Knowledge Co-Production for Place-Based Recreational Fishery Conservation in Charlotte Harbor, Florida: A Research and Application Plan

Prepared For:

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The Research and Application Plan is a result of a "co-production" process involving a large, facilitated stakeholder group serving as a Habitat Conservation Subcommittee of the Coastal and Heartland National Estuary Partnership Technical Advisory Committee. A list of stakeholder entities involved in the co-production of this report include:

- *Bonefish and Tarpon Trust*
- *Charlotte County*
- *Coastal and Heartland National Estuary Partnership*
- *Conservation Foundation of the Gulf Coast*
- *Florida Department of Environmental Protection*
- *Florida Fish and Wildlife Conservation Commission*
- *Fish and Wildlife Foundation of Florida*
- *Florida Sea Grant*
- *National Oceanic and Atmospheric Administration*
- *Punta Gorda Isles Fishing Club*
- *Southwest Florida Water Management District*
- *University of Florida Institute of Food and Agricultural Sciences*

Executive Summary:

Recent research has demonstrated that two economically important sportfish, *Centropomus undecimalis* (snook) and *Megalops atlanticus* (tarpon), thrive in small, ephemerally-connected, shallow ponds within a habitat mosaic of intertidal wetlands in Charlotte County, Florida. These habitats are threatened by development along their upland margin and the species have no explicit special habitat protections in State or Federal law despite their importance to the regional economy as sportfish. The National Oceanic and Atmospheric Administration (NOAA) RESTORE Science Program has funded research to generate actionable science to accelerate the development of protection strategies for these habitats to protect the nursery areas of these important species.

Historically, much of the coastal habitats of southwest Florida included salt marsh with isolated depressional wetlands and ephemeral creeks and ponds that would intermittently connect during the wet season. Development has displaced much of this historical habitat with estimates of salt marsh loss of ca. 50% in the Charlotte Harbor area. Many of the historical ponds in the landscape have been lost or replaced by stormwater detention ponds that do not mimic the natural geomorphic contours or hydrological connections of the natural ponds and much of the remaining natural pond habitat is restricted to state preserve systems such as the Charlotte Harbor Preserve State Park within the study area. However, development abuts these preserves, limiting the potential for landward expansion of coastal wetlands with expected sea level rise. In addition, older developed areas abutting the preserve route stormwater into the preserve, creating the potential for nutrient pollution and algae blooms in the existing preserved ponds.

To date, research on these habitats has focused on identifying what constitutes a productive system, documenting the presence of juvenile snook and tarpon, characterizing the prey community structure and riparian habitats in initial attempts to develop indices related to their potential productivity, and tracking fish movements in and out of the ponds. Pilot studies tracking movement of sportfish utilizing these ponds has suggested that they successfully emigrate from the ponds as large juveniles and recruit to the coastal fishery which supports a multi-million dollar industry. Water level

measurement instruments have been employed for a small subset of ponds to evaluate the inundation frequency sufficient to connect the ponds with the adjacent habitat mosaic of intertidal wetlands and creeks leading to the larger estuary. Yet, more research is needed to understand the specific habitat requirements necessary for productive utilization of these ponds by sportfish.

Through a series of facilitated workshops using a co-production process, the Florida Fish and Wildlife Conservation Commission (FWC) in cooperation with the Coastal & Heartland National Estuary Partnership (CHNEP) and Bonefish & Tarpon Trust (BTT) have developed this Research and Application Plan (Plan) to advance research on these habitats and reduce uncertainties associated with implementing policies to increase protections for these critical species. The Plan includes both research and policy recommendations and defines the linkages necessary to solidify science-based decisions on how to proceed with realistic options to implement as natural resource protections in Charlotte Harbor. This Plan will also serve as a foundation for similar research in other areas to inform protection and restoration efforts for similar intertidal wetland systems where anthropogenic activities have altered the natural function of these habitats, limiting their productivity.

The workshops focused on efforts to bridge the science and policy gaps and to advance efforts to increase protections for these species and their habitats while research continues. The identified research elements emphasized the need for additional fish surveys to document the full extent of juvenile sportfish habitat within the study area, baseline water quality assessments, continuation and expansion of fish tracking studies, and an evaluation of the relative efficacy of various restoration practices for the benefit of these species. This research will contribute to the refinement of an existing habitat characterization matrix. To fully evaluate risk to these habitats, hydrologic modeling of the drainage basins was also identified as a necessary component to develop a Vulnerability Index (VI) as well as a model to evaluate existing zoning and permitted land use and the potential effects of sea level rise on these habitats. The results of the VI will provide site-specific habitat scores reflecting both the value of the specific habitat to overall sportfish productivity in the system as well as the risk imposed on the habitat by future anthropogenic and climatic effects. The final VI will be a map in electronic form that can be overlaid on existing spatial data layers including permitted land use, existing

infrastructure and zoning information to integrate information on the natural resource requirements of these species into local ordinances and market-based incentive programs associated with Charlotte County's Transfer of Density Units (TDU) program. Creative solutions are required to implement actions to protect these habitats. An Overlay District (OD) is one such mechanism recommended through co-production that can be adopted locally to provide additional protections for these areas as development encroaches. Together, the VI and the OD form two central themes identified to guide the implementation of these protections. The Overlay District combines the research outcomes generating the VI along with recommended land use practices, current local ordinances, and land use planning information to codify special protections for these habitats in county and/or municipal Comprehensive Plans.

While research continues, threats from development persist for these habitats and are expected to increase in coming years and yet, funding for direct habitat conservation is insufficient and many small, isolated wetland ponds remain at risk for being filled and mitigated against without consideration for connectivity to their role as sportfish nurseries. In addition, social marketing approaches were identified as a potentially undervalued concept to influence developers, homeowner's associations and the general public to change behaviors to protect these habitats. A "Tarpon Friendly Community" campaign was one example of a potential campaign recommended to influence developers and homeowner's associations to adopt strategies to promote protection and conservation strategies in the watersheds of these habitats.

This Plan is intended to promote actions to protect juvenile tarpon and snook habitat while research continues on the specific requirements of these habitats, and how restoration practices can be optimized to mimic the natural function expected of these species as they migrate into and through the mosaic of intertidal wetland habitats required for their survival. Some aspects of this plan can be implemented immediately while other aspects rely on more research to complete. The key to the successful implementation of this Plan will be continued support of the local natural resource managers and stakeholders that have contributed to this Plan including the NOAA RESTORE Science Program who has provided much of the support for the novel research that has identified these habitats as a priority for protection. With continued engagement, these habitats can be protected from future threats and the science accumulated through

this research can be translated to other areas in the Gulf of Mexico and beyond to inform conservation and restoration efforts aimed to protect these economically important species.

Table of Contents

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I. Project Background

As the "Tarpon Capital of the World", Charlotte Harbor, Florida draws thousands of anglers annually to experience the region's vibrant recreational fisheries, including both common snook (*Centropomus undecimalis*) and tarpon (*Megalops atlanticus*). Supporting healthy habitats and fisheries has the added effect of creating community economic resilience through tourism and expenditures. Charlotte Harbor is known for its excellent sportfishing with almost 150 charter fishing guides and over 16,000 resident licensed anglers. A recently completed economic valuation study (CHNEP, 2020) determined the total economic impact of the Charlotte Harbor Basin is approximately $493.9 million annually with the principal driver being natural resource-based recreation (primarily tourism related to water-based recreation and charter fishing).

Groundbreaking research funded by a Resources and Ecosystems Sustainability, Tourist Opportunities, and Revived Economies of the Gulf Coast States Act of 2012 (RESTORE Act) grant discovered that tarpon and snook thrive in small, ephemerally-connected, shallow ponds within a habitat mosaic of intertidal wetlands in Charlotte County that lie against an upland margin vulnerable to human development. This discovery led to additional grant funding from National Oceanic and Atmospheric Administration (NOAA) RESTORE Science Program to collaboratively plan research and actions (described in this document) that will inform future decisions on how to manage these critical and unique sportfish habitats in Charlotte Harbor, Florida. These studies were part of a larger NOAA RESTORE Science Program opportunity to invest in the future of applied science, and ultimately, the sustainability of the Gulf of Mexico ecosystem. By investing in research on unique coastal marsh habitats NOAA hopes to generate "actionable science" to support local protection strategies that will contribute to the sustainability of these areas and the larger Gulf ecosystem. Place-based habitat protection through a local decision-making process is necessary to ensure persistence and sustainability of the community's ecologically and economically valuable natural resources.

Intertidal wetlands in their natural state include a habitat mosaic delivering a wide range of essential ecosystem services. In southwest Florida, salt marshes and mangroves forests, tidal creeks and ponds comprise a hydrologically interconnected network.

Ecosystem services of these tidal wetland ecosystems include: providing essential food, refuge, and critical nursery habitat for commercially and recreationally important species and their prey; improving water quality by filtering runoff and assimilating excess nutrients; reducing the effects of storm surge on coastal erosion and flooding; and mediating climate change by sequestering large quantities of the greenhouse gas carbon dioxide from the atmosphere. However, intertidal wetlands are becoming increasingly vulnerable to sea-level rise, sediment starvation, eutrophication and limits on landward migration (Couvillion et al. 2021, Ganju et al. 2017, Woods Hole 2021).

The Florida Fish and Wildlife Conservation Commission's (FWC) Fisheries Independent Monitoring (FIM) program, Mote Marine Laboratory (MML), and the Bonefish and Tarpon Trust (BTT) have documented productive fish nursery areas for juvenile tarpon and snook within a mosaic of intertidal mangrove creeks and ephemerally connected salt marsh/mangrove ponds in Charlotte Harbor, Florida (Adams et al. 2009, Stevens et al. 2007 Wilson et al. 2022: Figure 1). While tidal tributaries have primarily been identified as important habitats for snook (Adams et al. 2009, Barbour et al. 2014a and 2014b, Peters et al. 1998, Stevens et al. 2007, Wilson et al. 2022), the presence and high densities of juvenile snook, and particularly tarpon in many of the isolated and ephemerally connected coastal ponds in the study area is a novel finding (Blewett et al. 2020) that highlights the critical importance of the ponds within the habitat mosaic which are still present in some areas within the Charlotte Harbor estuary. Much of this highly productive habitat is located within the confines of established state parks and aquatic preserves (FDEP 2007, FDEP 2017); however, historical aerial imagery suggests much of coastal southwest Florida included areas with intertidal wetland and ephemerally connected ponds that have been lost to development and development continues to encroach on the watersheds of these habitats.

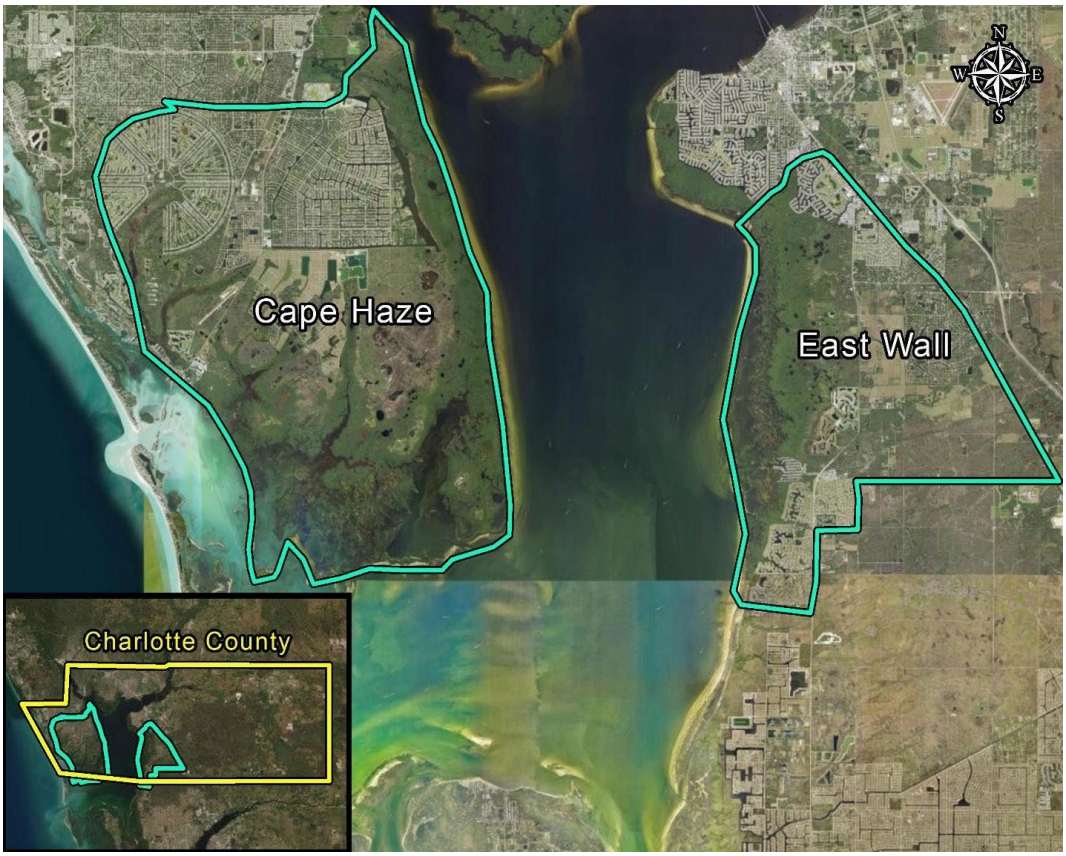


Figure 1. Project study area.

Development in southwest Florida prior to laws protecting the destruction of wetlands dramatically reduced the availability of these habitats in southwest Florida and within the study area. One local example is Punta Gorda Isles at the mouth of the Peace River in Charlotte Harbor. Historical aerial photography from the 1950's suggests this point contained many natural coastal pond habitats that were displaced by canal associated with development (Figure 2). This is not an isolated finding with similar outcomes observable throughout the Charlotte Harbor estuarine system including the lower Caloosahatchee River. While historically much of coastal southwest Florida contained these types of natural habitats, the study area now represents some of the last remaining undeveloped coastal features of this type in Charlotte County

Figure 2. Historical (1954) aerial imagery and current imagery (right) of Punta Gorda Isles in Charlotte Harbor Florida.

While much of the study area is within the State Preserve system, platted but undeveloped subdivisions abut the coastal preserves, limiting the potential for landward expansion of coastal wetlands with expected sea level rise. In addition, older developed areas abutting the preserve route stormwater into the preserve, creating the potential for nutrient pollution and algae blooms in the existing preserved ponds. The ephemerally-connected ponds are isolated during the dry season and hydrologically connected only during high wet season flows or extraordinary seasonal high tidal events. The reproductive life histories of snook and tarpon suggest they spawn during the summer wet season in synchronicity with wet season patterns that allow access via hydrologic connections of this habitat mosaic. The relative isolation of the tidally connected creeks and ponds, and the higher level of isolation of the ephemerally connected ponds, provide high levels of protection and ample prey in this area (Blewett et al. 2020), similar to marsh impoundments, which have been heavily studied on the east coast of Florida (Poulakis et al. 2002, Stevens et al. 2006, Robinson and Jennings 2014).

While juvenile tarpon are obligate users of mangrove and salt marsh habitats and are highly adapted to survive in hypoxic or anoxic conditions (Adams et al. 2013, Adams and Murchie 2015, Wilson et al. 2019 and references therein), habitat degradation caused by altered freshwater flows (e.g., increased total discharge volumes and "flashiness") and associated increases in pollutant loadings threaten the ecological integrity of the mosaic of tidal creeks and mangrove ponds that have been identified as critical habitat for juvenile snook and tarpon (Adams et al. 2009; Wilson et al 2019). The NOAA RESTORE Science Program has appropriately identified the necessity for place-based conservation of these areas using a local decision-making process to ensure their long-term viability and recognized that when considering habitat in statewide fishery management, local stakeholder input is required as local government decisions directly affect habitat through development, water quality, land acquisition, and restoration policies.

This document details a Research and Application Plan ("Plan"), developed using a natural resource community driven "co-production" process, to integrate research and policy attributes in order to accelerate the protection of these habitats and guide future restoration efforts.

Fundamentals of the Research and Application Plan

The National Research Council (NRC 2005) defined fundamental elements that a scientific plan should contain including: background information, an overarching theme, and implementation protocols. This plan follows that guidance by presenting the current state of knowledge on fish utilization of these habitats, current research and policy gaps that are needed for protection, and a framework for developing decision support tools to identify and apply the most appropriate protections for these areas at different spatial scales. This Plan identifies research that will inform management decisions on how and where to preserve and protect sportfish nursery habitat; and will aid in the prediction/avoidance/mitigation of adverse impacts to sportfish nursery habitat caused by incompatible development, inappropriate stormwater management, and the long-term stressors of climate change and to sea level rise. The Plan can be used by local, regional, state and federal agencies and organizations to identify, plan and implement strategic conservation land acquisition, habitat restoration and enhancement, regulatory mechanisms, and land use policies needed to effectively and efficiently conserve and manage sportfish nursery habitat. In addition, the Plan can be used to seek support for

research which informs fish habitat restoration plans, state and local land acquisition plans, and local land use policies.

Present State of Knowledge

The study area represents a habitat mosaic of tidal creeks and coastal ponds within expansive mangrove forest systems. A critical feature of this network is the presence of ephemerally connected ponds near the most upstream reaches of creeks. Adjacent to the preserve border, several man-made ponds have also been documented as potentially productive habitat for these sportfish and these ponds may be vestigial natural ponds that have been altered by development. Multiple scientific studies have been conducted on juvenile snook within or near the study area. These include studies investigating general habitat, distribution, and seasonality, as well as detailed life-stage habitat use and connectivity, and freshwater inflow effects on feeding ecology (Adams et al. 2009, Barbour and Adams 2012, Barbour et al. 2014a and 2014b, Stevens et al. 2007, Wilson 2022). In addition, several studies on juvenile tarpon have been conducted within or near the study area. Wilson (2015) examined the nursery habitat, density, growth, survival, and emigration of juvenile tarpon in Lemon Creek Wildflower Preserve on the Cape Haze peninsula. In the same location, Wilson et al. (2019) described a mark-recapture study to measure juvenile growth in an altered mangrove habitat in the Charlotte Harbor watershed and detailed how citizen science was used to identify juvenile habitat and characterize the habitats as natural or altered in the Charlotte Harbor and Indian River Lagoon area.

While both snook and tarpon spawn in the summer months in the Gulf of Mexico and utilize multiple habitat types throughout their life cycles, coastal habitats are required for their survival. Snook spawn in coastal passes and nearshore areas (Taylor et al. 1998), and their eggs are typically transported into estuarine mangrove habitats (Peters et al. 1998), while tarpon spawn offshore and their (leptocephali) larvae are transported inshore by coastal currents (Crabtree et al. 1992). Juveniles of both species seek out protected habitats, including mangrove creeks and coastal ponds as depicted for the tarpon life cycle in Figure 3 (adapted from the Nature Conservancy and the Loxahatchee River District (Poster series #3: www.loxahatchriver.org). Recent research by FWC suggests that intertidal wetlands with isolated coastal salt marsh/mangrove ponds serve a similar function for both juvenile tarpon and snook and that the two species may use

the habitat in ways different enough to reduce competition of resources in these areas (Blewett et al., 2020).

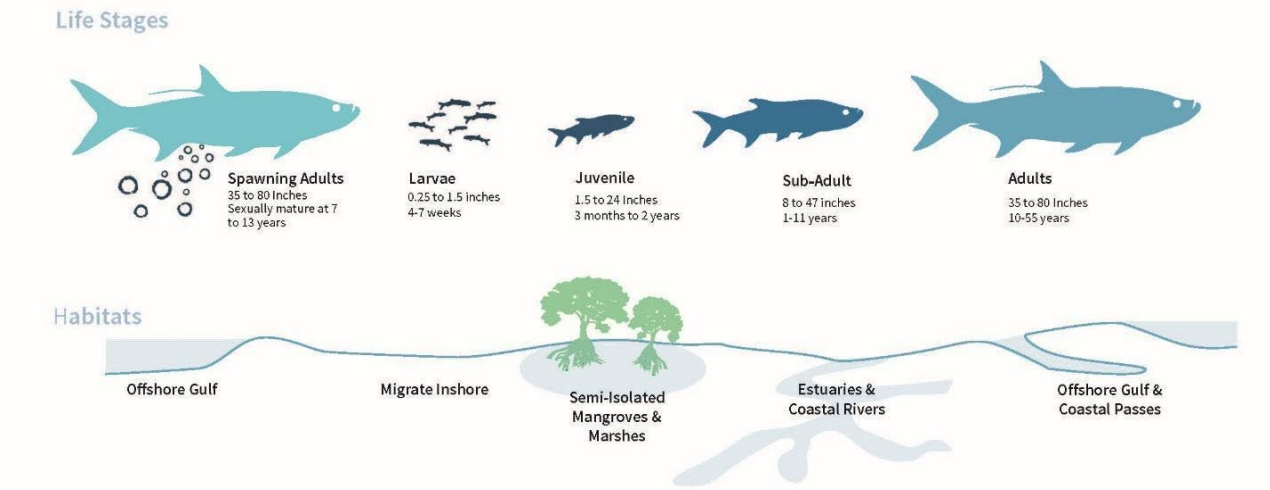


Figure 3. Tarpon life cycle (adapted from the Nature Conservancy and the Loxahatchee River District (Poster series #3: www.loxahatchriver.org).

Together the life history attributes of these species emphasize the need for protection of critical coastal mangrove, salt marsh and, particularly, coastal wetland ponds in the Charlotte Harbor estuary. While these species are included broadly within the definition of Aquatic Resources of National Importance and some intertidal wetland is considered "Essential Fish Habitat" for federally managed species like gray (mangrove) snapper (*Lutjanus griseus*) and red drum (*Sciaenops ocellatus*) within the Magnuson-Stevenson Act, tarpon and snook utilization of these coastal habitats, particularly the ponds, does not trigger any special protections with respect to regulatory permitting conditions for individual properties within the study area.

Habitat Changes over Time

Best estimates of historical salt marsh extent suggest at least fifty percent of the salt marsh habitat adjoining the Charlotte Harbor system has been destroyed since 1945 (Beever et al. 2012). Much of this loss occurred prior to the implementation of wetland protection regulations in the late 1970's. Figure 4 and Figure 5 compare conditions in the study areas in 1952, 1999, and current (2021) conditions. Obvious from these images is that land development within uplands has extended to the edge of estuarine wetlands in several locations, allowing little buffer for landward habitat migration due to projected sea level rise (ESA, 2019). Development activities have also changed local topography,

altering surface water flows, drainage rates and locations, and groundwater recharge (Garcia et al. 2020), with potentially detrimental impacts for juvenile sportfish and their prey (Sklar & Browder 1998, Adams et al. 2009).

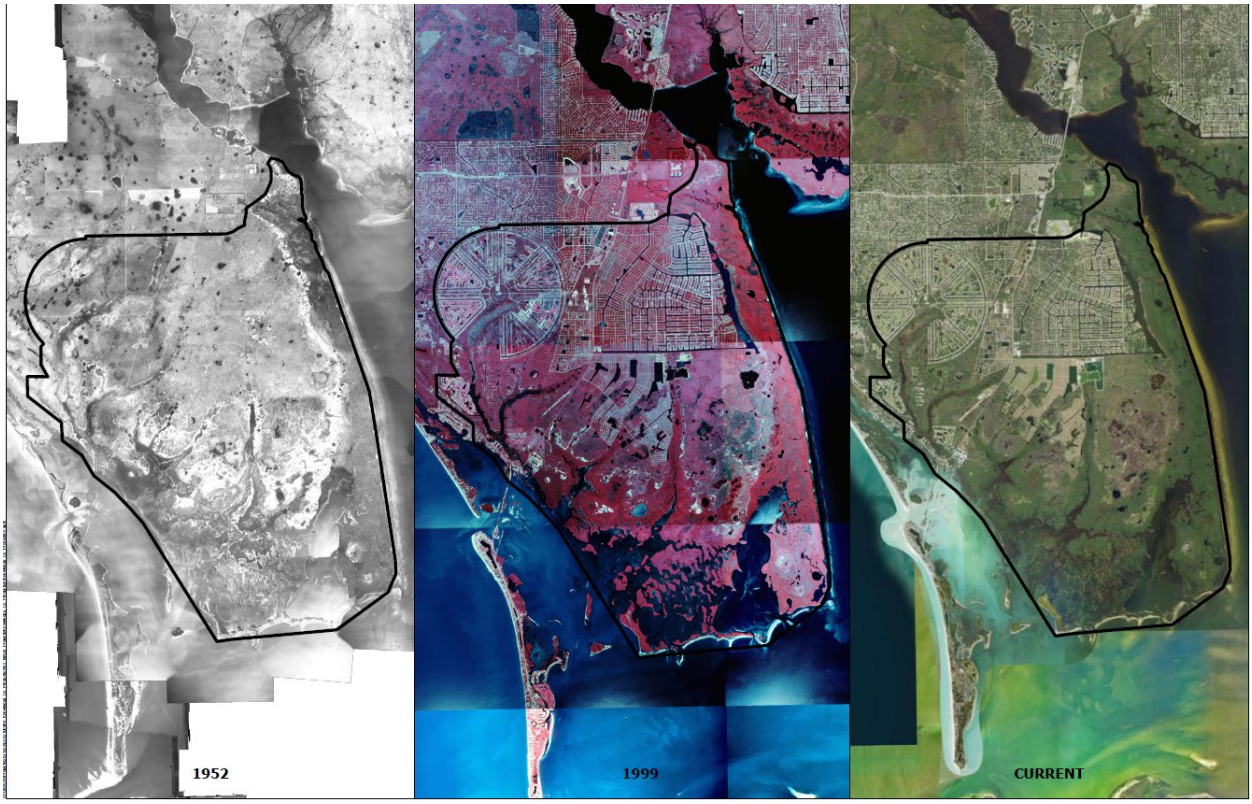


Figure 4. Aerial photographs of the Cape Haze area comparing the 1952 (left panel) and 1999 (center panel) conditions to the current condition.

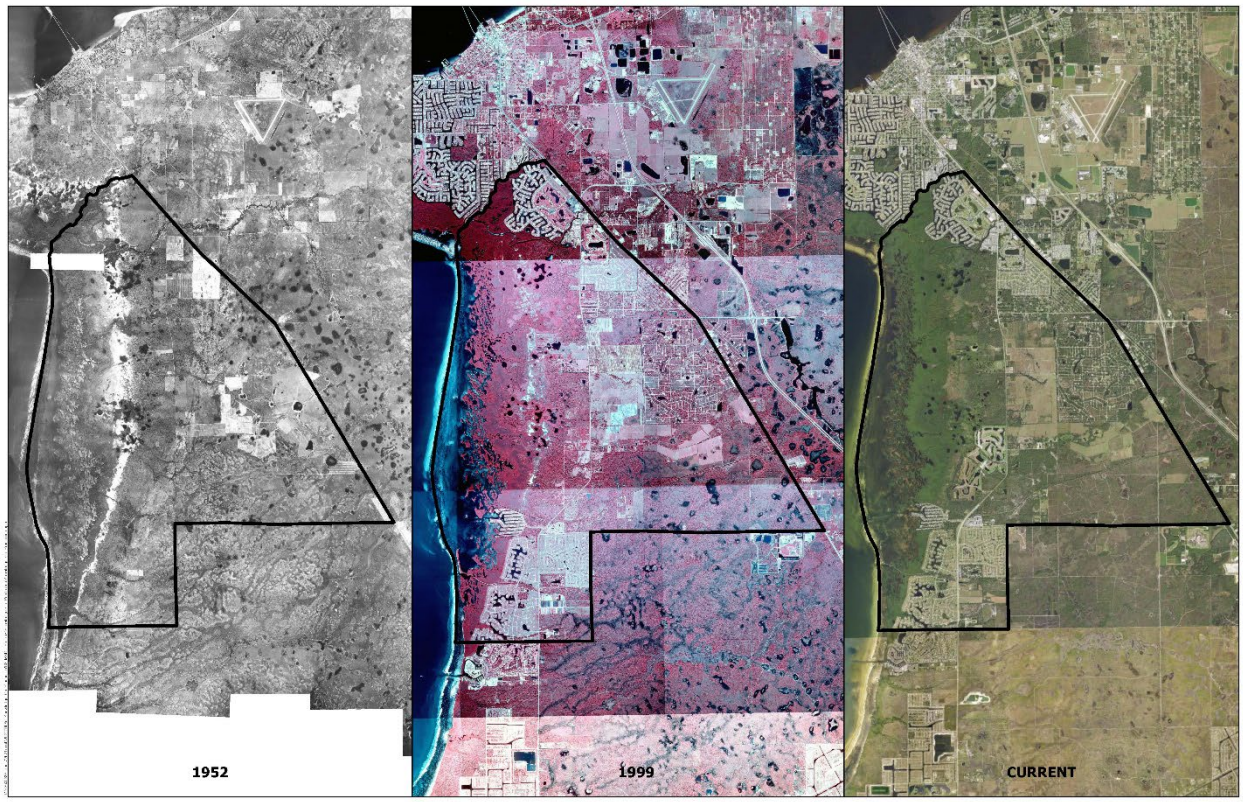


Figure 5. Aerial photographs of the East Wall area comparing the 1952 (left panel) and 1999 (center panel) conditions to the current condition.

Estuarine wetlands within the study area are now largely protected from further development due to public conservation ownership by the State of Florida, as well as federal and state regulatory protections. A recent CHNEP habitat restoration needs (HRN) report (ESA 2019), identified and prioritized habitat changes over time throughout the study area and identified the study area as a high priority for restoration and management (green in Figure 6). In general, tidal wetland acreage throughout Charlotte Harbor has been relatively stable since (1995) with a 2% loss in salt marsh habitats, a 1% gain in mangrove acreage and stable salt barren acreage. The stability of these habitats over the 1995-2011 study period is primarily due to regulatory protections at both the federal and state level in the 1970's with much of the identified area currently in conservation.

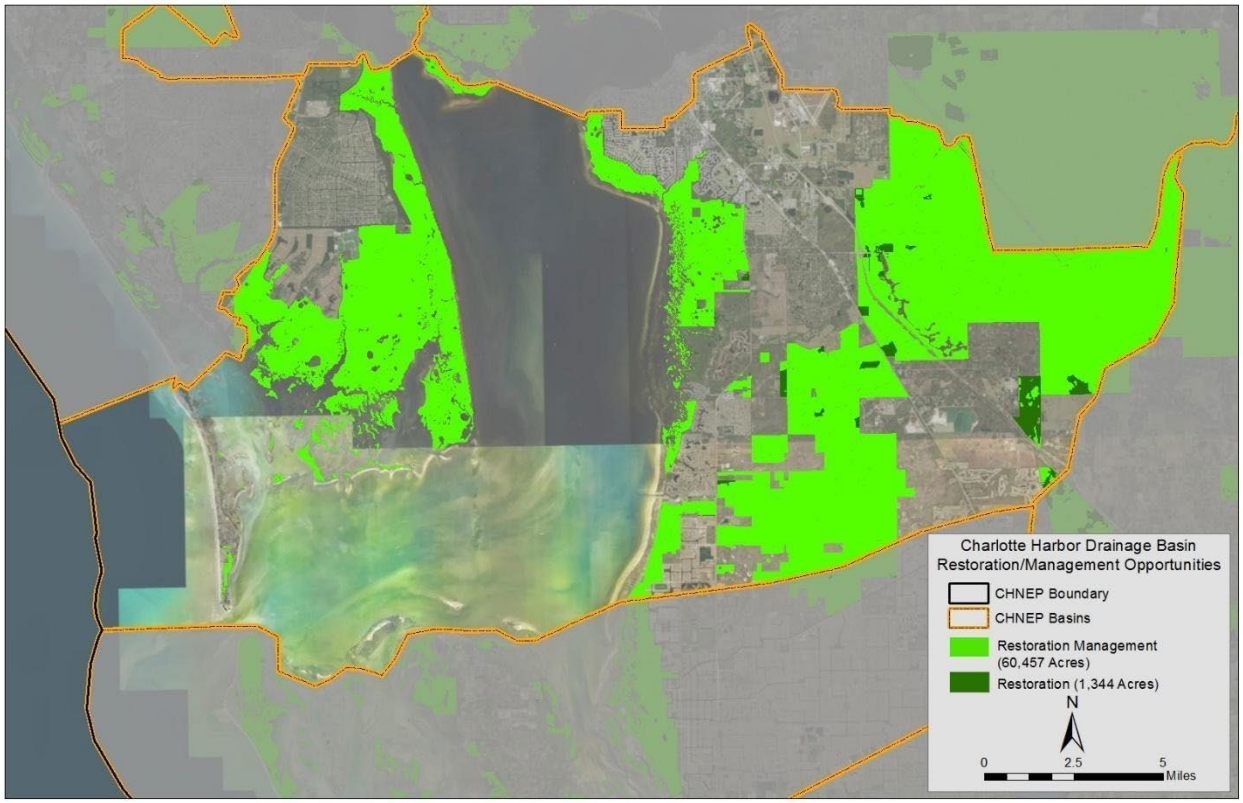


Figure 6. Areas identified as high priority restoration/management sites in the Charlotte Harbor basin by the CHNEP HRN project.

Goals, Objectives, and the Co-production Process

The goals of this plan are to:

1) identify challenges to the conservation of specific sportfish nursery habitats of the Cape Haze Peninsula and East Wall of Charlotte Harbor;

2) plan actionable research to inform management alternatives; and

3) develop decision support tools to help identify the most effective habitat protection approaches for these critical areas.

The overarching theme of the plan is achieving place-based habitat conservation through local decision-making processes. The specific objectives of this plan include developing a research plan to define the habitat requirements of these species, identifying stressors to both the species and their habitats, identifying expected responses to those stressors and identifying interventions that minimize negative effects on these species primarily through habitat protection. In addition, the plan contains a component to apply

known research to policy in an effort to accelerate current protections for these species. Together, the research and application chapters are designed as a template to guide future management actions necessary to conserve and protect critical tarpon and snook nurseries in Cape Haze and East Wall in Charlotte Harbor, and may serve as a template for extrapolating this effort to other critical habitats outside this place-based initiative.

Local natural resource managers and stakeholders play a critical role in protecting habitats through comprehensive plans, local ordinances, and development codes, as well as in identifying environmentally sensitive lands for protection and restoration. The research and policy recommendations presented in this plan were identified through facilitated science "co-production" with the Habitat Conservation Subcommittee (HCS) of the CHNEP as a venue to engage stakeholders and local resource managers (Figure 7). A series of four half-day workshops inclusive of all interested parties were held to facilitate the collection of data, identification of data gaps, and identification of needs for research and policy applications. These workshops were held using well-established techniques for gathering group input from resource managers, researchers and stakeholders essential for co-producing actionable science supporting sportfish nursery habitat protection. Co-production is a collaborative effort between managers, scientists, and partners that identifies decisions that need to be made, develops processes and outcomes to inform those decisions, and builds connections between disciplines and interests to achieve the best solutions for those needs (Beier et al. 2017). It has been demonstrated as an inclusive and effective method of fisheries management and conservation (Cooke et al. 2021). Co-production leverages the skills and knowledge of resource managers, science and academia, and funding partners to provide the right information for the benefit of habitat or resources in need. One aim of our use of co-production is to generate "actionable knowledge" (Blood, M.R. 2006), which is defined as the creative intersection between what we know and putting what we know into action. That is, the group recognized that actions could be taken to protect these habitats even though science and policy gaps remain hindrances to providing complete protections for these species.

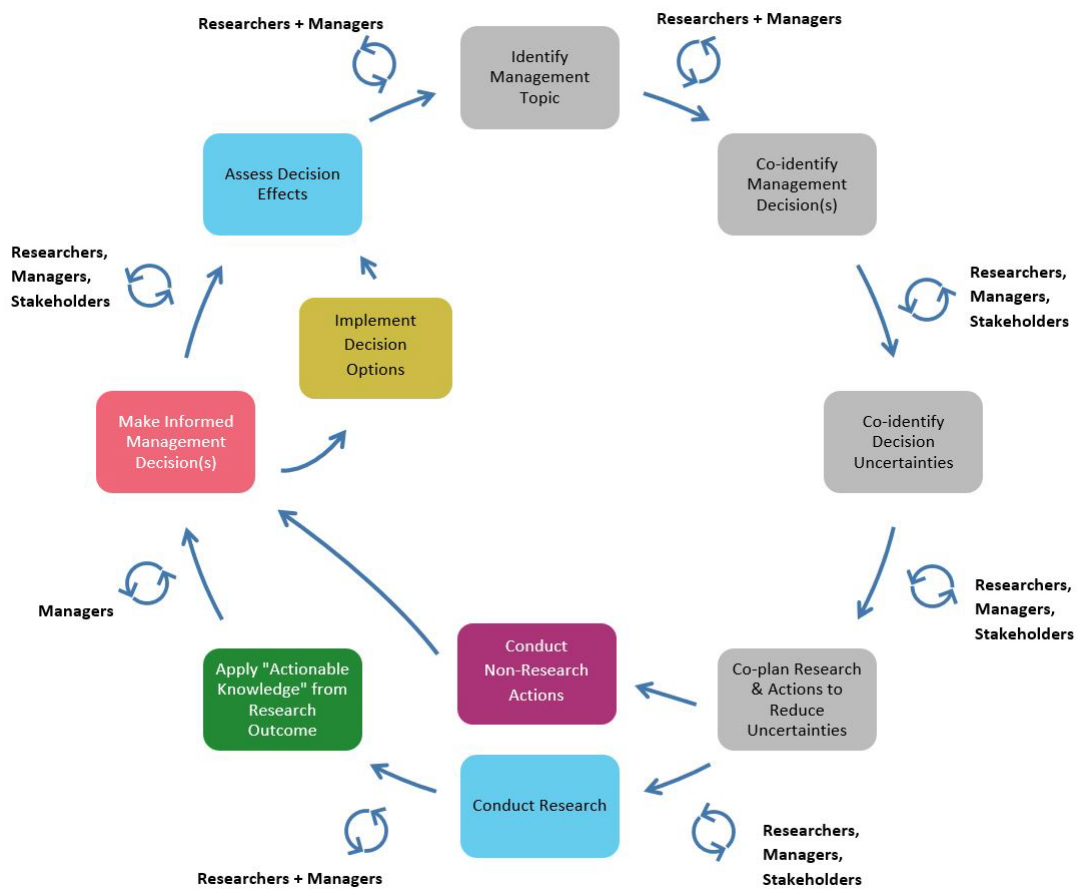


Figure 7. Science and management co-production process applied to develop the Research and Application Plan.

Relationship to Other Stakeholder Plans

This Plan defines actionable science to inform science-based policies and practices that can be used to accelerate habitat protections for the study area. The aim of this Plan is to inform future County Comprehensive Plans as well as potential permit conditions and to establish priorities for either land acquisition, conservation, protection and/or restoration. Thereby, this Plan will complement both the Charlotte County and the CHNEP Comprehensive Conservation and Management Plans. This plan addresses all principal Action Plans of the current CHNEP CCMP including: Water Quality Improvement; Hydrological Restoration; Fish, Wildlife, and Habitat Protection, and Public Engagement. This Plan also will be used to inform future revisions to the Charlotte County Comprehensive Plan (Charlotte 2050); a document that establishes the vision of the citizens about how the County will grow in the future (Charlotte 2050 Comprehensive Plan). The Comprehensive Plan contains goals, objectives, and

policies that will guide future development and preservation and includes elements for infrastructure, coastal planning, future land use, and natural resources applicable to study area. In addition, the newest FWC strategic action plan (FWC, 2020) defines a strategy for infusing a more proactive approach to address known challenges, and capitalize on opportunities for future-focused conservation. This Plan implements the FWC landscape conservation strategic initiative at the local level with a focus on marine fish habitat management by identifying a proactive approach to protect and restore critical sportfish habitats in Charlotte County, Florida.

Research and Application Plan Overview

This Plan includes chapters identifying and detailing the research needs (Chapter 2) and policy needs (Chapter 3) necessary to achieve full protection of these habitats as identified during the co-production process in accordance with NOAA's "Research Plan" guidance. Chapter 4 combines the research and policy needs into an "Application Plan" where the plans are organized into actionable components and central themes and a decision framework are identified to guide research outcomes towards the implementation of actions to protect these habitats. A synoptic overview of the plans is provided below.

Geographic Focus:

The Cape Haze peninsula and East Wall areas of Charlotte Harbor, Florida.

Natural Resource Focus:

The coastal habitat mosaic comprised of tidal mangrove and saltmarsh creeks and wetlands, and ephemerally connected ponds that provide critical nursery habitat for tarpon and snook, two sportfish species of considerable recreational and economic importance to the area.

Resource Management Issue Addressed:

Conservation of sportfish nursery habitat at risk of degradation or loss due to development, hydrologic alteration, pollution, and sea level rise.

Management Decisions Considered:

1) Land use, zoning, development, and environmentally sensitive lands protection policy amendments to the Charlotte County Comprehensive Plan.
2) Siting and design of sportfish habitat protection, restoration, enhancement, and creation project opportunities.

Identified Management Uncertainties:

1) Fully identified locations of sportfish nursery habitat on the East Wall.
2) Effects of various development densities in platted neighborhoods proximal to sportfish nursery habitat, primarily on Cape Haze, and development within watersheds of nursery habitats that may change hydrological characteristics.
3) Range of sportfish nursery habitat protection, creation, enhancement, restoration designs most effective for recruitment, growth and survival (e.g., appropriate fish passage connectivity, size, watershed size, hydrology for prey production, protection of juvenile snook and tarpon from predation).

Research and Policy Themes to Reduce Management Uncertainties:

1) **Fisheries:** sportfish and fish community ecology, habitat locations and utilization, growth, movement, and recruitment.
2) **Habitat Function and Management:** hydrology, projection of development impacts and effects of sea level rise on functionality and quality.
3) **Habitat Protection, Conservation and Preservation:** strategies and methods to maximize conservation incentives, influence policies, and improve effectiveness of conservation efforts for estuarine sportfish habitat in Charlotte Harbor, FL.

II. Research Plan

The facilitated co-production workshops identified research needs and developed action items to build on existing information to address gaps necessary to effectively apply place-based fishery habitat protection in Cape Haze and East Wall areas of Charlotte Harbor.

Specific Research Themes

Specific research themes or issues have been identified reflecting potential threats to critical nursery habitats for tarpon and snook in the study area. These themes include habitat quantification, direct habitat loss, impacts to (and of) hydrology, immigration and emigration, water quality impacts, and sea level rise. The research necessary to address these themes are detailed in the subsections below.

Habitat Quantification and Prioritization

Within the habitat quantification theme, several research needs have been identified. These are listed in the bullets below with paragraphs explaining the current status, rationale, and applications.

Identify Nursery Habitat Extent and Quality with Additional Fisheries Monitoring.

While the extent of potential tarpon and snook habitats within the study area has been estimated (Figure 8), only a small portion of the habitat has been sampled. Previous NOAA RESTORE Science Program funding enabled FWC fisheries scientists to sample about a third of the available coastal ponds on the Cape Haze peninsula between 2019-2022 including six restored waterbodies off west branch Coral Creek. Ideally, unexplored Cape Haze and East Wall habitats of Charlotte Harbor should be explored and subsampled. Currently, the proportion of habitat that is viable and accessible by juvenile tarpon and snook is unknown. The entire habitat mosaic represents potential nursery areas critical for these species and their prey; however, the unique coastal pond features within the study area are particularly understudied and their function as nurseries for tarpon and snook are a primary research interest of this plan. Therefore, research is

needed for synoptic surveys of unsampled coastal ponds within the study area to be conducted to clearly identify tarpon and snook nurseries. Additional research characterizing the habitat value and relative threat level from potential impacts can also be assessed during this synoptic sampling effort where it fills gaps in existing knowledge.

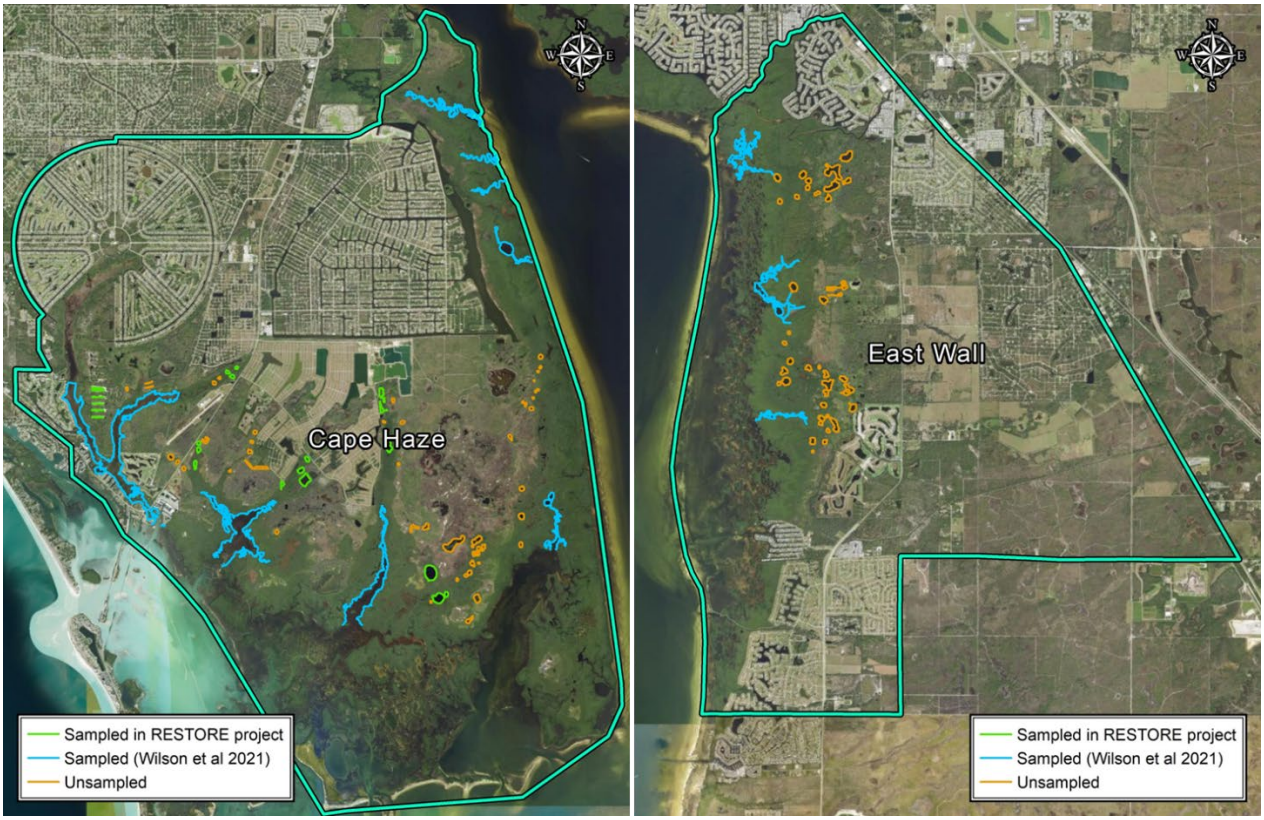


Figure 8. Extent of potential tarpon and snook habitat in the Cape Haze (left) and East Wall (right) portions of the study area.

Application: A defined "sampling universe" of tarpon and snook nursery ponds in the study area with an initial characterization of their condition, and relative and potential value.

Fish Tracking Study

An important benchmark for evaluating the relative value of nursery habitat is ensuring that enough juvenile fish are surviving in the nursery and that they are able to move out of the nursery and contribute to the adult population. In this case, the movement of tagged tarpon from isolated coastal ponds to well-connected tidal creeks can constitute contribution of coastal pond nursery habitat to the adult tarpon population in the estuary. Acoustic telemetry will be used to assess the conditions that allow for tarpon emigration from coastal ponds. It is possible that a habitat can hold juvenile fish, but that these fish can become trapped. This is particularly true for tarpon that can enter as a leptocephalus larvae (shaped like a ribbon) and grow to a relatively large size (500 mm total length) before emigrating from their nursery. Tracking movement of juvenile tarpon from their nursery habitat is possible with the use of acoustic telemetry. For example, acoustic receivers can be placed in a chain of coastal ponds and the receiving tidal creek. These receivers detect the presence of tagged fish (tag life of 1.5 years). Previous work has shown that conditions of high water level, typically the passage of tropical storms, is what allows for juvenile tarpon emigration from coastal ponds. The specific water levels that allow for this, combined with knowledge of marsh elevation, can inform hydrologic models. One goal of this research task is to track the movement of juvenile tarpon at two study sites (each being a chain of ponds and a receiving tidal creek) along the eastern shoreline of Charlotte Harbor where this type of work has not yet been conducted.

Acoustic telemetry will help determine if the nursery habitats are functioning properly (i.e., juvenile tarpon are surviving and in fact moving to the estuary), and if so, can provide specific hydrologic information to inform policy needs. Initial setup of acoustic receivers and water level loggers will occur in the first year, followed by tagging in years two and three. The tags will be active through year four.

Application: Information gained from tracking juvenile fish use of natural marsh ponds and emigration to the estuary will be used in management. First, determining whether nurseries are functional will help prioritize specific sites for protection. Understanding the amount of marsh flooding needed to allow for sportfish emigration is needed to inform stormwater engineering of any developments upstream and to understand which upstream habitats may be used by juvenile sportfish in the future under different sea-level rise scenarios. Specifically, an understanding of the marsh elevations and connection types (i.e., culvert dimensions) that promote use of created ponds by juvenile tarpon can be used to adaptively manage ponds and can be used directly in restoration planning of future projects.

Monitor Sportfish Growth at Restored Habitats in Charlotte County

An important benchmark of restored nursery habitat is that juvenile fish grow at rates comparable to natural habitats. In this task, juvenile fish growth is compared between restored habitat and nearby natural habitats. Juvenile growth can be determined by analyzing daily growth rings that form on the otolith (ear bone) of the fish as well as from tagging studies. For example, a 60 day old fish (determined from daily ring counts) that is captured at a size of 60 mm total length yields a growth rate of 1 mm per day. As part of the larger sampling design, a subset of juvenile fish, including the species of interest and their primary prey, will be collected from a subset of ponds representing "natural", "degraded" and "restored" habitat types over the course of the monitoring period. These samples will be used for analysis of daily growth. This analysis, which occurs under a microscope in a laboratory, will occur in years 3 and 4 after an adequate number of fish are collected.

Application: Research will determine relative effectiveness of restoration techniques employed for sport fish and compare to growth across habitat restoration types. Comparisons will inform future habitat restoration strategies targeting snook and tarpon early life stage habitat.

Evaluate Restoration Design Effectiveness with Additional Monitoring

Habitat enhancement, restoration, and creation can be effective management tools to offset impacts to habitat quality and loss of habitats. Habitat management for juvenile snook and tarpon should include quantitative goals and monitoring to measure progress against pre-impact values and natural conditions. Monitoring questions and surveys should be structured to draw conclusions about management action effectiveness. To date, two enhancement projects adjacent to the study area have aimed to improve sportfish nursery habitat: Coral Creek Restoration Phase II (Figure 9) and Lemon Creek Wildflower Preserve Restoration (Figure 10). The two projects employed different designs, however, only Coral Creek has had rigorous quantitative assessment of design effectiveness for sportfish recruitment, growth, survival, and fish passage connectivity.

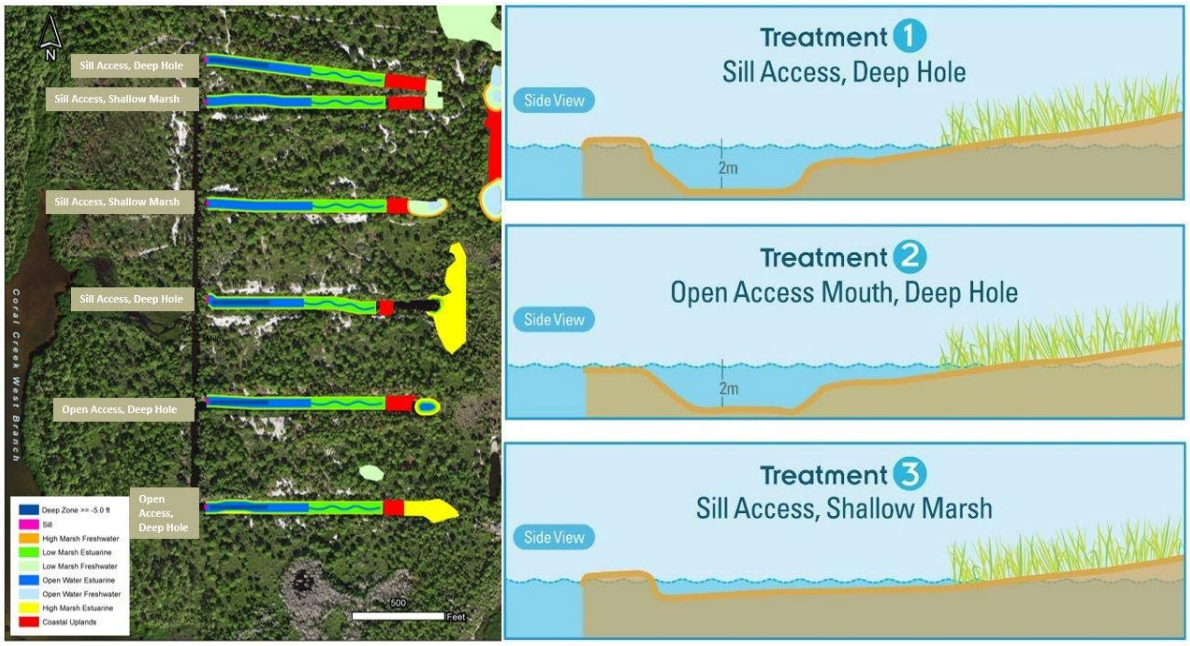


Figure 9. A juvenile fish nursery habitat restoration project at Coral Creek including 3 different treatment designs with varying depths and fish passage regimes.

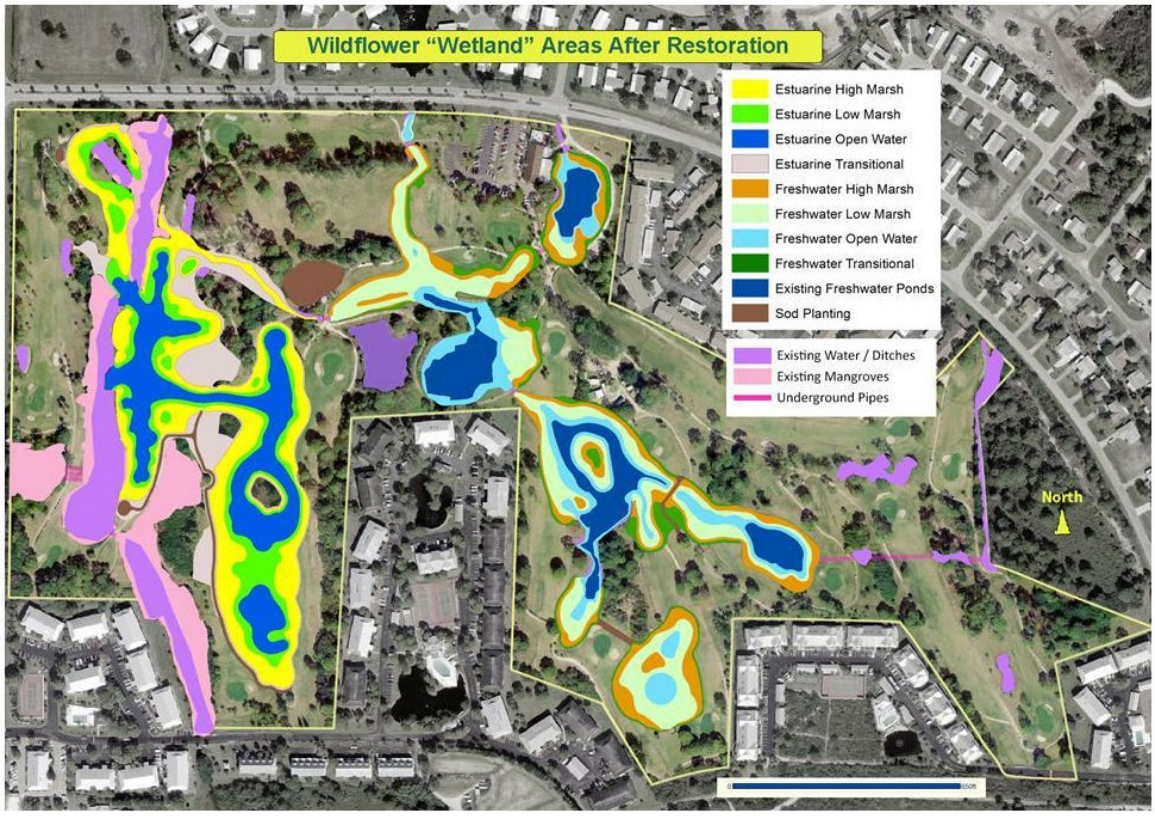


Figure 10. Juvenile fish nursery habitat restoration at Lemon Creek Wildflower Preserve expanded pond and marsh area and complexity.

In 2014, BTT, FWC, the Southwest Florida Management District (SWFWMD) and CHNEP partnered to create a habitat restoration design that specifically targeted juvenile tarpon and snook nursery habitat. Land surrounding Coral Creek is owned by the State of Florida and managed by the Florida Department of Environmental Protection. Since this site features 6 independent remnant canal systems that share a single tidal inlet, 3 different treatments were designed to not only test if nursery habitat restoration is successful, but specifically which design features were most effective.

- Treatment 1 - a sill at the mouth of the experimental waterbodies which only provides access during high tides and high water events and precludes fish passage during lower tides. Behind the mouth is a depression about 2m deep that spans ¼ - ⅓ of the total canal length.

- Treatment 2 - an open mouth to provide constant fish passage at all tides followed by the depression described in Treatment 1.

- Treatment 3 - a sill mouth to restrict fish passage with the removal of the deep depression to mimic a shallow meandering tidal stream.

BTT completed 16 months of pre-restoration monitoring using seine nets and cast nets to capture juvenile tarpon and snook and implant Passive Integrated Transponder (PIT) tags to estimate survival and abundance, calculate growth, and track movement and emigration from the system for comparison after restoration. Following habitat restoration completion in 2018, BTT collaborated with FWC to sample juvenile tarpon and snook as well as the community assemblages also present. Three different types of seine nets were used (alternating monthly) for a total of 22 post-restoration monitoring events. Again, tarpon and snook were implanted with PIT tags to compare the same parameters assessed during pre-restoration monitoring. It's important to note that although the study was focused on tagging and tracking juvenile sportfish in nursery habitat, it was also measuring habitat productivity. A habitat that has better juvenile sportfish metrics is a habitat that is ultimately functioning more closely to a natural habitat with higher productivity. Preliminary data shows that nursery habitat restoration of a tidal creek system is indeed effective with higher abundance and higher growth rates. The specific habitat treatment that is most effective is still in analysis.

Habitat restoration can be used as an effective tool for habitat degradation and loss. However, an effective habitat restoration should 1) have a quantitative measure for success that includes a baseline for comparison before and after restoration, 2) feature designs for a specific species or habitat, and 3) inform future habitat restoration projects.

An additional research need identified during the co-production process was to conduct post restoration analysis of monitoring metrics applied during surveys at Wildflower Preserve to inform management decisions about which design attributes provide the best return on investment for restoring habitat for juvenile snook and tarpon in the study area.

Application: Evaluation of relative effectiveness of varying restoration practices for juvenile tarpon and snook as well as tracking the timing and conditions under which these species emigrate from coastal ponds to the downstream estuary.

Refine Vulnerability Index to Characterize Estuarine Wetlands

Since 2016, Bonefish & Tarpon Trust (BTT) has been using anglers and guides as citizen scientists to identify and classify juvenile tarpon habitats. To date, BTT has collected data on 14 juvenile tarpon nursery sites in Charlotte County that have not been sampled by FWC (Wilson et al. 2022). When sites are reported by anglers they are asked to submit GPS locations and to classify the site as "natural" or "altered/degraded". Field technicians then visit each site to gather *in situ* data and classify the site. Angler-reported juvenile tarpon sites classified as "natural" were automatically ear-marked for habitat protection while sites reported as "altered/degraded" were ranked for habitat restoration using a system of GIS data layers that includes characteristics pertaining to restoration feasibility, tarpon biology and habitat connectivity. The habitat restoration characteristics include:

- Publicly managed vs. private land
- Protected vs. non-protected waterway
- Distance to wastewater treatment plants
- FWC Estuary Prioritization
- Distance to passes
- Locations classification (natural vs. altered)
- Adjacent habitat classification (emigration)
- Inland migration/sea level rise and watershed/hydrological alteration

The BTT has developed an initial ranking score for each characteristic from 0-10 (lowest is best) and scores are summed across characteristics for each site to achieve an overall "Vulnerability Index" (VI) score for each site. Research is needed to refine and validate this VI across the study area. A geographic map overlay that combines juvenile tarpon nursery habitat initial rankings with data layers would categorize locations within the study area that have the highest risk of being affected by anthropogenic and/or climactic pressures. For example, a nursery site classified as "natural" that falls under an area that the County deemed as likely to be developed would rank as "High" in the VI.

Conversely, a degraded nursery habitat with low potential for restoration that falls under an area in the County that is at low risk for development would rank as "Low" in the VI. Data layers to include in further VI refinement may include:

- Existing and future land use
- County zoning
- Plats and parcels
- Sewerage and reclaimed water infrastructure
- Future hydrology impacts determined by modeling
- Sportfish presence
- Water quality
- Emerging threats to sportfish habitat

Application: a validated habitat vulnerability index for juvenile snook and tarpon habitat within the study area that can be used to prioritize sites for protection, conservation and restoration.

Minimize Direct Habitat Loss

In Florida, wetlands are defined in Florida Statute [373.019(27)] as [`*those areas that are inundated or saturated by surface water or groundwater at a frequency and a duration sufficient to support, and under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soils*']. Soils present in wetlands are classified as hydric and prevalent vegetation in wetlands generally consists of facultative or obligate hydrophytic macrophytes and includes swamps, marshes, bayheads, bogs, cypress domes and strands, sloughs, wet prairies, riverine swamps and marshes, hydric seepage slopes, tidal marshes, mangrove swamps and other similar areas. These areas filter stormwater runoff and provide habitat for a myriad of species including spawning, nesting, and foraging habitats. Isolated wetlands can become connected during extreme wet weather events linking the terrestrial and aquatic coastal ecosystems which is an important attribute to consider with respect to this project. However, isolated wetlands are also susceptible to degradation from development pressures as more people look to

live near the coast. Wetlands, especially isolated wetlands, can be impacted by dredging and filling or even eliminated completely under specific permit conditions. The Uniform Mitigation Assessment Method (UMAM) defines wetland function within the regulatory framework regulating the degree to which mitigation is required. Development impacting less than 4000 square feet of isolated wetlands can be accomplished under a general permit without mitigation if the UMAM scores are low. Larger impacts require mitigation which must occur in the same basin and for the same wetland type but not necessarily within the connectivity of the existing habitat mosaic. Mitigation is designed to offset loss of a wetland by either improving wetland function of other wetlands in the area or by preserving wetlands in nearby areas using mitigation banks though it doesn't account for potential nonlinear deficits accrued by disconnecting isolated estuarine wetland ponds from the large habitat mosaic.

One example of isolated wetland habitat loss within the study area is provided in Figure 11 where expansion of a local commercial property resulted in the temporary loss of an isolated natural wetland pond within the study area. This process was completely legal and the pond was subsequently replaced by an adjacent stormwater pond but demonstrates that while these ponds have state and Federal protections they are not immune to alteration. We do not know if this pond served as nursery habitat for these species but this type of alteration, while completely legal within the existing rules, represents a potential loss of habitat if these nursery habitats are not considered in the mitigation process.

Figure 11. Example of permitted isolated wetland pond losses.

The emphasis of this example is that, in coastal areas, isolated wetland habitats traditionally scored by UMAM may not consider the unique characteristics of these habitats with respect to the novel research suggesting these ponds are key habitats for the success of tarpon and snook. The UMAM is a general framework for assessing relative wetland functions; but it can be tailored to capture unique habitat values for sportfish nurseries. Therefore, additional research needs are to document and characterize isolated coastal wetland pond habitat importance for snook and tarpon in the study area using methods described above to convince authorities of special importance of these habitats within the study area and minimize losses on remaining natural nursery habitat for these species.

Application: Re-evaluation of isolated wetland characterization in the estuarine setting within the context of connectivity to habitat critical to juvenile tarpon and snook habitats.

Assess Hydrologic Impacts

Intertidal wetland areas within the study area include tidal creeks and ponds connected by large areas of mangrove forest that inundate and dry out as a function of tidal amplitude and freshwater inputs from the watershed. Often this mosaic of habitats include small channels that connect larger depressional areas including larger pond habitats. The ability of juvenile fish to fully utilize the habitat mosaic is highly dependent on tidal dynamics but also reliant on hydrologic characteristics influenced by the watershed including the delivery of freshwater flows and sediment to the estuary. Hydrology is especially important in connecting the ephemeral ponds within the study area to the tidal creek network to ensure both recruitment and emigration of juvenile snook and tarpon utilizing these habitats. Insufficient frequency of access, or conversely, permanent connections with tidal creeks that would allow predator species access to these ponds, would be deleterious to the function of these habitats as refuges. Current hydrology is not well understood, though recently FWC has deployed some real time water level recording instruments in several of its routinely sampled ponds. Hydrologic/hydraulic (H&H) modeling is required to gain a better understanding of the hydrologic requirements of the hydrologic flow paths affecting water levels and connectivity with the larger estuary within the study area. These models can be used to develop and assess potential measures to mitigate the impacts of adjacent development, such as facilities to increase hydrologic storage and stormwater treatment, as well as various surface water rerouting alternatives.

The model of choice for this type of analysis is the Interconnected Channel and Pond Routing model, version 4 (ICPR4). ICPR began as a 1D H&H model more than 35 years ago with a focus on modeling hydraulically interconnected and interdependent pond systems. In the late 1980's hydrodynamic channel and pipe flow were added, and in 2008 a quasi-2D groundwater module was added. ICPR4 was released in 2014 and includes both 1D H&H and fully integrated 2D surface water and groundwater flow with an emphasis on interactions between surficial aquifer systems and surface water bodies.

There are three primary building blocks in ICPR4: Nodes, Links and Basins. The computational framework is formed from these building blocks for the 1D portion of ICPR4 and the approach is often referred to as a "Link-Node" modeling concept. Nodes are placed at strategic locations in the drainage network. Elevations are calculated at nodes based on inflows, outflows and storage characteristics. Water is moved from node to node via links such as pipes, channels, weirs, pumps, and bridges among others. Figure 12 below shows a typical Link-Node network developed in ICPR4.

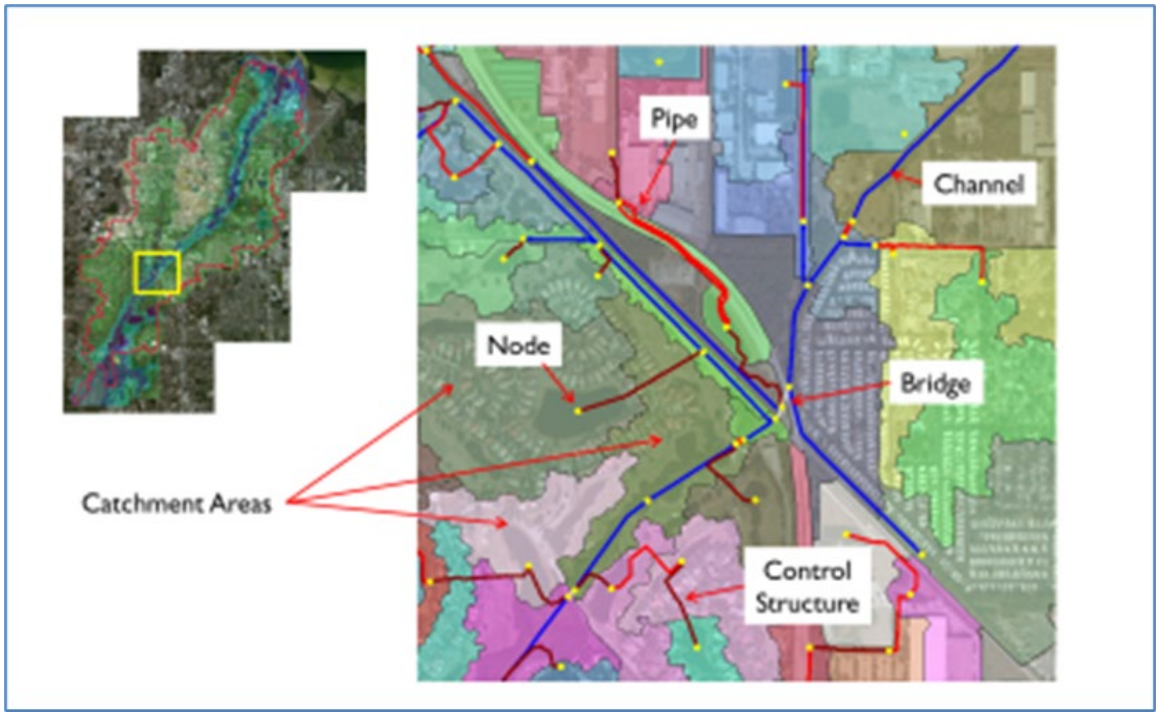


Figure 12. Typical Link-Node Diagram Developed in ICPR4.

Stormwater runoff can be calculated using traditional unit hydrographs and delivered to any node in the model. Several options are available for infiltration losses and rainfall excess computations. ICPR4 includes several optional tools to help expedite 1D model construction. These tools extract data from GIS map data layers. For example, a breakdown of soil and land cover combinations for each catchment area can be automated inside ICPR4. Channel cross sections can be extracted from a ground surface digital elevation model (DEM developed from LiDAR data), as well as storage characteristics for lakes, detention ponds, and wetland depressions. Modeled flows can be linked to site-specific ambient water quality data to develop pollutant loadings associated with storm events, as well as seasonal and annual pollutant loads.

The Meadows is an old, platted subdivision located just north of the Cape Haze portion of Charlotte Harbor Preserve that was designed and partially developed prior to current state stormwater regulations. Internal roads and a stormwater management system were constructed decades ago; however, the infilling of residential units was limited by a lack of water, sewer, and electrical infrastructure. Charlotte County has recently completed the installation of water and sewer infrastructure, and a private utility is providing electrical service. It is expected that this subdivision will buildout quickly with the recent provision of this infrastructure. Charlotte County owns the stormwater management system and is responsible for the operation and maintenance of the system. Accordingly, the opportunity exists to modify the stormwater management system such that water quantity and quality impacts to downstream critical fishery habitats can be mitigated or avoided.

A critical need for this project is the development of an H&H model for the Meadows subdivision to assess existing and potential future stormwater flows and pollutant loads from the site under various management scenarios. Requirements for the development of an ICPR4 model include: digital elevation data; mapping of sub-basins and catchments; existing pond storage volumes; and the location, size and capacity of the existing pipe/channel network and outfall structures. Much of this information can be derived from existing plans; however, site-specific survey data will also be needed (e.g., depth and storage volume of existing ponds.

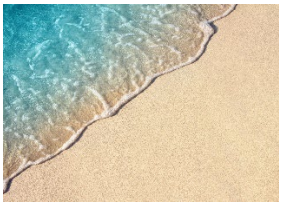
With the necessary input data in hand development of the model is relatively straightforward. Once the model is developed and calibrated various management scenarios affecting discharge volumes and pollutant loads can be simulated and compared to the existing condition. Management scenarios could include: rerouting of stormwater flows; increasing pond storage and nutrient uptake capabilities (e.g., littoral shelves); and modified outfall structures. It may also be desirable to model scenarios where existing wetland and stormwater ponds are allowed to accommodate tidal flooding and sea level rise such that areal extent of critical fishery habitats is actually increased over time.

Research needs include:

- Mapping/modeling flow paths to the ponds mainly from platted but undeveloped lots in Cape Haze
- Determining inundation frequency necessary for species immigration and success.
- Identifying current stormwater design, review of drainage capacity.

- Identify current and/or develop new hydrologic models for these areas to be able to evaluate built out scenarios and cumulative impacts.
- Sediment loads

Application: Estimation of optimal stormwater design to maintain natural ecological function of ponds and creek network including immigration and emigration periods for tarpon and snook.



Evaluate Water Quality

Very little information is known on the water quality of these systems. Limited physical chemistry (e.g. salinity, dissolved oxygen) data exist associated with fish data collection efforts; however, no nutrient data or quantitative estimates of primary production exist in these ponds. Because these ponds are shallow with little exchange during the dry season and tend to be located at the interface of development pressure, they may be particularly sensitive to nutrient inputs. Previous fish surveys have documented ponds within the study area with proliferate macroalgal blooms confirming the potential of these ponds to become eutrophic. Therefore, more research is needed to understand the current water quality conditions across the range of ponds within the study area. Baseline data needs to be collected on nutrients, chlorophyll, and contaminants at minimum along with in situ physical chemistry data. The data collection should include nutrient and chlorophyll a data from hydrologic sources (inputs) to the ponds, within the ponds and in the receiving waterbody. A synoptic sediment sampling effort for contaminant profiles would be a valuable addition to the sampling. Likewise, benthic microalgae chlorophyll content could be estimated from surficial sediment samples. A qualitative macrophyte characterization should accompany the sampling and consideration should be given to the deployment of continuous recorders for synoptic (3-5 day) estimates of net ecosystem metabolism as estimated using continuous dissolved oxygen measurements.

Application: baseline characterization of water quality across a habitat gradient. Additional metrics to add to habitat index scores. Better understanding of dynamics of

nutrient inputs, assimilation, export for various habitat types. Management level targets and thresholds for water quality stressors.

Estimate Habitat Evolution Under Sea Level Rise Scenarios

The coastal intertidal wetland habitat mosaic in the study area are very susceptible to the potential impacts of climate change, particularly sea level rise. There is substantial evidence in southwest Florida estuaries that historically monotypic needle rush (*Juncus roemerianus*) salt marshes are gradually being invaded by mangroves, and that the salinity regime in these habitats is becoming more saline over time. In addition, results from the HRN study showed that there have been increases in salt barren habitat where there is adequate slope area for higher high tides to create hypersaline areas. The habitats identified by FWC as critical to the life histories of tarpon and snook are currently undergoing dynamic changes caused by climate change and sea level rise that will change the quality and quantity of these habitats over time as sea level rise affects hydrologic flushing of the semi-isolated marsh/mangrove ponds, and higher king tides and tropical storm events expose these areas to more frequent inundation. Protecting these critical habitats from future physical and hydrological alterations is essential; however, perhaps equally important is conserving and/or restoring adjacent upslope areas to allow for landward migration of the full range of tidal wetlands (e.g., mangroves, salt marshes, salt barrens, tidal creeks) in response to sea level rise.

The Habitat Evolution Model (HEM) is a GIS-based habitat evolution model developed to estimate the change in acreages of seagrass, mangrove, salt marsh, oligohaline/freshwater marsh, and salt barren habitats in Gulf coast estuaries over time as a function of predicted future conditions. The model pairs current habitat distributions with elevation data, and then extrapolates future habitat distributions based on sea level rise projections and topography. The model produces maps of habitat distributions and calculates habitat acreages on decadal intervals. The HEM is based on the concepts developed in the Sea Level Affecting Marshes Model (SLAMM) developed by US EPA in the mid-1980's but improves upon SLAMM in several ways by:

- Creating flexibility to edit the habitat categories to facilitate crosswalks from site specific vegetation mapping.

- Updating the decision tree to change from one habitat category to another based on biological processes.

- Creating a structure that allows for different "modules" to be added to or updated in the model. For example, the module that determines areas of freshwater influence can be refined so that changes in freshwater flows can be simulated in conjunction with hydrodynamic modeling.

Importantly, the HEM allows for habitats to evolve in the "reverse direction." For example, mangroves can convert to low salt marsh (due to localized freshwater inflow) or to high salt marsh (due to sediment accretion).

A HEM has been developed as part of CHNEP's Habitat Restoration Needs project (ESA, 2018) which incorporates the study area. This model can be used to evaluate potential sea level rise scenarios on habitat evolution within the project areas. Figure 13 below shows a typical model output graphic. The current Charlotte Harbor HEM model (ESA 2018) was used to look at habitat evolution under baseline conditions across the entire estuarine system, and to test the sensitivity of the model to different model parameters. An identified research need was to revise the existing HEM by scaling down and refining the model to simulate baseline and future conditions specifically for the Cape Haze and East Wall study areas. Subsequent model runs could be conducted to evaluate potential habitat restoration projects, which can be compared to habitats projected under baseline conditions to quantify enhancement benefits over time.

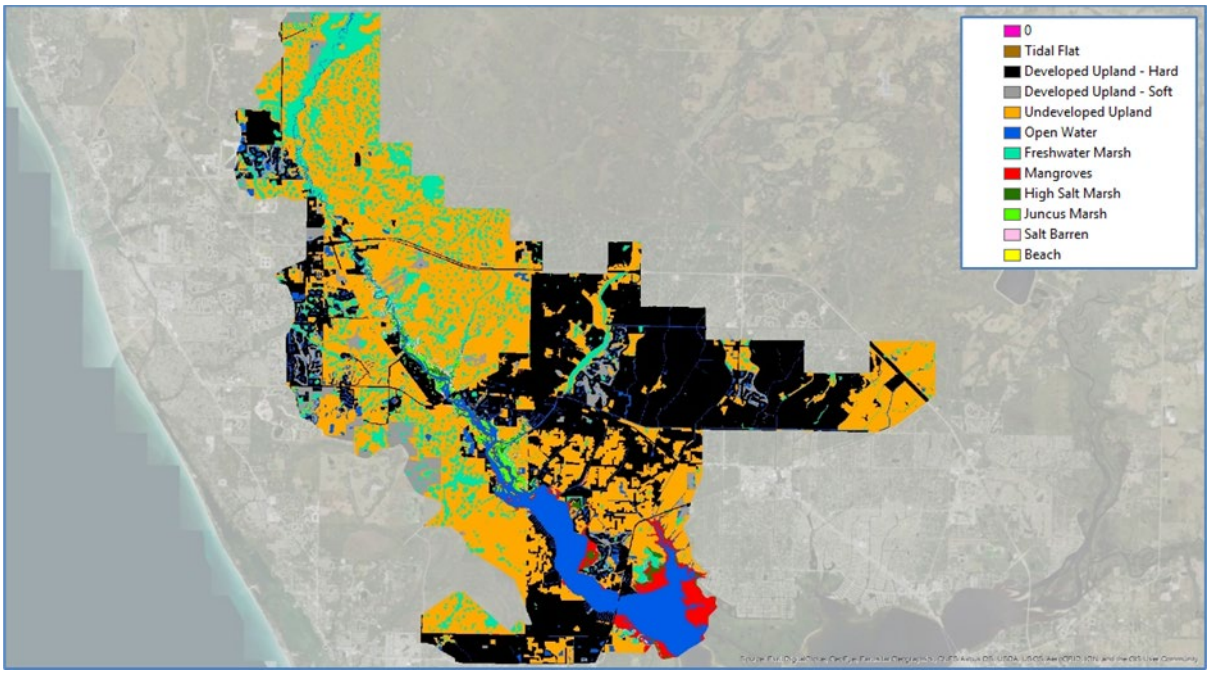


Figure 13. Example Habitat Evolution Model output.

Required model inputs include:

- High resolution topography (LiDAR),
- Vegetation occurrence and dominance field data,
- Tidal datums,
- Projected future sea level rise scenarios,
- Habitat-specific accretion rates, and
- Freshwater influence.

The HEM has been set up to easily allow the addition of spatially explicit modules as they become available. For example, a new module can be developed to represent changes to the area of freshwater influence in response to changes in flow. Currently, the HEM replicates the SLAMM method for determining freshwater and brackish marsh habitats based on a polygon input defining the area of freshwater influence. In the current HEM for Charlotte Harbor, the area of freshwater influence is defined by the boundary between the existing salt and brackish/freshwater habitats. This method is sufficient if the freshwater input does not change over time. As a next step to further develop the model, the freshwater influence module could be refined to simulate changes in the area of freshwater influence in response to changes in freshwater flows (e.g., to evaluate habitat response to reduced or increased freshwater baseflows). This module could be

developed in conjunction with other proposed modeling (hydraulic/hydrodynamic modeling) in the study area. Needed model updates and refinements include:

- Spatial refinement to the study area
- Refine model with improved NOAA sea level rise projections to look at feasibility of facilitation habitat shifts.
- Identification of freshwater ponds upstream that may become nurseries and future habitat.
- Identify opportunities for enhancement/future habitat.

Application: Model predictions of habitat transitions under realistic sea level rise scenarios. Forecasts of potential future habitat areas due to impacts of sea level rise. Identification of critical coastal "reservation" areas in the study area to be protected through public conservation land acquisition or other land use mechanisms such as rolling easements.

III. Policy Plan

The co-production process identified a series of policy needs, as well as existing policy tools that may be implemented to achieve effective management of these critical nursery habitats for tarpon and snook. The policies are categorized as Conservation/Preservation, Local Ordinances, Alternative Conservation Mechanisms, and Social Marketing Approaches. This chapter begins with a description of current protections already in place, describes identified policy gaps and then outlines specific policy themes and how they may be used to enhance protections for tarpon and snook in Charlotte County.

Current Protections

Current habitat protections applicable to these areas include State and Federal protections of wetlands, water quality, and environmentally sensitive low lying upland habitats which are described below.

Federal and State Habitat Protections

The regulation of wetlands is carried out at the federal level by the United States Environmental Protection Agency (US EPA) and the United States Army Corp of Engineers (USACE), and at the state level by the Florida Department of Environmental Protection (FDEP) (Olexa and Borisova, 2021). Federal protection of wetlands stems from multiple sources including the federal Clean Water Act (CWA) and the National Environmental Policy Act (NEPA). Specific requirements of the Federal Endangered Species Act (ESA) can also apply if any changes in a wetland could alter the habitat of a protected species. On the state level, FDEP is the primary agency responsible for wetland protection. This agency has the authority to protect environmentally sensitive wetland areas and areas designated to be of critical state concern. In addition, FDEP has the permitting authority to regulate dredge and fill activities for freshwater wetlands and waters of the United States. The FDEP has received delegated authority for Federal CWA Section 404 permitting from the USACE for freshwaters, but the USACE still retains regulatory authority for estuarine/marine wetland impacts.

Florida's Environmental Resources Permit (ERP) Program is administered jointly by the FDEP and the Water Management Districts. The Florida program also regulates the alteration of uplands that may affect surface water flows and "isolated" wetlands falling

outside of federal jurisdiction. Florida's Water Management Districts have also adopted Management and Storage of Surface Waters (MSSW) rules that regulate activities in wetlands and are authorized to establish specific permitting criteria for dredge and fill operations in connected and isolated wetlands (see link).

Florida has the ability to establish Areas of Critical State Concern (ACSC) to manage impacts on coastal wetlands that have unique habitat or cultural value (FS 380.05). This law gives the state planning agency, the Division of Community Planning (DCP), the ability to establish ACSCs based on unique habitat or cultural value and the nature of the threat that may be endangering these areas. The program is intended to protect resources and public facilities of major statewide significance, within designated geographic areas, from uncontrolled development that would cause substantial deterioration of such resources (see link). The DCP has the authority to review local and regional plans that could affect the ACSCs and can recommend purchase of state lands in these areas including estuarine wetland habitats.

Water Quality Protections

The protection of water quality in Florida is governed by both federal and state law, including:

- The Federal Clean Water Act
- Outstanding Florida Waters
- Non degradation clauses in FDEP rule
- Impaired WBIDs

The Clean Water Act (CWA, 33 U.S.C. §1251 et seq. [1972]) is the primary federal law in the United States governing water pollution and establishes the basic structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters. The CWA made it unlawful to discharge any pollutant from a point source into navigable waters, unless a permit authorized under the CWA was obtained. The National Pollution Discharge Elimination System (NPDES) permit program of the United States Environmental Protection Agency (US EPA) controls these "point source" discharges. Industrial, municipal, and other facilities must obtain permits if their discharges go directly to surface waters. The act has undergone changes (amendments) over time and today, states, tribes, and federal agencies use a dual

approach to address water quality: point sources are controlled by permit programs, effluent limits, monitoring, and enforcement, and water body integrity is supported by water quality standards that address all sources of impairment, including point source and nonpoint pollution (i.e., polluted runoff), habitat degradation caused by changes in runoff patterns, and other stressors.

The Clean Water Act requires that the surface waters of each state be classified according to designated uses. Florida has six classes with associated designated uses, which vary in degree of protection required. Water quality criteria have been established for each classification (62-302.500 and 62-302.530, F.A.C.). While some criteria are intended to protect aquatic life, others are designed to protect human health. Water quality standards also include narrative criteria for pollutants and other conditions not specifically listed. Site-specific criteria replace the statewide default criteria in cases where site-specific information supports different numeric criteria.

In addition to the surface water classifications used by the State of Florida, a water may be designated as an Outstanding Florida Water (OFW, 62-302.700 F.A.C.). This special designation is applied to certain waters deemed worthy of special protection because of its natural attributes and is intended to protect existing good water quality. While most OFWs are within the state or federal parks system, other waters may be designated as OFWs if they meet certain criteria. The study area of this publication includes two OFWs: the Cape Haze Aquatic Preserve and Gasparilla Sound-Charlotte Harbor Aquatic Preserve.

The FDEP identifies waterbodies and water segments (WBIDs) that are not meeting the applicable water quality standards and designated uses based on the Impaired Waters Rule (62-303 and 62-302, F.A.C.). If sufficient data are available and a water body is verified as "impaired" due to a pollutant (the waterbody is assigned Category 5 and has been placed on the Verified list), a Total Maximum Daily Load (TMDL) must be developed for the water body.

Current Policy Gaps

In reviewing existing current policies, the co-production process identified several potential policy gaps that may serve as impediments to fully protecting these habitats. These potential impediments are listed in the bullet points below:

- Wetland regulatory (UMAM) habitat scores for isolated wetlands in tidally connected waters likely under- represent the importance of these habitats to recreational gamefish species, particularly tarpon, snook, and their prey.
- The critical intertidal wetland habitats identified by FWC and BBT exist within Charlotte County's Coastal High Hazard Area but Charlotte County protections do not directly prohibit development if other entities approve development permits.
- Platted but undeveloped lots adjacent to the study area in Cape Haze were permitted in the 1970's when a lack of adequate land use policy protections were in place and are now grandfathered in at the parcel scale.
- There is a lack of dedicated protections for natural hydrologic connectivity to emergent tidal wetland habitats adjacent to the preserves.

Specific Policy Themes

The following sections detail the specific policy themes identified during the co-production process including: encouraging habitat conservation; enhancing local ordinances, exploring permit modifications, investigating social marketing approaches and improving education to increase protections of juvenile nursery habitats for tarpon and snook.

<u>Encourage Habitat Conservation</u>

In Florida, factors affecting the loss of biological diversity include population growth and associated habitat loss, habitat fragmentation, over-exploitation, pollution,

non-native species, disease and impacts of climate change (Endries et. al. 2009). According to the Endangered Species Act of 1973, habitat conservation provides "esthetic, ecological, educational, historical, recreational and scientific value" intended to counter factors contributing to the loss of biological diversity. Habitat conservation means retaining and preserving or restoring land to a natural state in perpetuity but does allow for sustainable uses on the property and creative arrangements, including public private partnerships.

There are many entities at the federal, state, and local level (including public agencies, not-for-profit land trusts and other non-governmental organizations) that provide funding and assistance for habitat conservation and restoration. Often land acquisition requires the collaboration of multiple agencies in the form of matching dollars to ensure collaborative partnerships for maintaining the land over time. Therefore, habitat conservation generally requires both "funders" and "implementers" to ensure that priority lands are acquired and maintained in a manner consistent with the objectives. Strategies for acquiring land involve straight fee ownership (i.e. outright purchase) based on fair market value sale, a bargain sale, or an outright donation. Funding sources include public (federal, state, and county) and private (foundations, individuals, and corporations) sources. Conservation easements provide a tax break for the property owner, but need to be established legally "in perpetuity" such that future owners must adhere to the easement agreement. Conservation easements provide a legal agreement between an implementer and the owner that prevents the owner from using that land in a way not approved in the agreement or that would damage the conservation values of the property. Conservation funding agents include both Federal and State entities as listed below:

Federal Agents:

- Land and Water Conservation Fund: funding for new and additions to federally owned lands and state grants.
- Federal Agency Grant Programs
    - U.S. Forest Service, Forest Legacy Program: funds to acquire forest lands.
    - U.S. Department of Agriculture, Natural Resource conservation Service (USDA NRCS): funding for the purchase of conservation easements on working agricultural lands (Agricultural Conservation Easement Program) and degraded wetlands (Wetland Reserve Easement Program)

- U.S. Fish & Wildlife Service: the North American Wetlands Conservation Act (NAWCA) provides funding to acquire and restore wetlands and associated uplands; the National Coastal Wetlands Conservation Grants are given to States to protect wetlands.
- USDA NRCS Wetland Reserve Easements, which also provide wetlands restoration funding, and NAWCA grants are most applicable to this project area.

State funding:

- Florida Forever: Florida's statewide conservation and recreation lands acquisition program purchasing lands and conservation easements or properties on Florida Forever Priority List. Florida Forever is primarily funded with the real estate transfer tax, but in recent years funding has included direct appropriations from the state legislature and a portion of the American Rescue Plan (Public Law 117-2). Within the Florida Forever programs, funding is allocated to various resource types including:
  - Florida Ecological Greenways Network (FEGN): FEGN is one of the Florida Forever evaluation criteria; the Florida Wildlife Corridor Act (July 2021) focuses a portion of the Florida Forever funds on critical habitat linkages that are defined as Priority 1, Priority 2 or Priority 3 areas within the FEGN.
  - Florida Community Trust Grants: state grants to local governments and land trusts to acquire parks and open space.
- Rural and Family Lands Protection Program: Florida Department of Agriculture and Consumer Service's agricultural land easement acquisition program. While the program could assist in protecting upstream rural lands to protect the water quality in Charlotte Harbor, the program has not been funded by the state legislature in several years.

Local Government Funding programs:

- Conservation Charlotte: On November 7, 2006, Charlotte County citizens approved an environmentally sensitive lands acquisition program authorizing up to $77 million in bonds to be paid for by a .20 mil ad valorem tax (~20 cents on every $1,000 of tax assessed land value) for 20 years. https://www.charlottecountyfl.gov/departments/community-services/natural-resources/conservation-charlotte/

- Charlotte County Land Acquisition Trust Fund: funds from developers who make a payment-in-lieu-of-transfer under the TDU program (see below) to buy environmentally sensitive lands. https://smartpreservation.net/charlotte-county-florida/

Partners and Additional Funding programs:

- National Conservation Organizations: groups working on a case-by-case basis in the region: The Nature Conservancy, Trust for Public Land, The Conservation Fund, Ducks Unlimited, American Farmland Trust.
- Conservation Foundation of the Gulf Coast (CFGC) – nationally accredited land trust working throughout southwest Florida including Charlotte County. https://www.conservationfoundation.com/
- Local conservancies working within specific Charlotte County communities: Lemon Bay Conservancy
- National Fish & Wildlife Foundation (NFWF) – Created by Congress in 1984, NFWF has grown to become the nation's largest private conservation grant-maker to protect and restore our nation's fish, wildlife, plants and habitats. https://www.nfwf.org/programs Current funding programs that may be applicable to the study area include the America the Beautiful Challenge, National Coastal Resilience Fund, and the Southeast Aquatics Fund.

Prioritizing areas for conservation is an ongoing process that requires consistent planning and opportunity driven execution. In general, within the study are it is recommended that the importance of low-lying coastal wetland conservation providing unique habitat types for success of juvenile sportfish in Charlotte County be emphasized by supporting reauthorization of Charlotte County's acquisition program for environmentally sensitive lands (Conservation Charlotte), increasing efforts to preserve current connectivity of estuarine wetland habitats where they exist, and restoring connectivity of estuarine habitat mosaics impacted by habitat fragmentation and other physical alterations.

Application: Low-lying coastal lands will be conserved for the landward migrations of coastal wetlands in response to sea level rise in perpetuity and can be restored.

Enhance Local Ordinances

Charlotte County Transfer of Density Units (TDU): Charlotte County uses a TDU program to balance growth and land use planning by allowing platted but undeveloped properties within the County to be exchanged to transfer density away from environmentally sensitive lands or those lying in high hazard areas susceptible to threats from sea level rise. The program is also designed to preserve archeological, historic, and environmentally sensitive lands though it operates much like a private marketplace. The program has been around in some form since the 1980s and is one of very few in Florida with a capped density. Each lot has a density associated with it and density can be transferred to allow more development in certain areas while removing density from other areas. Charlotte County allows developers the option of purchasing and transferring actual density units or contributing to the county's Land Acquisition Trust Fund (LATF: Conservation Charlotte). Once the density is severed off of a property, the property goes into a conservation easement and cannot be developed though the owner maintains the property rights.

Rolling Easements: Based on the premise that eventually some land must give way to sea level rise, the US EPA has been promoting a range of incentives and land use controls that limit hard development on coastal lands that are projected to be inundated by sea level rise. These approaches are aimed providing incentives for owners of low-lying coastal lands projected to be inundated by sea level rise to limit economic uses of their lands to low intensity "soft" development such as agriculture, rangeland, parks, golf courses, etc.). In so doing, space for the landward migration of coastal wetlands in response to sea level rise is maintained, while minimizing economic losses associated with "retreat" from the coastal zone and abandonment of coastal infrastructure.

Critical Habitat Overlay District: The establishment of an "Overlay Districts" (also called Overlay Zones) in local government comprehensive plans is a common land use control mechanism used for a variety of purposes such as targeting areas for special protections given unique geographic features of an area of interest. The purpose of an

Overlay District (OD) is to allow for the application of specific regulations to a distinct geographic area. The identified geographic area warrants special consideration due to a unique situation or practical difficulties resulting from the historic development pattern. One possible approach to addressing the objectives of this Plan involves the establishment of an overlay for the critical sportfish habitats defined herein, as well as the drainageways that flow to these areas. The OD would be "mapped" in GIS to increase public awareness of the issue. Land use controls applicable to the overlay district could include increased stormwater attenuation and treatment requirement, maintenance of native vegetation, and fertilizer controls.

Application: The potential to enhance local ordinances represents an opportunity to maintain local control of landuse planning options while providing additional protections for tarpon and snook nursery areas. While the TDU program is market driven, acknowledging that some platted but undeveloped properties within the study area may provide more value as fish habitat than as developed property. The Overlay District is one potential method to increase the potential value of the density unit for specific parcels that are at most risk to be developed and also most impactful as an adverse effect to the nursery habitats. These options, including rolling easements, provide alternative additional local mechanisms by which the County can both maintain individual property rights while also providing options for land owners to incentive conservation of undeveloped, environmentally sensitive lands.

Explore Permit Modifications

The fact that these areas have not been developed to date means that there is a potential opportunity to affect the stormwater routing of future development through an Environmental Resource Permit (ERP) to minimize hydrologic impacts to the study area. In Cape Haze, existing individual platted lots pre-date ERP standards and were grandfathered into existing development code such that no additional local permitting is needed though the lot must still meet all state and federal requirements. However, if large tracts of individual lots are aggregated, an ERP may be required for redesign of the

aggregated section providing the opportunity to adjust the stormwater engineering to minimize impacts. Some platted and semi-developed areas such as the Meadows precede ERP permitting. In these areas the county may have local review authority to require modifications to the drainage plans to meet sportfish habitat needs. However, for new development where ERP permits will be issued by the SWFWMD, FWC and/or the County has standing to comment on those permits and request additional stormwater treatment and attenuation requirements be incorporated as special conditions in those permits.

- ➢ Use baseline hydraulic model to identify critical areas to maintain current flow paths as a GIS layer for natural resource managers.
- ➢ Establish methods to incentivize property owners to redesign their property to support habitat, water quantity, and water quality.
- ➢ Communicate with other entities (e.g. SWFWMD, public works, DOT) on the importance of maintaining flow paths

Application: Local ordinances provide local authority to control land use development in environmentally sensitive areas such as coastal high hazard zones. While the types of local controls vary, they are proposed in this application to enhance protection of sensitive pond habitats by limiting development, better controlling stormwater runoff and maintaining natural drainage patterns as development pressures increase.

Investigate Social Marketing Approaches

We consider social marketing approaches to be anything outside of the regulatory or fee-based policy frameworks that motivates people to change their behaviors in a manner that benefits themselves, the environment and society. Social marketing integrates marketing concepts with other sociological and psychological principals to influence behaviors that benefit individuals and society. It aims to create positive change in strategic way that is efficient for both the recipients and the provider of the product.

Social marketing is an underutilized technique to increase awareness in environmental causes and create change for the benefit of the environment but requires dedicated funding and commitments. The field has evolved from being mostly an education and outreach tool into a quantitative field of research which include pre-post behavioral assessment scores, random selection, and statistical hypothesis testing to optimize and determine efficacy of the campaigns. In the context of this study, targeting homeowner's associations and developers planning to build out lots in subdivisions abutting the preserves were suggested as effective avenues to promote the value of these habitats as an incentive to living sustainably with nature. One campaign that was workshopped during the co-production process was the creation of a "Tarpon Friendly Community" campaign. This campaign would include developing a logo and promotional messaging describing the unique habitat for the area and educational information describing the value and vulnerabilities of these habitats for tarpon and snook. Florida-Friendly Landscaping™ (FFL) is a great example of a social marketing campaign that has been effective at reducing water use and pollution to local waterways in Florida. FFL is a partnership between the University of Florida, Institute of Food and Agricultural Sciences (UF/IFAS Extension) and the Department of Environmental Protection (FDEP). The main goal of FFL is to reduce nonpoint source pollution by promoting proper fertilization, irrigation, and pesticide practices for use on both residential and commercial landscapes to both conserve water and assist with the health of Florida's water resources.

Application: Targeted outreach to promote the value of these coastal pond and marsh habitats as critical for tarpon and snook success. If communities can embrace protection of these habitats, it reduces the need for more formal actions while increasing the environmental sustainability of the local area.

Improve Education

The need to educate key audiences about the exceptional value of these ponds as juvenile sportfish habitat has been a consistent theme throughout discussions of the elements of this plan. Education is different from social marketing in the sense that the focus is more on providing information on existing knowledge related to the topic at hand as opposed to trying to influence change in behaviors that may benefit the environment. Of course, education itself can influence change in a positive way. One theme identified in the co-production process was the need to maintain a foundational knowledge base among natural resource managers, city managers and the civil engineers tasked with approving permit applications and modifications in the study area as to the importance of these habitats for tarpon and snook. Maintaining an educational presence to provide information on how these habitats function for tarpon and snook and what can be done to protect the habitats was considered a key piece of the overall research and Application plan.

Application: Maintain and increase knowledge base acquired on habitat protection and conservation among natural resource managers, permitting entities and the general public regarding the value and requirements of these habitats as tarpon and snook nurseries.

IV. Research and Policy Implementation

The goal of this project was to identify research and policy gaps related to the protection of critical nursery habitats for sportfish in Charlotte Harbor, FL and to co-produce a plan to address these issues. This chapter represents the Application Plan component of the study. Stakeholders have been engaged as active and equal participants in the Plan are considered essential to its long-term success. The watersheds to these habitats are predicted to undergo development in the very near future and there is an urgent need to take actions to develop protection strategies while additional research is being conducted. Therefore, this chapter is devoted to identifying how future research can inform policy while also highlighting policies that can be pursued independent of more research to help protect these critical habitats as a place-based example that can be transferable to other areas of interest to the NOAA RESTORE Science Program.

The research plan has emphasized the need for additional fish surveys to document the full extent of juvenile sportfish habitat within the Cape Haze and East Wall study areas and the refinement of a vulnerability index to prioritize those habitats based on existing and forecast future threats. Baseline water quality assessments are also necessary to characterize the nutrient and contaminant conditions associated with the ponds and adjacent inputs and outputs. Hydraulic and hydrologic modeling of the drainage basins is necessary to understand current routing of stormwater throughout the basins and to forecast the effects of future development on the landscape. Likewise, a place-based Habitat Evolution Model was recommended to evaluate the potential effects of sea level rise on these habitats as a planning tool. Habitat restoration projects adjacent to the study area provide the opportunity to evaluate restoration design effectiveness and inform feasibility assessments of both conservation and restoration options within the study area.

Several policy gaps were identified that, if addressed, would increase protections for habitats both within and outside the study area. Direct habitat loss has been observed in locations adjacent to the study area. Because the research on the use of these ponds as sportfish nurseries is novel, there is a lack of consideration of the importance of these habitats in such regard when evaluating impacts of fill and mitigation activities for small, isolated wetland ponds. Therefore, many small, isolated wetland ponds remain at risk for being filled and mitigated against without consideration for connectivity to their role

within the habitats mosaic critical for these sportfish nurseries. Threats from development persist and are expected to increase in coming years and yet, funding for habitat conservation is lacking. One of the most effective local environmentally sensitive land acquisition funding programs, Conservation Charlotte, has been nearly entirely expended until voter reauthorization in 2028. This leaves only market-based options associated with the County's TDU program as an opportunity to reduce development density in areas of private ownership unless other conservation funding sources are secured. Other state and federal land acquisition funding opportunities exist but typically require matching dollars for state or local entities to initiate, leaving a need for creative solutions to acquire the most vulnerable habitats identified in the research plan. Alternative mechanisms identified for habitat conservation included special district overlays to protect unique features within the study area and allow for specific local ordinances to be established to protect these unique habitats, permit modifications to attenuate stormwater routing, and options for rolling easements to allow properties most susceptible to impacts of sea level rise to be protected from development. The role of non-regulatory or fee-based social marketing endeavors was also highlighted by the Plan to provide creative community-based solutions that engage and increase public awareness of the social interactions with the environment.

Organizing Actionable Science

Implementation of the individual research and policy elements identified in Chapters 2 and 3, requires organization and prioritization. Central themes were identified to organize the individual elements into actionable work products. The central themes, prioritization, and timelines are provided in the sections below.

Central Themes

The individual research and policy elements were arranged by how they inform final outcomes and products (Figure 14). The Vulnerability Index (VI) and the Overlay District (OD) have been identified as two central themes for implementation of this plan. The VI is seen as a central theme of the research element because it integrates individual research outcomes from the fish habitat surveys, hydrologic modeling studies, and habitat evolution modeling to generate site-specific scores for all potential habitats in the population. Outcomes of the VI will be used to inform the OD by providing site specific locations of critical habitat vulnerabilities threatened by anthropogenic influences.

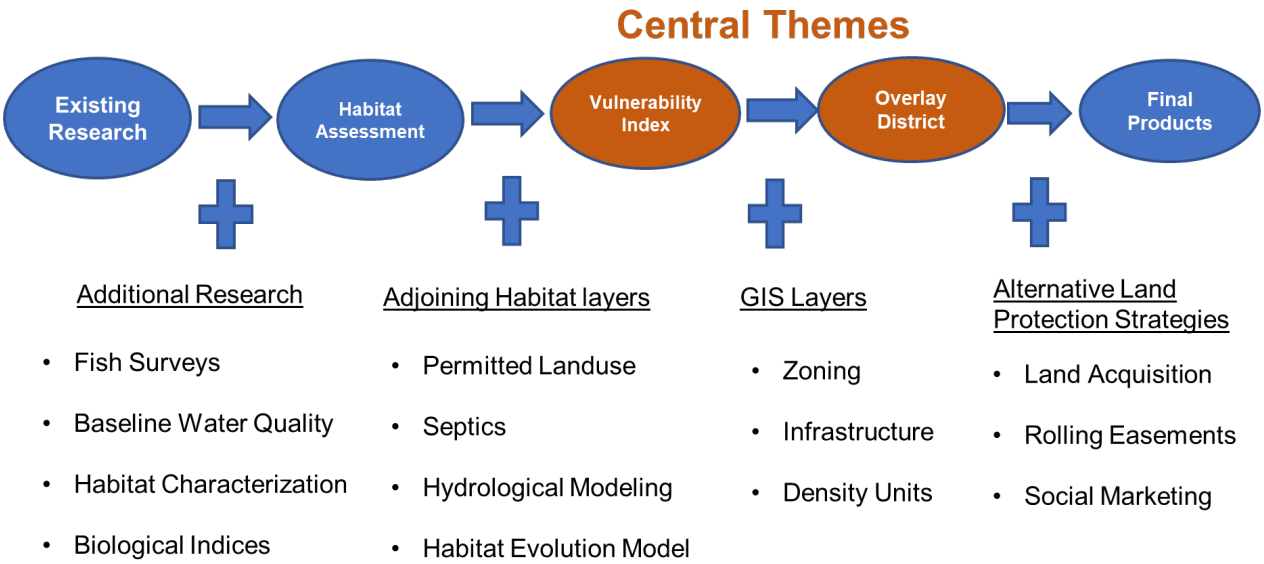


Figure 14. Organization of elements necessary to complete the proposed phase II work effort.

An example decision framework developed as part of the co-production process for a hydrologic modeling outcome is portrayed in Figure 15. These types of decision frameworks will be used to generate the final VI scores. The OD combines the research outcomes with recommended land use practices, current local ordinances, and land use planning information to codify special protections for these habitats in county and/or municipal Comprehensive Plans. Ultimately, implementing these two central themes, along with enhanced land protection strategies including acquisition, conservation easements, and social marketing campaigns completes the work necessary to implement this plan.

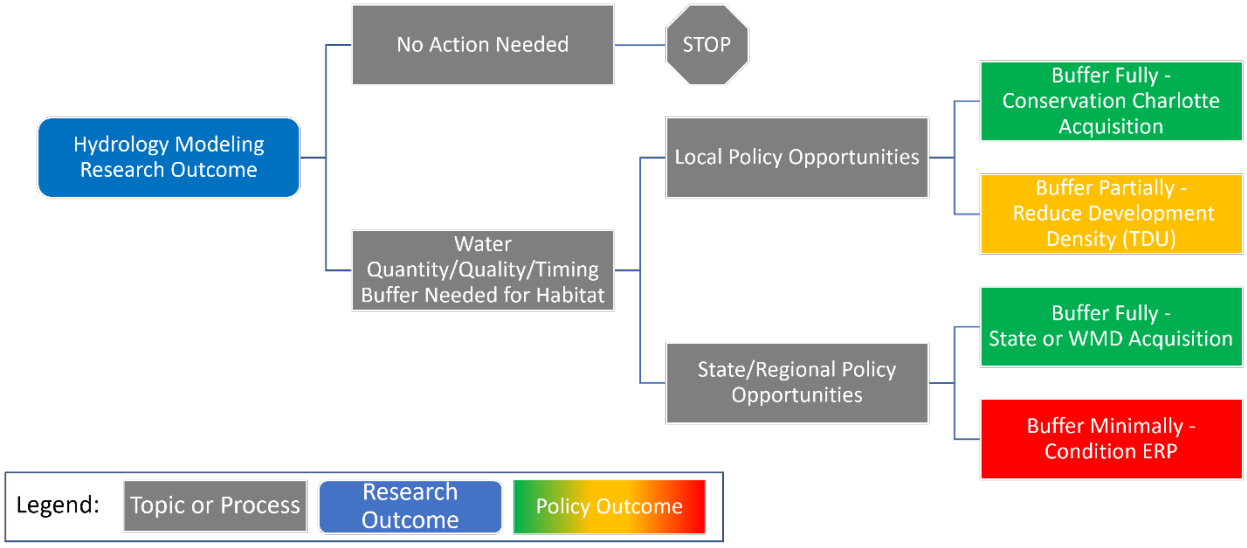


Figure 15. Example of a Policy Application Decision Tree.

Outcomes of the co-production process informed the development of decision support tools to organize and prioritize the research needs into actionable science. A master decision framework is presented in Figure 16 where the future planning efforts are organized by themes that guide the individual future research elements and results of those research elements inform decision options for how best to provide protections, if necessary, for site specific elements of the overall plan. This master decision framework will be used to guide future research and policy options as research continues.

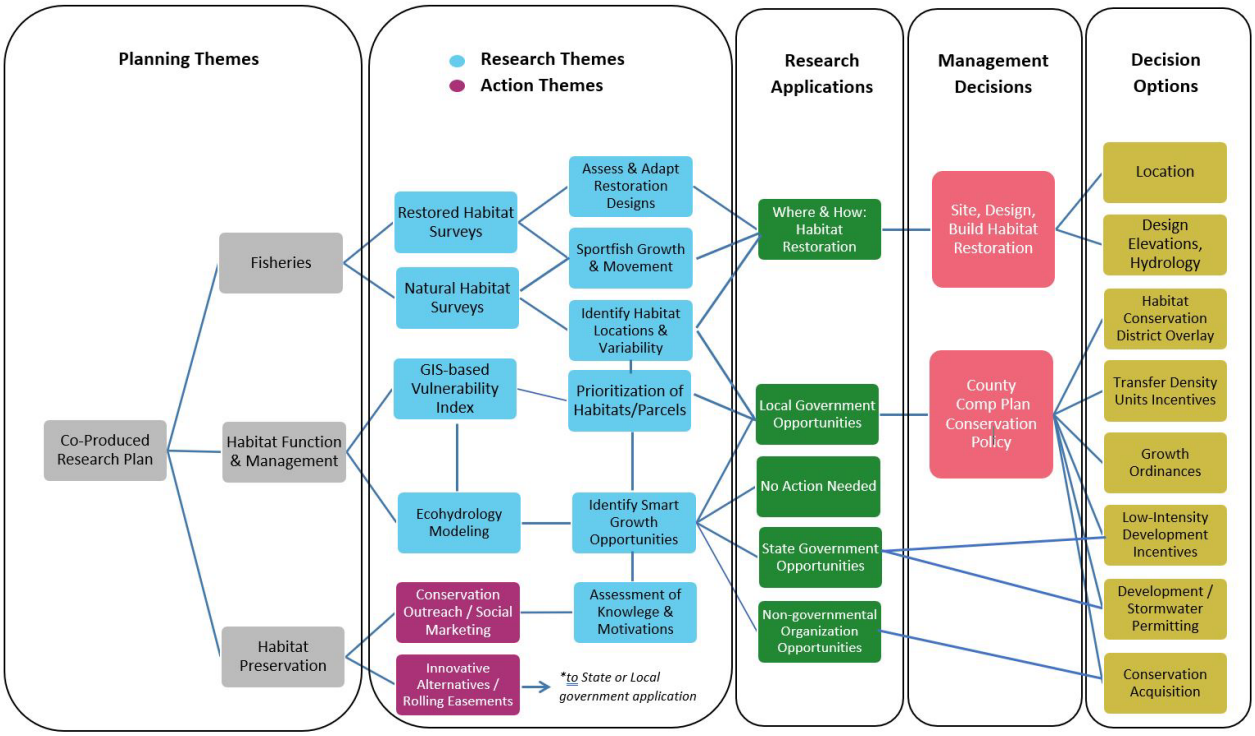
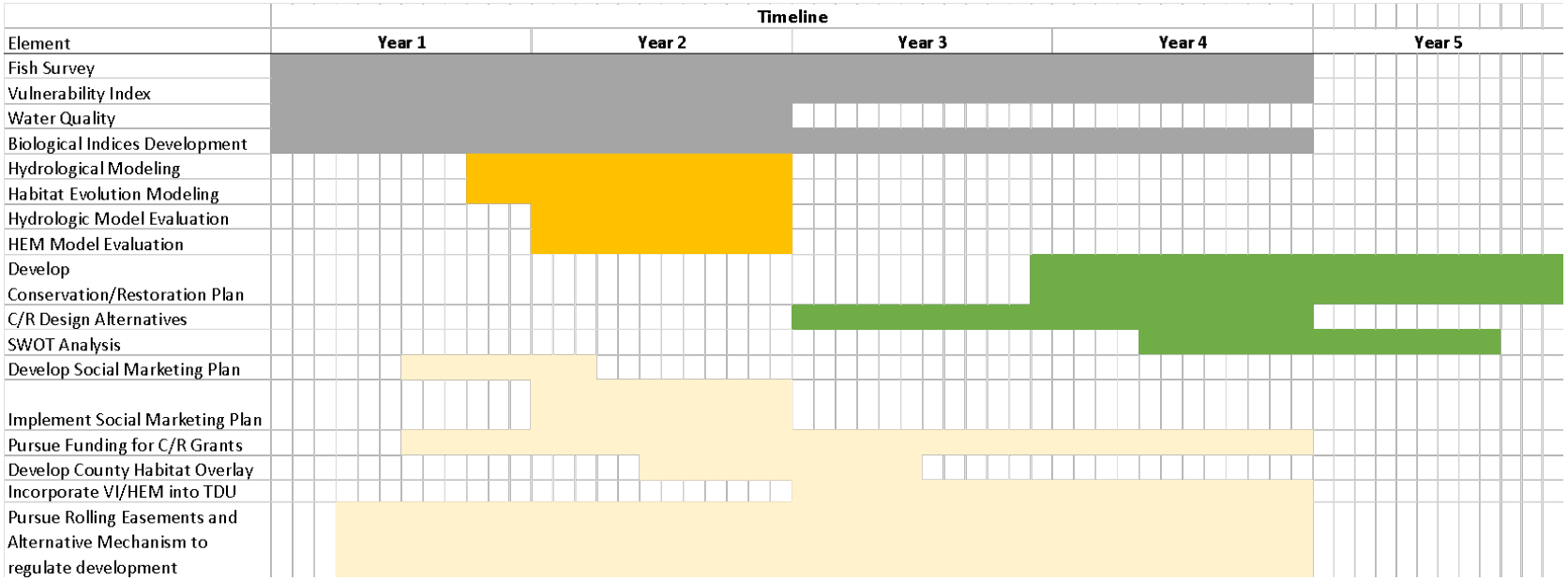


Figure 16. Master decision framework based on outcomes of the co-production process.

Prioritization and Timelines

The timeline for implementation of the research and policy elements is provided in Table 1. The research elements associated with the fish data collection efforts will be the quickest components of phase to initiate since FWC will be the primary grant recipient. Principal elements of the research plan include surveys to refine the extent of the habitat (where juvenile snook and tarpon occur in the landscape) and biological indices including inundation frequencies optimal for the successful immigration and emigration. These actions combined with hydrological and HEM modeling will help inform the VI as an integrative measure of the biological condition of the habitat and its susceptibility to anthropogenic disturbance. Principal policy elements focus on encouraging both professionals devoted to protecting the public good, as well as the general public, to participate in activities that reduce threats and management uncertainties to these habitats through strong local ordinances and social marketing campaigns. The local ordinances must be strongly science-based and therefore will be implemented later in the process. However, social marketing campaigns can be initiated immediately and funding for acquisition of land is a constant pursuit that can be augmented with other actions identified in this plan.

Table 1. Anticipated year of initiation for elements of Phase II of place-based fishery habitat conservation in Charlotte Harbor, FL



Individual Work Plan Summaries

This section provides induvial work plan summaries for elements of the plan identified for future research or actions. The individual work plans describe the need, objective, methods, expected outcomes and potential partners for each element. Not all of these individual work plans will be proposed as part of the NOAA RESTORE Science Program Executing Actionable Science 2023 funding opportunity, but all are listed here to provide potential future partners with funding opportunities an organized path forward to pursue the research topics identified as part of the grant. The individual work plans are organized by either Fisheries Research, Habitat Function, or Habitat Protection and Conservation needs.

Fisheries Research Work Plans

As described in Chapter 2, additional research is necessary to reduce management uncertainty associated with the exact habitat requirements for these species within the study area. Additional fish sampling is required to refine our understanding of the habitat requirements necessary to implement policies needed for protection of these habitats. We intend to leverage previous RESTORE grant studies within and adjacent to the study area (Figure 17) to refine hypotheses related to tarpon and snook habitat requirements by conducting additional surveys, estimating relative growth estimates among functional pond types, tracking emigration to the larger estuary, and developing habitat indices relevant to characterizing their function and need for additional protections. The following work plan summaries detail these proposed work efforts.

Figure 17. Locations of planned fisheries research and surveys completed during previous RESTORE Act grant studies.

1. **Define sportfish nursery extent within the two study areas**

Need: FWC has sampled roughly a third of the coastal ponds on the Cape Haze peninsula under a previous RESTORE grant; however, over forty ponds in that area remain unsurveyed. At the East Wall of Charlotte Harbor, almost all the coastal ponds remain unsurveyed.

Objective: To define the extent of potential sportfish habitat, this work plan proposes a desktop evaluation to identify all ponds in the study area and baseline fisheries sampling in a representative subset of these unsurveyed ponds.

Methods: Conduct a baseline sampling effort to identify potential sportfish nurseries (documenting presence or absence of tarpon or snook), sample water conditions associated with coastal ponds (i.e., dissolved oxygen, temperature, and salinity), and assess habitats and connectivity with the adjacent intertidal habitat mosaic.

Year initiated: Year 1

Expected Outcomes: This baseline survey will define the population of interest and extent of potential pond habitats within the study area, refine logistics of sampling these habitats, and characterize the habitat of unsampled ponds relative to the previously sampled ponds. This baseline effort will inform all future studies by ensuring research is feasible and representative of the population of interest.

Research Entity: FWC FWRI

2. Implement multi-year sportfish and fish community sampling to understand interannual variation and to inform hypotheses driven studies.

Need: Reduce management uncertainties related to the habitat requirements of tarpon and snook.

Objective: Determine factors contributing to the success of juvenile tarpon and snook in coastal pond habitats by implementing a reference-based sampling design.

Methods: A sportfish monitoring design will be used to characterize interannual variation of tarpon and snook and fish community structure (including small-bodied prey species) and inform more hypotheses driven ("special") studies (related to factors affecting growth and emigration; see bullets 3 and 4). The relative success of juvenile tarpon and snook will be characterized by sampling 15 coastal ponds (6 Cape Haze [reference sites sampled during previous RESTORE work] and 9 East Wall [new reference sites]) over multiple years and seasons, spanning the headwaters of seven different tidal creek systems.

Year Initiated: Year 1

Expected Outcomes: Identify environmentally sensitive sportfish nursery areas, describe habitat utilization by sportfish and their prey, characterize habitat quality, extend the time series of existing data collection, and inform restoration needs within the study area.

Research entity: FWC FWRI

3. Fish Tracking Study

Need: There is a need to understand the conditions under which tarpon and snook can emigrate from these coastal ponds and contribute to the adult population.

Objective: Using acoustic telemetry, tag juvenile tarpon at several study sites (each being a chain of ponds and a receiving tidal creek) to track residence, inter-pond movements, and emigration.

Methods: Acoustic receivers (Innovasea VR2Ws) will be placed in a series of connected ponds and their receiving tidal creeks. Juvenile tarpon will be tagged with acoustic transmitters (Innovasea V9 tags; 1.5 year tag life) within the coastal ponds. Together with water level dataloggers, specific conditions (e.g., passing of tropical storms) that allow for tarpon emigration from coastal ponds and tidal creeks can be determined.

Year Initiated: Initial setup of acoustic receivers and water level loggers will occur in the first year, followed by tagging in years two and three. The tag life span is approximately 1.5 years.

Expected Outcomes: At natural ponds, determining the specific requirements for tarpon emigration will help prioritize specific sites for conservation, inform the vulnerability index, and inform stormwater engineering of any developments upstream or in future under different sea-level rise scenarios. Research at the Lemon Creek Wildflower restoration site will determine the effectiveness of restoration techniques employed for sport fish (e.g., creation of marsh ponds). Specifically, an understanding of the marsh elevations and connection types (i.e., culvert dimensions) that promote use of created ponds by juvenile tarpon to inform future restoration efforts.

Research entity: FWC FWRI

4. Differential Growth Rate Evaluation

Need: Fish growth rates are an indicator of habitat quality and differential growth rates among habitats characterized using the initial habitat characterization will inform the Vulnerability Index.

Objective: Compare growth rates among ponds for a subset of species captured in the routine monitoring studies over time.

Methods: Juvenile growth can be determined by analyzing daily growth rings that form on the otolith (ear bone) of the fish. For example, a 60-day old fish (determined from daily ring counts) that is captured at a size of 60 mm total length yields a growth rate of 1 mm per day. A subset of juvenile fish including tarpon, snook and their important prey collected during the study will be used for analysis of daily growth.

Year Initiated: Fish samples will be collected throughout the study and otolith analysis will occur in years 3 and 4, after an adequate number of fish are collected.

Expected Outcomes: Research will determine relative effectiveness of restoration techniques employed for sport fish and compare to growth across habitat restoration types. Comparisons will inform future habitat restoration strategies targeting snook and tarpon early life stage habitat

Research Entity: FWC FWRI

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Habitat Function and Management Work Plans

Habitat functional assessments include the need to refine the habitat VI scores and conduct hydrologic and sea level rise modeling to evaluate the potential changes to these habitats under development and climate change pressures, respectively. Ultimately, these risk assessments are combined to generate the final VI scores that will inform the Overlay District. The work plans for each of these needs is further defined below.

1. Vulnerability Index for Juvenile Sportfish Habitats

Need: An integrative metric of habitat suitability and vulnerability has been identified as a central theme of this study in order to characterize all ponds within the study area according to their need for management protections.

Objective: Integrate individual research outcomes from the fish habitat surveys, hydrologic modeling studies, and habitat evolution modeling to generate site-specific vulnerability scores for all potential habitats in the population. The VI will incorporate the habitat characterization framework developed by BTT and augment it with additional research on susceptibility to changes in anthropogenic pressures associated with development and sea level rise.

Methods: Methodologies for incorporating these individual attributes will require organizing a team of experts to derive final index scores using a co-production approach and finalizing the scoring methodology into a GIS based layer that can inform policy by identifying and quantifying various threats to juvenile sportfish habitat productivity and persistence.

Year Initiated: Year 1

Expected Outcomes: Vulnerability Index will be used to inform policy decisions related to prioritizing protection of most-threatened habitats and serve as the foundation for the Overlay District proposed as an additional central theme of this plan.

Research Entity: BTT, FWC, FWRI, CHNEP, potentially a contracted consultant.

2. Hydrological modeling prediction of potential development impacts on sportfish nursery habitat sustainability and functionality

Need: An integrated hydrologic & hydraulic (H&H) model is needed to evaluate hydrologic flow paths under existing and potential build out conditions in the watersheds associated with critical sportfish ponds in the Cape Haze study areas.

Objective: Use a H&H model to quantify existing and potential future surface water and groundwater flows and pollutant loads to the habitats under various build out scenarios and develop and assess potential measures to mitigate the impacts of adjacent development.

Methods: The Interconnected Channel and Pond Routing model, version 4 (ICPR4) is proposed to evaluate flow paths under current conditions and run various management scenarios affecting discharge volumes, pond storage and pollutant loads. The model will require some survey data and calibration. Once developed for the current condition, management scenarios rerouting of stormwater flows; increasing pond storage and nutrient uptake capabilities (e.g., littoral shelves); and modified outfall structures can be considered.

Year Initiated: Year 1

Expected Outcomes: The model results will be used in combination with outcomes of research elements defining appropriate inundation frequencies and other habitat requirements to maintain sustained function of nursery ponds to inform the Vulnerability Index to identify which ponds are most susceptible to adverse changes in inundation frequencies associated with changes in stormwater flows under built out scenarios

Research Entity: University of Florida IFAS or potentially a contracted consultant

3. Habitat Evolution Modeling under sea level rise scenarios

Need: There is a need to understand the potential migration of habitats upslope under realistic sea level rise scenarios.

Objective: Refine current CHNEP HRN model **(**i.e. the Habitat Evolution Model (HEM) to focus specifically on habitats within the study area to evaluate potential migration of habitats upslope under realistic sea level rise scenarios.

Methods: The current HEM will need to be refined for the study area and revised by scaling down and refining the model to simulate baseline and future conditions specifically for the Cape Haze and East Wall study areas. Subsequent model runs could be conducted to evaluate potential habitat restoration projects, which can be compared to habitats projected under baseline conditions to quantify enhancement benefits over time. Some field elevation data will also be required. The freshwater influence module will be refined to simulate changes in the area of freshwater influence in response to changes in freshwater flows (e.g., to evaluate habitat response to reduced or increased freshwater baseflows).

Year Implemented: Year 1

Expected Outcomes: Identify specific habitat locations vulnerable to loss of function due to Sea Level Rise. Incorporate information in Vulnerability Index which informs ordinances and measures associated with proposed Habitat Conservation Overlay District.

Research Entity: A contracted consultant, CHNEP

Habitat Protection and Conservation Work Plans

Habitat protection and conservation strategies are an ongoing need in this area. While habitat conservation programs have and will continue to pursue opportunities to acquire lands, funding limitations and the requirement of a "willing seller" limit opportunities for land acquisition and therefore other methods are required to supplement protections in the study area. The work plans described in this section are meant to supplement existing efforts to acquire lands and transfer density away from the most vulnerable habitats for tarpon and snook.

1. Develop an Overlay District Implementation Plan

Need: There is a need for additional protections of these habitats established within County Comprehensive planning documents and integrated into assessments of current County mechanisms to control growth in environmentally sensitive lands.

Objective: Develop an Overlay District to complement already existing zoning ordinances as an additional layer of protection for sportfish habitat within the study area.

Methods: The final outcomes of the Vulnerability Index will define the geographic extent and prioritization ranking of habitats down to the parcel scale. This geographic "layer" will serve as an "Overlay" that can be superimposed over existing zoning regulations to improve protections for tarpon and snook. However, integrating this layer into current landuse management practices will require working with the County government to propose amendments to their comprehensive planning documents. For example, one protection might be the requirement for a vegetated buffer and additional setback requirements for development adjacent to critical pond habitats. Those specific requirements (e.g. distances required) need to be explicitly identified and language crafted to define the special protections required by the Overlay. The Overlay can cross multiple existing zoning districts but note that modifications to the list of permitted uses or possible special uses are normally not a part of an overlay zone. The special protections will be identified by the additional research proposed in this document and this work plan is to define those special protections

Year Implemented: Year 3

Expected Outcomes: The Overlay District will serve as the central repository of information integrated in a manner that will have direct applicability to the protection of critical sportfish habitat in Charlotte Harbor, Fl

Research Entity: CC, CHNEP, FWC, FWRI, a contracted consultant

2. Maximize Effectiveness of Charlotte County Market-Based Incentives to Preserve Fish Habitats

Need: Currently, the identification of environmentally sensitive lands within the study area does not consider the special protections that may be required to protect tarpon and snook habitat in the study area and there is a need to increase protections by investigating market forces that promote or discourage transfers, and incorporating specific habitat considerations of tarpon and snook into the decision making processes regarding valuations of transfer units.

Objective: This work plan proposes research to incorporate the Overlay District information to maximize effectiveness of the TDU program market-based zoning policies by investigating market forces that promote or discourage transfers, and incorporating specific habitat considerations of tarpon and snook into the decision making processes regarding valuations of transfer units.

Methods: A science-based decision making approach will be developed using The Vulnerability Index, and Overlay District layer to define decision rules that could improve the effectiveness of Charlotte County's environmentally sensitive land acquisition program (Conservation Charlotte) by prioritizing habitat for conservation. The TDU and Conservation Charlotte program are already implemented in synchrony and the additional information provided by the VI and OD will complement these existing tools (or future tools such as rolling easements) to help maximize sportfish protections in the study area.

Year Implemented: Year 1

Expected Outcomes: Refined market incentivization mechanism for the County's existing TDU and acquisition programs to achieve density reduction targets related to areas with identified environmentally sensitive sport fish nursery habitats

Research Entity: Undetermined, potentially a University, or contracted consultant.

3. Development & implementation of a juvenile sportfish habitat conservation social marketing campaigns

Need: There is a need to encourage all entities that have the power to effect the habitats for juvenile tarpon and snook to exhibit behaviors that help protect these species.

Objective: Use strategic targeting of homeowner's associations and developers planning and a rigorous survey design to build out lots in subdivisions abutting the preserve to promote the value of these habitats as an incentive to living sustainably with nature and exhibit behaviors that protect the species.

Methods: Develop campaigns such as "Tarpon Friendly Community" campaign to change behaviors towards the protection of these habitats. Campaigns would include: a rigorous pre-post survey design, developing a logo and promotional messaging describing the unique habitat for the area and educational information describing the value and vulnerabilities of these habitats for tarpon and snook. Public outreach and video messaging are other effective tools that may be used to promote the habitat value and need for protection of these species. The campaigns can occur independent of any further research and should be enacted as soon as possible to engage potential developers and homeowners.

Year Implemented: Year 1

Expected Outcomes: Acceptance by homeowner's associations, developers, natural resource managers and the general public that there are benefits to promoting the protection of these areas as critical sportfish habitats.

Research Entity: Sea Grant, CHNEP, UF/IFAS, and/or a contracted consultant.

Data Management and Information Transfer

Research conducted following this Plan will collect multiple types of environmental and sociological data. All datasets will have location information and descriptive metadata. GIS products will be point or polygon vector files. Derived products from model outputs will be stored as PDF files, and databases of fisheries information collected may be stored as nonproprietary digital (machine-readable) formats (CSV, DBF, XML). All FWC FWRI programs will have project and database level metadata records prepared in the FWC FWRI's metadata management application (MetaRep), a searchable database that can be exported to XML and that contains, geographic extent and detailed descriptions. Data will be stored on FWC servers backed up in multiple locations and available for no cost upon request. Data formats will be NOAA National Centers for Environmental Information (NCEI) compatible in the event that NCEI is selected as a data host. Additionally, reports, data, and end products will be made available on the CHNEP Water Atlas page which has been generated with the support of the NOAA RESTORE Science Program.

End users of the information generated by this study have been engaged as investigators and partners in the study's research co-production design; they will be continually updated on outcomes as they are developed. Outcomes will also be communicated through existing outlets on the national, Gulf-wide, state, and local levels, such as OneNOAA Seminars, Gulf of Mexico Oil Spill & Ecosystem Science Conference, CHNEP technical meetings, and Florida's Estuarine Restoration Teams. Additionally, the CHNEP will transfer outcomes to the greater ecological community through the Association of National Estuary Programs.

Enacting habitat conservation policy

FWC, CHNEP, and BTT will develop an approach for transferring research findings and products to Charlotte County administration and elected Commissioners. Methods should start with engaging in the County's landuse planning and Comprehensive Plan revision process which will begin in 2027. Obtaining conceptual approval to pursue policy recommendations for habitat conservation by Commissioners at public hearings, and engaging administrative staff to transfer knowledge, should follow. If policy recommendations stemming from research outcomes are adopted by Charlotte County Board of County Commissioners, then layers and data from the VI and OD will be transferred to Charlotte County

Government GIS (see link) and Charlotte County Utilities Map Book (see link) for governmental and public use, and publication in Comprehensive Plan updates or amendments in 2028.

Sportfish habitat restoration

FWC researchers will work closely to transfer knowledge about habitat restoration design effectiveness to FWC managers and other entities that perform and fund habitat restoration (e.g. SWFWMD, CHNEP, NOAA). The outcomes of research will contribute to a decision-making support tool that will offer specific guidance on future restoration designs and monitoring approaches. Comparison of designs will inform regional fish habitat management through FWC's Aquatic Habitat Conservation and Restoration Section which conducts 7–15 estuarine habitat restoration projects annually, as well as programs conducted by other organizations.

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