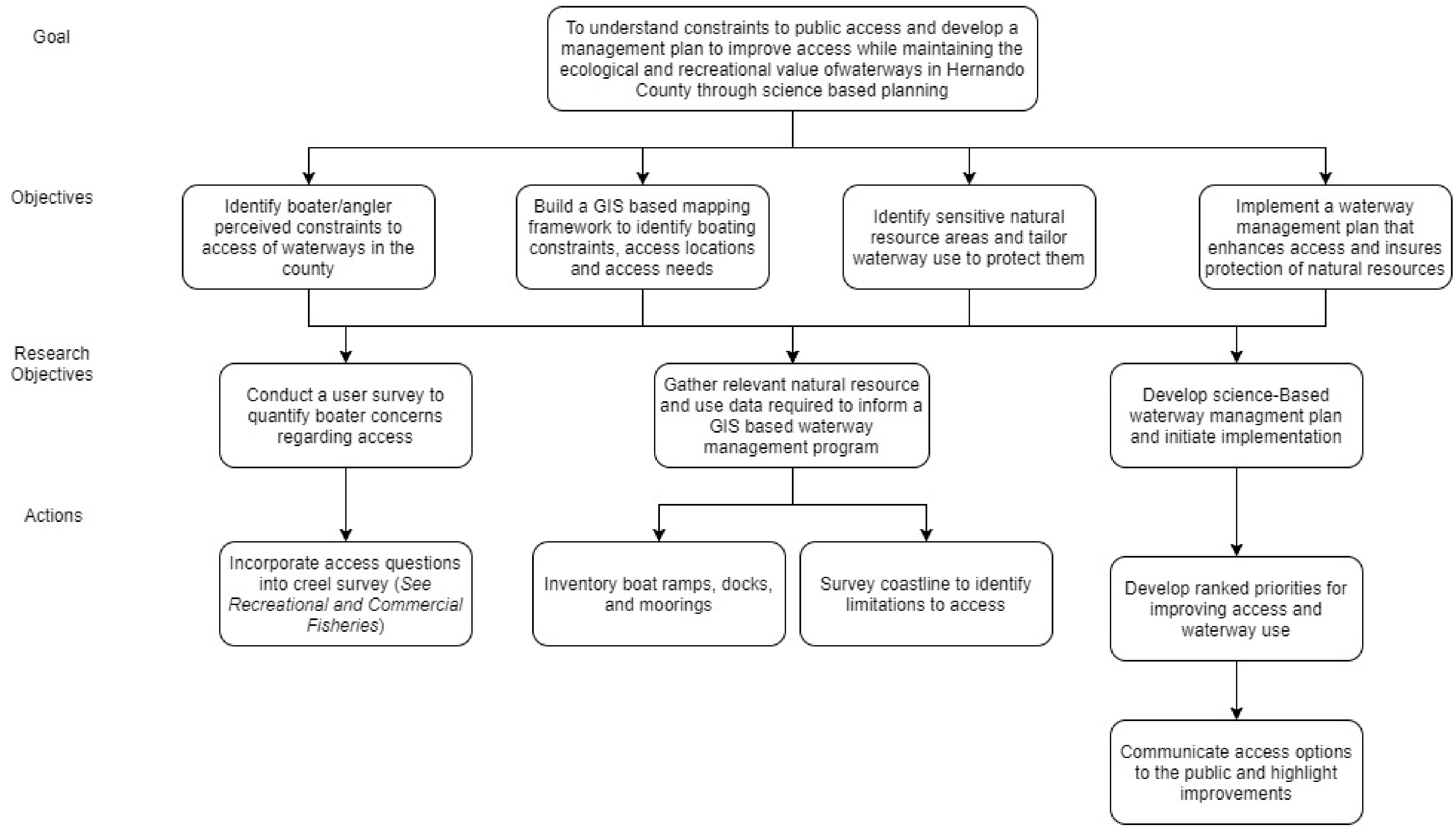
Goal
To understand constraints to public access and develop a management plan to improve access while maintaining the ecological and recreational value ofwaterways in Hernando County through science based planning
Objectives
Identify boater/angler perceived constraints to access of waterways in the county
Build a GIS based mapping framework to identify boating constraints, access locations and access needs
Identify sensitive natural resource areas and tailor waterway use to protect them
Implement a waterway management plan that enhances access and insures protection of natural resources
Research Objectives
Conduct a user survey to quantify boater concerns regarding access
Gather relevant natural resource and use data required to inform a GIS based waterway management program
Develop science-Based waterway managment plan and initiate implementation
Actions
Incorporate access questions into creel survey (*See Recreational and Commercial Fisheries*)
Inventory boat ramps, docks, and moorings
Survey coastline to identify limitations to access
Develop ranked priorities for improving access and waterway use
Communicate access options to the public and highlight improvements

Literature Review and Research Objectives

Goal 5. Vessel Navigation and Water Access

Background:

As described in the other sections of this plan, recreational uses (e.g., fishing, snorkeling, paddling) along the Hernando County coastline are a vital part of the county's economy. However, access (eg., boat ramps, parking, and canal access) and extensive shallow water may be limiting the number of users and, ultimately, hindering the quality of recreational experiences available for boaters within the county. There is a clear need for science-based management of waterways within this region. In addition, it is also necessary to identify impediments to access and develop strategies to reduce such impediments, while protecting the quality of natural resources in the region.

Florida's growing population has led to an increase in boating and waterways use in many areas of the state. As of 2007, the rate at which boat registration increased was greater than population growth of the state (Swett et al. 2009). This growth highlights the increasing use of Florida's waterways which in turn places growing pressure on infrastructure and natural resources.

Two effects of these pressures are manatee collisions and seagrass scarring. Since 1976, boat collisions account for approximately 24% of all manatee deaths (United States Fish and Wildlife Service 2001). Reducing this is important because watercraft related mortality has the highest impact on resilience and growth of Florida manatee populations (Runge et al. 2007). Seagrass scarring is another issue that has profound impacts on natural resources throughout the state. In some cases, it can take over five years for a site to recover from the impacts of scarring (Bourque et al. 2015). The complex problems associated with increased waterways use require balancing public usage with the management of natural resources. Science-based planning and management can ensure the safety of users, protection of natural resources, and continued access.

Goal: To understand constraints to public access and develop a management plan to improve access while maintaining the ecological and recreational value of waterways in Hernando County through science based planning

Project Success Criteria

- Identify boater/angler perceived constraints to access of waterways in the county
- Build a GIS-based mapping framework to identify boating constraints, access locations and access needs (e.g., Swett et al. 2009)
- Identify sensitive natural resource areas and tailor waterway use to protect them
- Implement a waterway management plan that enhances access and insures protection of natural resources.

Research Objective: Conduct a user survey to quantify boater concerns regarding access

Action: Incorporate access questions into creel survey to understand boater/angler concerns about access (*See Recreational and Commercial Fisheries*)

- Identify locations where access is limited
- Understand how access limitations affect their use of coastal locations
- Identify novel solutions from users

Research Objective: Gather relevant natural resource and use data required to inform a geographic information systems (GIS)based waterway management program

Action: Inventory boat ramps, docks, and moorings

- Data from the fisheries creel survey may be helpful (*see Recreational and Commercial Fisheries*)
- Use satellite imagery to identify access locations, parking areas, and limits on boating capability

Action: Survey coastline to identify limitations to access

- Compile bathymetry data to identify locations limiting access or likely for ecological harm (e.g., shallow seagrass, oyster reefs)
- Quantify canal access and potential choke points for crowding of vessels

Research Objective: Develop science-based waterway management plan and initiate implementation

Action: Develop ranked priorities for improving access and waterway use

- Use GIS layers and angler/boater survey to rank priority areas for improved access
- Identify constraints to enhanced access and possible solutions for each priority
- Explore funding sources for implementation of access improvements

Action: Communicate access options to the public and highlight improvements

- Work with Florida Sea Grant for outreach to the public on waterway management plan
- Develop signage and flyers for distribution at boat ramps, marinas and motels
- Include best boater practices including “Be Safe Seagrass” boating guidelines

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Goal 6: To ensure the ecological integrity of Hernando County's unique assemblage of seagrass bed habitats and interspersed hardbottom.

Objective 6.1: Protect and enhance the quality and quantity of seagrass habitat within Hernando County.

Strategy 6.1.1: Complete a comprehensive assessment of the spatial extent of seagrass habitat and spatially characterize the relative quality of that habitat, including areas of heavy prop scarring and areas for future restoration and mitigation.

Strategy 6.1.2: Conduct a survey to determine baseline boater awareness of prop scarring and proper anchoring practices in Hernando County.

Strategy 6.1.3: Based on the results of the assessment and baseline survey, develop an action plan to address prop scarring and proper anchoring practices through education, management and enforcement.

Strategy 6.1.4: Develop a long-term program to monitor seagrass coverage, health and trends, and to coordinate monitoring, mapping and research across the greater Nature Coast/Big Bend region.

Objective 6.2: Protect and enhance the quality and quantity of hardbottom habitats within Hernando County.

Strategy 6.2.1: Complete a comprehensive assessment of the spatial extent of hardbottom habitat, and spatially characterize that habitat, including areas of special significance and areas of intensive and/or incompatible use.

Strategy 6.2.2: Assess coral and sessile invertebrate abundance and composition on hardbottom habitat within Hernando County, and identify areas of special significance.

Strategy 6.2.3: Based on the results of the hardbottom assessment, develop an action plan to protect and manage hardbottom through education and consideration of special management areas: including sea turtle, coral and sponge refugia, areas that are most appropriate for non-consumptive ecotourism, no-anchoring areas, and areas where moorings and/or designated anchoring may be provided for sport fishing and non-consumptive tourism.

Strategy 6.2.4: Investigate opportunities, such as mitigation, to promote hardbottom restoration at damaged sites, including the use of damaged coral fragments to grow healthy colonies.

Objective 6.3: Promote scientific research, management and science-based tourism related to sea turtles and sea turtle habitat within Hernando County.

Strategy 6.3.1: Conduct studies to determine the composition, distribution, and ecology of sea turtle assemblages within Hernando County to provide baseline data for research and management, and to provide a platform for long term research.

Strategy 6.3.2: Monitor sea turtle “sleeping rocks” (at hardbottom outcroppings), and potential nesting beaches, to identify any areas that should be considered for special management considerations.

Strategy 6.3.3: Collaborate with established research institutions to promote long term research into sea turtle ecology and behavior in interspersed seagrass and hardbottom habitats.

Objective 6.4: Develop and maintain public education, continuing law enforcement education and citizen science programming around Hernando County’s unique assemblage of seagrass bed habitats and interspersed hardbottom through collaborations with Florida Sea Grant, the Nature Coast Biological Station and other qualified marine education organizations.

Strategy 6.4.1: Develop and conduct workshops and trainings with the public regarding marine wildlife interactions, identification, and rescue.

Strategy 6.4.2: Develop and install informational and educational signage in areas of strategic importance for access and navigation, such as boat ramps, fishing piers and navigation channels.

Strategy 6.4.3: Develop programming for community marine debris cleanup events.

Strategy 6.4.4: Conduct workshops with law enforcement on regulations protecting and/or managing seagrasses, corals, sea turtles and other protected marine wildlife, and marine water quality.

Strategy 6.4.5: Promote marine citizen science to increase the reach and extent of basic and applied research, and to create a culture of resource ownership among the residents of Hernando County.

Strategy 6.4.6: Conduct a thorough review of Hernando County ordinances related to the marine environment, including seagrasses, marine wildlife, fisheries, and boating to ensure consistency with state statutes and regulations, and FWC regulations.

Hardbottom and Seagrass Key Policy Resources

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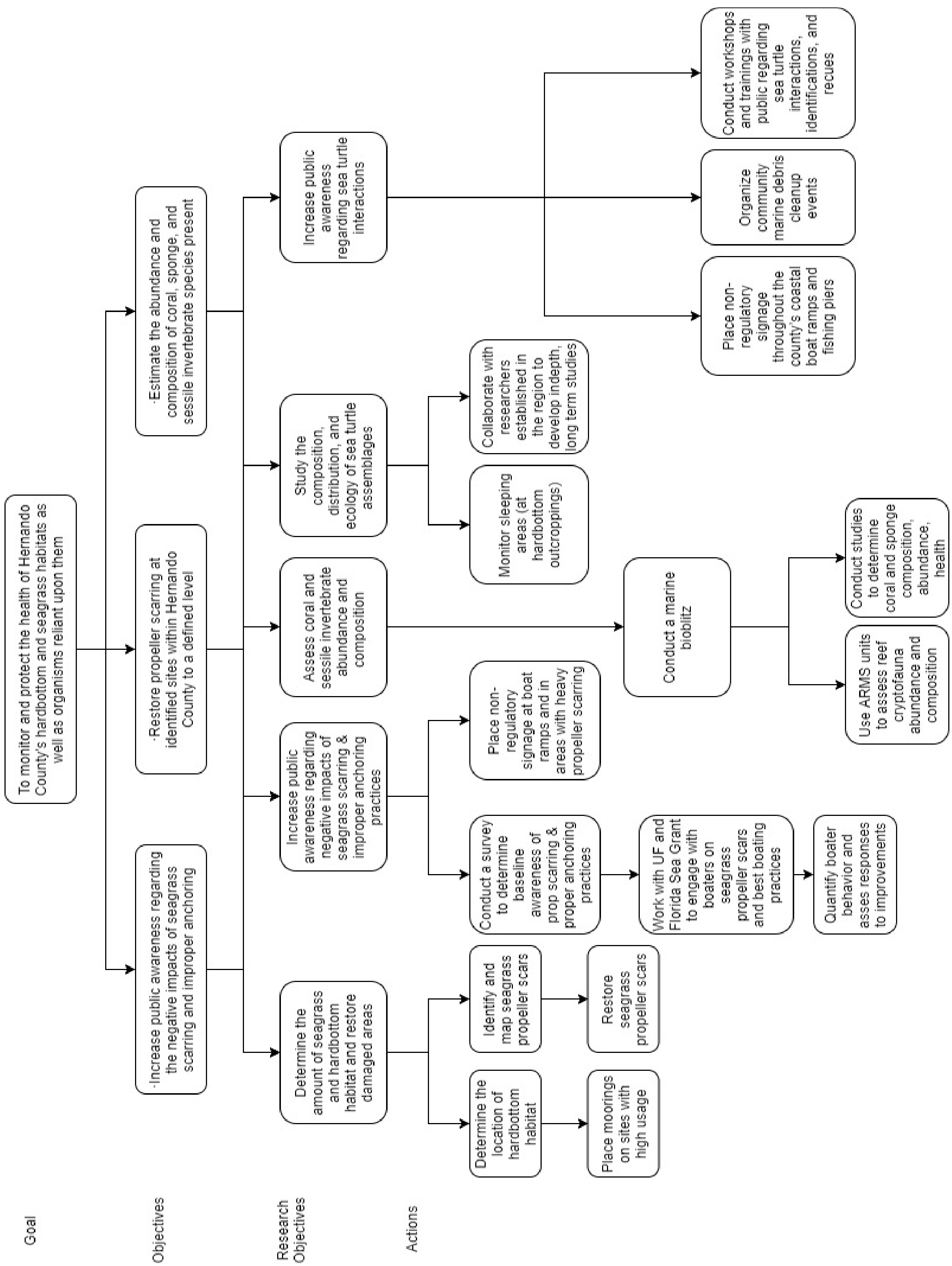
Goal
Objectives
Research Objectives
Actions
To monitor and protect the health of Hernando County's hardbottom and seagrass habitats as well as organisms reliant upon them
·Increase public awareness regarding the negative impacts of seagrass scarring and improper anchoring
·Restore propeller scarring at identified sites within Hernando County to a defined level
·Estimate the abundance and composition of coral, sponge, and sessile invertebrate species present
Determine the amount of seagrass and hardbottom habitat and restore damaged areas
Increase public awareness regarding negative impacts of seagrass scarring & improper anchoring practices
Assess coral and sessile invertebrate abundance and composition
Study the composition, distribution, and ecology of sea turtle assemblages
Increase public awareness regarding sea turtle interactions
Determine the location of hardbottom habitat
Place moorings on sites with high usage
Identify and map seagrass propeller scars
Restore seagrass propeller scars
Conduct a survey to determine baseline awareness of prop scarring & proper anchoring practices
Work with UF and Florida Sea Grant to engage with boaters on seagrass propeller scars and best boating practices
Quantify boater behavior and asses responses to improvements
Place non-regulatory signage at boat ramps and in areas with heavy propeller scarring
Conduct a marine bioblitz
Use ARMS units to assess reef cryptofauna abundance and composition
Conduct studies to determine coral and sponge composition, abundance, health
Monitor sleeping areas (at hardbottom outcroppings)
Collaborate with researchers established in the region to develop indepth, long term studies
Place non-regulatory signage throughout the county's coastal boat ramps and fishing piers
Organize community marine debris cleanup events
Conduct workshops and trainings with public regarding sea turtle interactions, identifications, and recues

Literature Review and Research Objectives

Goal 6. Hardbottom and Seagrass

Background:

Hernando County, situated along the springs coast, exhibits interesting geological and hydrological features that lead to extensive seagrass and hardbottom habitats. Seagrass beds within this region, both inshore and offshore, constitute some of the largest continuous beds within the state of Florida (Dawes et al. 2004, Yarbro and Carlson 2016). In fact, Choice et al. (2014), estimated that a vast 728 km^2 of seagrass beds within Hernando County comprises 24% of Florida's largest seagrass bed. Being almost 4.5 times that of Tampa Bay, seagrass beds in Hernando County extend approximately 25 miles offshore and are typified by a mix of dense, sparse, and bare areas. These areas are intermixed with scattered hardbottom forming complex habitat patterns. Hernando County's seagrass beds contain both monotypic and highly diverse stands and high seagrass species diversity in this region is a product of its pristine water clarity (Choice et al. 2014). Typical seagrass species within the region include Turtlegrass (*Thalassia testudinum)*, Manateegrass (*Syringodium filiforme*), and Shoal Grass (*Halodule wrightii).* Locally, Turtlegrass is the most common species (Yarbro and Carlson 2016). However, Star Grass is present near the Chassahowitzka River (*Halophila engelmannii)* and Widgeon Grass *(Ruppia maritima)* can be found near the Weeki Wachee River (Choice et al. 2014).

Over the years, various seagrass mapping efforts have been conducted within the region (Kolasa and Craw 2009, Kolasa et al. 2011, Baumstark et al. 2013, Baumstark et al. 2016, Yates et al. 2017). However, none of these have covered Hernando County comprehensively. In 2009, the Seagrass Integrated Mapping and Monitoring (SIMM) Program was created by FWC with the goal of regularly monitoring the health and abundance of Florida's seagrasses statewide (Yarbro and Carlson 2016). Their goal is to assess all seagrasses statewide every six years. Their most recent report, released in 2016, indicates that the health and abundance of Springs Coast's seagrass beds are stable/improving.

While the results of Yarbro and Carlson (2016) are promising, continued efforts to protect seagrass beds within Hernando County are both ecologically and economically beneficial. Within the state of Florida, various economically significant fish and shellfish species are reliant on seagrass beds during critical life history stages (Hall-Scharf and Stallings 2014, Hall-Scharf et al. 2016, Yarbro and Carlson 2016). Additionally, seagrass roots and rhizomes play an important role in sediment stabilization and trapping of fine sediment (Duarte 2009). Based on all these and additional ecological services, it is estimated that Florida's seagrass beds are worth approximately $20 billion a year (Costanza et al. 1997, Orth et al. 2006, Yarbro and Carlson 2016). Thus, continued regional efforts to protect seagrass beds are vital to protect and improve the economic vitality of the region. Seagrass beds also play an important role in supporting local tourism including scalloping, fishing, snorkeling, wildlife viewing, and scuba diving (Duarte 2009, Yarbro and Carlson 2016). Unfortunately, these activities which sustain local economies can also damage the ecosystems that support them. Most seagrass propeller scars are a result of careless boater behavior and poorly marked navigational channels that is not only dangerous to boaters but can also be detrimental to the seagrass habitat. Once a seagrass bed has been damaged, it recovers very slowly, if at all (Bourque et al. 2015).

Hardbottom outcroppings are common in the region and support a complex species community. These are the result of limestone which was weathered producing karst. Local rivers and springs produce relatively small sediment loads, resulting in exposed hardbottom areas that are colonized by corals, sponges, and sessile invertebrates. The live rock and coral communities that result provide important habitat for many ecologically valuable reef fish, invertebrates, and endangered sea turtle species. In addition, the complicated facultative symbiotic relationship of Robust Ivory Tree Coral (*Oculina robusta*) with its zooxanthellae have led to periodic, temporary bleaching events which require further investigation (Correspondence with Dr. Gustav Paulay). While the region supports a diverse hardbottom community, assessments of these habitats within Hernando County have historically been minimal (Collard and D'Asaro 1973, Baumstark et al. 2016). There is minimal data available to inform assessments on coral disease and mortality within Hernando County. In fact, the only known work within the region was conducted on Robust Ivory Tree Coral (*Oculina robusta*) (Kolasa 2015). The complicated facultative symbiotic relationship of *O. robusta* with its zooxanthellae have led to periodic, bleaching events which also warrant further investigation (Correspondence with Gustav Paulay). Due to their ecological importance, future research efforts regarding hardbottom mapping, coral abundance/health, and species composition are recommended.

Various sea turtle species identified within the region utilize both seagrass and hardbottom habitats. These species include the Green turtle (*Chelonia mydas*), Loggerhead turtle (*Caretta caretta*), and the Kemp's Ridley turtle (*Lepidochelys kempii*) (Schmid 1998). In Florida, juvenile Loggerhead and Green turtles can be found in nearshore habitats year-round (Ehrhart et al. 2007). In contrast, Kemp's Ridley turtles migrate offshore, to west-central, or the south-west coasts of Florida during the winter when sea surface temperatures drop below 18° C (Gitschlag 1996, Schmid et al. 2003, Schmid and Witzell 2006). However, juvenile and sub-adult Kemp's Ridley turtles exhibit high sight fidelity to seasonal foraging grounds just north of Hernando County (Schmid et al. 2003, Schmid and Witzell 2006). Juvenile and subadults utilize both nearshore live bottom and seagrass beds for foraging (Schmid et al. 2003). In particular, patchy seagrass mixed with hardbottom is associated with areas of high use (Herren et al. in press). Much of Hernando County's marine area typifies this habitat, making it an important location for future research.

Long-term monitoring of sea turtles throughout the region is important given concerns over harmful algal blooms, ecosystem shifts, climate change, and the global loss of seagrass (Waycott et al. 2009; Lapointe et al. 2015). Despite observations of these threatened and endangered species in Hernando County, most research conducted throughout the area has focused on Cedar Key, Florida and Crystal River, Florida (Schmid 1998, Schmid et al. 2003, Schmid and Barichivich 2005, Schmid and Witzell 2006). However, a comprehensive vessel-based survey of the Big Bend region, which includes Hernando County, conducted by the University of Florida and its affiliates is expected to start in 2018. The stated objectives of this study are to identify areas of high turtle abundance and use predictive models to determine the abiotic and biotic factors driving their spatial and temporal distributions.

Based on this review, we highlight the following as areas where future research and community education is highly recommended in Hernando County. Efforts aimed at reducing the impacts of seagrass scarring and improper mooring are vital to ensuring the ongoing health of these habitats. In addition, the locations of hardbottom in Hernando County should be identified. This will aid in the assessment of the abundance and composition of coral and invertebrate species at specific sites throughout the S-MAP area. Lastly, we recommend assessments of the habitat use, abundance, species composition, and behavior of sea turtles within Hernando County to sure that these threatened and endangered species are appropriately protected and managed.

Goal: To monitor and protect the health of Hernando County's hardbottom and seagrass habitats as well as organisms reliant upon them

Project Success Criteria:

- Increase public awareness regarding the negative impacts of seagrass scarring and improper anchoring
- Restore propeller scarring at identified sites within Hernando County to a defined level
- Estimate the abundance and composition of coral, sponge, and sessile invertebrate species present in Hernando County

Research Objective: Determine the amount of seagrass and hardbottom habitat within Hernando County and restore damaged areas

> **Action:** Collaborate with other agencies and research institutions to utilize side scan sonar, multibeam, and aerial imagery (satellite or aircraft) to determine the location of hardbottom habitat within Hernando County
>
> **Action:** Collaborate with other agencies and research institutions to identify and map seagrass propeller scars in Hernando County
>
> **Action:** Collaborate with other agencies and research institutions to restore seagrass propeller scars
>
> **Action:** Place moorings on sites with high usage
>
> - Studies could be designed to determine the effect of additional moorings on reef damage within Hernando County

Research Objective: Increase public awareness regarding negative impacts of seagrass scarring & improper anchoring practices

> **Action:** Conduct a survey to determine baseline awareness of prop scarring & proper anchoring practices in Hernando County
>
> **Action:** Work with UF and Florida Sea Grant to engage with boaters on seagrass propeller scars and best boating practices
>
> - Conduct workshops regarding seagrass safe boating practices

Action: Place non-regulatory signage at boat ramps and in areas with heavy propeller scarring

- Note that the highest levels of prop scarring are noted adjacent to Weeki Wachee Gardens (Sargent et al. 1995)
- Work with UF and Florida Sea Grant to expand the Scars Hurt program

Action: Quantify boater behavior and assess responses to improved education, improved boater practices, and reduced seagrass scarring

Research Objective: Assess coral and sessile invertebrate abundance and composition in Hernando County

Action: Collaborate with researchers, Florida Sea Grant, and the community to conduct a bioblitz of Hernando County's marine area (see https://research.nhm.org/disco/bioblitz2016/index.html as an example)

- This type of survey provides information about biodiversity, presence and absence of species, and location
- Location information for certain species can be helpful in planning additional research throughout Hernando County's marine area
- Samples can be collected for genetic analysis

Action: Conduct transect or quadrant studies to determine coral and sponge composition, abundance, health (Sullivan and Chiappone 1992, Holt et al. 2013)

- This can incorporate a citizen scientist element (Holt et al. 2013)

Action: Use ARMS units to assess reef cryptofauna abundance and composition **(**https://www.pifsc.noaa.gov/cred/survey_methods/arms/overview.php)

- Retrieve ARMS units annually to process collections
- Samples can also be preserved for genetic analysis

Research Objective: Study the composition, distribution, and ecology of sea turtle assemblages within Hernando County

Action: Monitor sleeping areas (at hardbottom outcroppings) to identify individuals and determine behavior patterns at specific sites within Hernando County

- Snorkeling surveys or remote video observations can be utilized (Rincon-Diaz et al. 2011, Pelletier et al. 2012)
    - Note that the use of remove video observations could overlap with other research goals throughout the S-MAP plan (*see Artificial Reefs*)
    - Both sampling techniques could incorporate citizen science
- Research permitting requirements related to sea turtles should be considered before any project starts

Action: Collaborate with researchers established in the region such as the Florida Cooperative Fish and Wildlife Research Unit and the Archie Carr Center for Sea Turtle Research to develop in depth, long term studies

- Permits already held by collaborators should be considered
- Citizen scientist initiatives could also be incorporated into these efforts as well

Research Objective: Increase public awareness regarding sea turtle interactions

Action: Work with UF and Florida Sea Grant to conduct workshops and trainings with public regarding sea turtle interactions, identifications, and recues

Action: Place non-regulatory signage throughout Hernando County's coastal boat ramps and fishing piers

Action: Work with UF and Florida Sea Grant to organize community marine debris cleanup events

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