Site Profile
of the
Guana Tolomato Matanzas National Estuarine Research Reserve

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This site profile has been developed in accordance with National Oceanic and Atmospheric Administration regulations. It is consistent with the congressional intent of Section 315 of the Coastal Zone Management Act of 1972, as amended, and the provisions of the Florida Coastal Management Program. August, 2009

The views, statements, findings, conclusions, and recommendations expressed herein are those of the author and do not necessarily reflect the views of the State of Florida, National Oceanic and Atmospheric Administration, or any of its sub-agencies. August, 2009.

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Preface

The Guana Tolomato Matanzas National Estuarine Research Reserve (GTMNERR), designated in 1999, is one of 27 estuarine reserves included within the National Oceanic and Atmospheric Administration's National Estuarine Research Reserve System (NERRS). As part of the NERRS program, each reserve is required to develop a site profile, which describes the estuarine and terrestrial ecosystems represented within the site; outlines ongoing research and monitoring; and identifies site-specific research needs and priorities.

This site profile includes an introduction to the Reserve; an environmental overview of the GTMNERR estuaries; a description of biotic habitats; an overview of the Reserve's programs and partnerships; a summary of research conducted within the Reserve; and suggestions for future research and monitoring.

This document is intended to provide guidance for the future direction of the GTMNERR's research and monitoring programs and will be made available to all potential users, including scientists, environmental managers, local planners, elected officials, and environmental educators.

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LIST OF ACRONYMS

ATV	All Terrain Vehicle
BMP	Best Management Practices
BMAP	Basin Management Action Plan
CAMA	Coastal and Aquatic Managed Areas
CDMO	Centralized Data Management Office
CFR	Code of Federal Regulations
CICEET	Cooperative Institute for Coastal and Estuarine Environmental Technology
CRCP	Coral Reef Conservation Program
CZM	Coastal Zone Management
CZMA	Coastal Zone Management Act
DHR	Division of Historical Resources
DNR	Department of Natural Resources (now FDEP)
EEC	Environmental Education Center
ERD	Estuarine Reserves Division
F	Fahrenheit
F.A.C.	Florida Administrative Code
F.A.W.	Florida Administrative Weekly
FCMP	Florida Coastal Management Program
FDACS	Florida Department of Agricultural and Consumer Services
FDEP	Florida Department of Environmental Protection
FDOF	Florida Department of Agricultural and Consumer Services, Division of Forestry
FIU	Florida Institute of Technology
FLUCCS	Florida Land Use Cover and Forms Classification System
FNAI	Florida Natural Area Inventory
F.S.	Florida Statutes
FWC	Florida Fish and Wildlife Conservation Commission
FWRI	Fish and Wildlife Research Institute
GPS	Global Positioning System
GIS	Geographic Information System
GRF	Graduate Research Fellowship
GRMAP	Guana River Marsh Aquatic Preserve
GRWMA	Guana River Wildlife Management Area
GTMNERR	Guana Tolomato Matanzas National Estuarine Research Reserve
IWRMN	Integrated Water Resources Monitoring Network
IWW	Intracoastal Waterway
LAMP	Lighthouse Archeological Maritime Program
NCB	Northern Coastal Basin
NERR	National Estuarine Research Reserve
NERRS	National Estuarine Research Reserve System
NIH	National Institute of Health
NMS	National Marine Sanctuary
NOAA	National Oceanic and Atmospheric Administration
OFW	Outstanding Florida Water

PCAP	Pellicer Creek Aquatic Preserve
ppt	Parts Per Thousand
SCS	Soil Conservation Service
SJRWMD	St. Johns River Water Management District
SR	State Road
STORET	Storage and Retrieval Database
SWAMP	Surface Water Ambient Monitoring Program
SWIM	Surface Water Improvement and Management Plan
SWMP	System-wide Monitoring Program
TMDL	Total Maximum Daily Load
UCF	University of Central Florida
UF	University of Florida
UM	University of Miami
UNH	University of New Hampshire
U.S.C.	United States Code
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WMD	Water Management District

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Overview

Florida conjures up romantic visions of warm breezes, sandy beaches and sunny skies. With more than 1,100 miles of shoreline, and 2,500 miles of navigable waters, including lakes, bays, and estuaries, it is easy to see why Florida is considered one the Nation's premier destinations for those interested in natural outdoor activities. The Guana Tolomato Matanzas National Estuarine Research Reserve (GTMNERR or Reserve) in northeast Florida contains those features that attract tourists to Florida. Most important though, are the many species of subtropical and temperate plants and animals that co-inhabit the Reserve, making it a key location to study climate change and other global ecological processes. The Reserve's relatively pristine condition and unique climate and biodiversity are ideal for scientific research and study.

The Reserve serves as an important habitat for migrating species including calving North Atlantic right whales and serves as a critical feeding and resting location for migrating shorebirds along the North American Atlantic flyway. Manatees, wood storks, roseate spoonbills, bald eagles and peregrine falcons find refuge in the GTMNERR.

In addition, the Reserve is located in a region with the oldest record of European occupation and has a rich assortment of cultural resources dating to the pre-Columbian era, thereby providing a valuable resource for archeological research and interpretation.

The GTMNERR is located south of the City of Jacksonville, in St. Johns and Flagler Counties, on the northeast coast of Florida.The GTMNERR is geographically divided into a northern (Figure 1) and southern component (Figure 2), separated by the City of St. Augustine. The Reserve is connected to the Atlantic Ocean via the St. Augustine Inlet and the Matanzas Inlet.

The Reserve encompasses approximately 64,487 acres of submerged lands and uplands. These lands include salt marsh and mangrove tidal wetlands, oyster bars, estuarine lagoons, upland habitat and offshore seas. The estuarine ecological system produces a rich abundance of marine life including numerous commercially and recreationally valuable species. The Reserve also contains the northernmost extent of mangrove habitat on the east coast of the United States (Zomlefer et al. 2006).

The northern component (referred to locally as Guana) is associated with the Tolomato and Guana River estuaries. It consists of the Guana River Marsh Aquatic Preserve (GRMAP), Guana River Wildlife Management Area (GRWMA), Stokes Landing Conservation Area and Deep Creek State Forest. The GRMAP extends three miles into the Atlantic Ocean, and encompasses the estuarine (tidal) waters of the Tolomato and Guana Rivers, interior impoundments, marshes, swamps and five artesian wells. The northern component also includes the upland areas of the former Guana River State Park.

The southern component is associated with the Matanzas River estuary, extending from Moultrie Creek to south of Pellicer Creek. The southern component of the Reserve consists of Pellicer Creek Aquatic Preserve (PCAP), Faver-Dykes State Park, Washington Oaks Gardens State Park, Moses Creek Conservation Area, Pellicer Creek Conservation Area, Fort Matanzas National Monument, Princess Place Preserve, The River to Sea Preserve at Marineland, and other State sovereign submerged lands adjacent to the Matanzas River within the GTMNERR boundary.

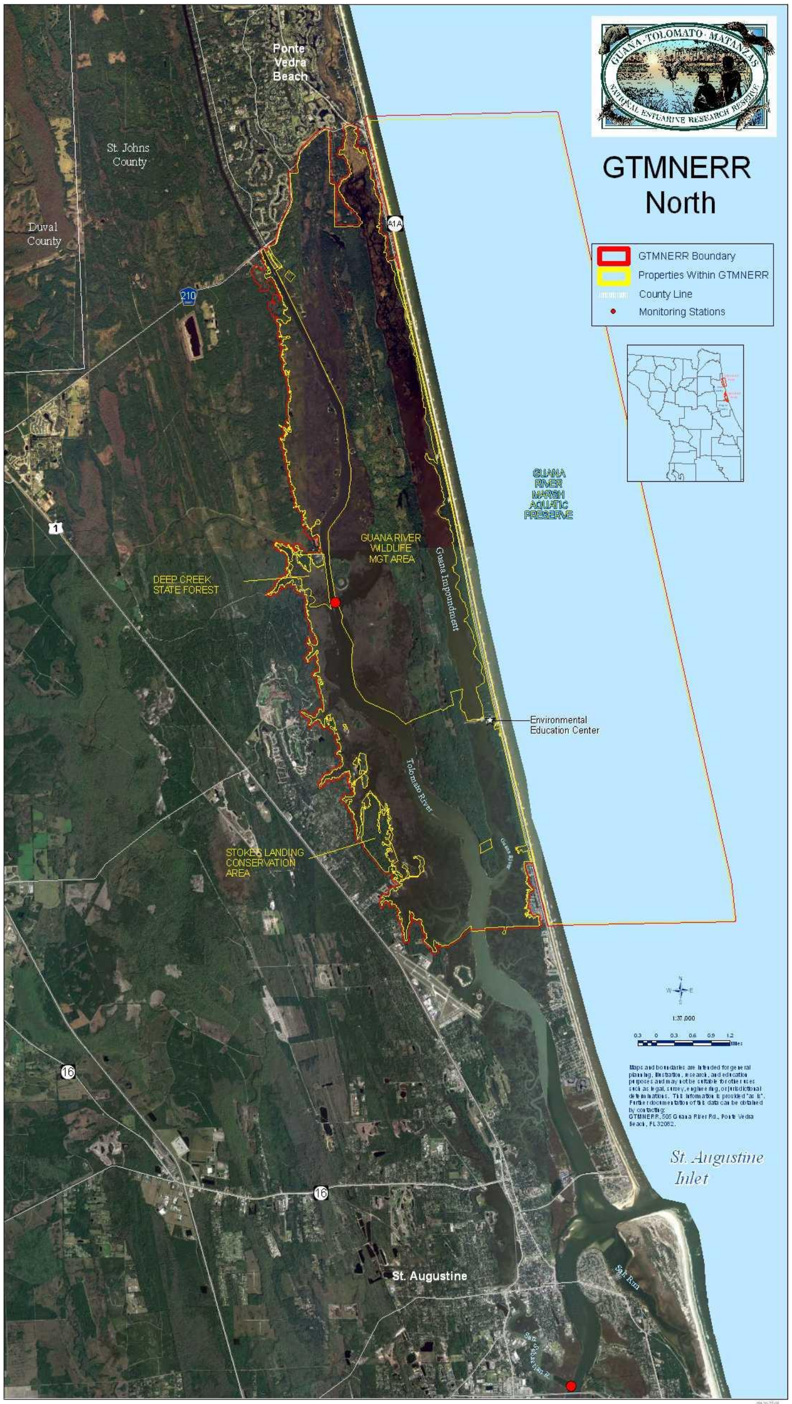


Figure 1. The GTMNERR is geographically divided into a northern and southern component, separated by the City of St. Augustine. The northern component (referred to locally as Guana) is associated with the Tolomato and Guana River estuaries.

Figure 2. The GTMNERR southern component is associated with the Matanzas River estuary, extending from Moultrie Creek to south of Pellicer Creek.

Estuarine Habitats at the Reserve

The Guana Tolomato Matanzas (GTM) River estuarine ecosystem exhibits a wide variety of habitat types. Pinelands (30%) are the predominant upland habitat type within the drainage basin, followed by shrub and brushlands (14%), and hardwood hammocks (10%). Barren (mostly disturbed) lands make up only 10% of the watershed. Coastal salt marsh and open water habitat comprise nearly 15% of the watershed.

Salt marsh is the major estuarine habitat in the GTMNERR, and occurs along the boundaries of the estuaries throughout the Reserve. This habitat type occupies more than 20% of the total land cover of the Reserve. Dominant plants include Glasswort (*Salicornia* spp.), saltwort (*Batis maritima*), saltmarsh cordgrass (*Spartina alterniflora*), and black needlerush (*Juncus roemerianus*).

Tidal flats found in this estuary are typically intertidal sand and mud flats flanking river mouths, creeks, sounds and channels. These flats lie between the extreme spring high and low tide lines. While the areas may appear relatively barren, this habitat supports a large population of infaunal organisms as well as a variety of transient fish and wildlife.

Oyster reefs are found in the intertidal portions of the Reserve estuarine system. They serve to locally decrease turbidity by trapping sediment and stabilizing erosion. Oysters provide hard substrate and habitat for many other species including, mud crabs (*Rhithropanopeus harrisii*), blue crabs (*Callinectes sapidus*), and amphipods. More detailed descriptions of the estuarine and other habitats in the GTMNERR are discussed in the Section on *Biotic Habitats and Community Structure*.

The diversity of communities present in the GTMNERR provides habitat for a wide variety of fish and wildlife. A species list recently compiled for the GRMAP indicates the presence of at least 44 mammal, 358 bird, 41 reptile, 21 amphibian, 303 fish, and 580 plant species. A partial list of estuarine and marine fish and invertebrates compiled for the general area by the Whitney

Laboratory records 270 species. The most current comprehensive species list for the GTMNERR is found in Appendix A.

The variety of habitats within the GTMNERR are essential to many protected species (eight plants and forty-eight animals) including the Anastasia Island beach mouse (*Peromyscus polionotus phasma*), gopher tortoise (*Gopherus polyphemus*), least tern (*Sterna antillarum*), marine turtles: loggerhead (*Caretta caretta*), leatherback (*Dermochelys coriaciea*) and green turtle (*Chelonia mydas*), and North Atlantic right whale (*Eubalaena glacialis*). In addition, the striped newt (*Notopthalmus perstriatus*), one of Florida's rarest vertebrate species, occurs within the GTMNERR. Some of the many rare listed birds of the GTMNERR include: great egret (*Ardea alba*), white ibis (*Eudocimus albus*), black-crowned night heron (*Nycticorax nyticorax*), least tern (*Sterna antillarum*), bald eagle (*Haliaeetus leucocephalus*), tricolored heron (*Egretta tricolor*), wood stork (*Mycteria americana*) and roseate spoonbill (*Ajaia ajaja*).

Commercially valuable species of organisms that occur in the GTMNERR for all or part of their life cycle include oysters (*Crassostrea virginica*), quahog clams (*Mercenaria spp*.), blue crabs

(*Callinectes sapidus*), stone crabs (*Menippe mercenaria*), white shrimp (*Penaeus setiferus*), brown shrimp (*Penaeus aztecus*), striped and white mullet (*Mugil cephalus* and *M. curema*), gag grouper (*Myctoperca microlepis*), black seabass (*Centropristis striata*), gray snapper (*Lutjanus griseus*), lane snapper (*L. synagris*), flounder (*Paralichthys lethostigma and P. dentatus*), bluefish (*Pomatomus saltatrix*), menhaden (*Brevoortia tyrannus*) and thread herring (*Opisthonema oglinum*).

Recreationally valuable sport fishing species present include tarpon (*Tarpon atlanticus*), spotted sea trout (*Cynoscion nebulosus*), weakfish (*C. regalis*), snook (*Centropomus undecimalis*), red drum (*Sciaenops ocellata*), black drum (*Pogonias cromis)*, spot (*Leiostomous xanthurus*), croaker (*Micropogon undulatus*), sheepshead (*Archosargus probatocephalus*), crevalle jack (*Carynx hippos*), gag grouper (*Myctoperca microlepis*), black seabass (*Centropristis striata*), gray snapper (*Lutjanus griseus*), lane snapper (*L. synagris*), pinfish (*Lagodon rhomboides*), whiting (*Menticirrus americanus*), Florida pompano (*Trachinotus carolinus*), flounder (*Paralichthys* spp.), striped mullet (*Mugil cephalus*), and sailor's choice (*Haemulon parri*).

The State of Florida has five surface water classifications (62-302.400 Florida Administrative Code (F.A.C.)), with specific criteria applicable to each class of water. In addition selected waters may be designated as an Outstanding Florida Water (OFW; 62-302.700 F.A.C.) worthy of special protection because of its natural attributes. This special designation is applied to certain waters, and is intended to protect existing good water quality. In the northern section of the GTMNERR, surface waters within the GRMAP are designated as an OFW, while in the southern portion, Pellicer Creek has OFW status. National, state and county conservation areas surround Pellicer Creek making it one of the last undisturbed tidal marsh creek systems along the east coast of Florida.

Historical and Cultural Resources
The first inhabitants of northeast Florida adapted to Late Glacial conditions with a technology and settlement pattern suited to the hunting of scarce and large animals in a dry climate. Even at quite low population densities the environmental influences of these Paleo Native Americans may have included hunting to extinction a number of large vertebrate species (Miller 1991). Between 10,000 and 5,000 years ago, the most fundamental changes to the environment were natural in origin. As sea level rise slowed to its pre-industrial rate, water resources, small game, and plant resources became more accessible. This condition enhanced settlement in coastal locations. By about 5,000 years ago the coastal environment of Florida had become similar to the present day situation. Native Americans living on the coast took advantage of the relatively stable and abundant seafood, an important source of protein. As human populations became more sedentary in response to stable conditions, opportunities for specialized collection and domestication of plants increased along with the duration of settlements.

The GTMNERR region is of special sociological and archeological interest because of the comprehensive documentary record of human settlement and landscape modifications. There are detailed records commencing in the mid-sixteenth century of Native American, Spanish, French, British and American inhabitants and their cultures.

A total of 22 recorded archaeological sites occur within the boundaries of the area directly managed by the Reserve. Known sites include a burial mound, numerous shell middens, a Spanish mission (probably La Natividad de Nuestra Senora de Tolomato), and homestead sites from the British, Second Spanish and Territorial Periods (Newman 1995).

Other areas of exceptional historical significance within the GTMNERR include:

- Faver-Dykes State Park has five identified sites with artifacts from the full range of cultural periods: Orange, St. Johns, Saint Augustine and Second Spanish from the Hepworth Carter Plantation site.
- Washington Oaks Gardens State Park has several nineteenth and early twentieth century sites associated with the Bella Vista Plantation, as well as sites associated with the ornamental gardens dating from the late 1930s--1950s. In addition the area has several middens in fair to good condition.
- Princess Place Preserve has Florida's oldest commercial orange groves planted in the early 1800's. The land is part of the original land grant from the Spanish Government in the late 1700's; it may be the only contiguous land grant remaining from that time period. The site contains one of Florida's first in-ground swimming pools.
- Matanzas Inlet, at Fort Matanzas National Monument, was the scene of crucial events in Spanish colonial history. The defeat of French soldiers here in 1565 initiated Spain's establishment of its first permanent colony in Florida. The construction of Fort Matanzas in 1740-42 was Spain's attempt to stop British encroachments on St. Augustine (Smith 2006).

Underwater archeological resources in the GTMNERR are lesser known. A systematic maritime archaeological survey in St. Augustine waters was conducted by Southern Oceans Archaeological Research, Inc between 1994 and 1997, and focused on locating offshore shipwrecks surrounding St. Augustine's inlet (Franklin and Morris 1996). The most significant discovery of this survey was the shipwreck Industry, a British supply ship lost May 6, 1764. This wreck remains the oldest yet located in St. Augustine's waters (Morris et al. 1998). The St. Augustine Lighthouse and Museum began funding maritime archaeology in St. Johns County, in 1997, and in 1999, established the Lighthouse Archaeological Maritime Program, or LAMP. In both 2007 and 2009 the GTMNERR co-sponsored, along with LAMP, the Annual Northeast Florida Symposium on Underwater Maritime Archaeology, a symposium on underwater archaeology to bring together experts in this field and to promote collaboration on future research and educational initiatives within the Reserve.

National Estuarine Research Reserve Program

The National Estuarine Research Reserve (NERR) System was created by the Coastal Zone Management Act (CZMA) of 1972, as amended, 16 U.S.C. Section 1461, to augment the Federal Coastal Zone Management (CZM) Program. The CZM Program is dedicated to comprehensive, sustainable management of the Nation's coasts.

The Reserve system is a network of protected areas established to promote informed management of the Nation's estuaries and coastal habitats. The Reserve system currently consists of 27 reserves in 22 states and territories, protecting over one million acres of estuarine lands and waters.

The Reserves serve as living laboratories for agency staff, visiting scientists and students. They serve as platforms for long-term research and monitoring as well as reference sites for comparative studies. The integration of research and monitoring provides a scientific basis to improve the understanding of coastal systems.

As stated in the NERR regulations, 15 Code of Federal Regulations (CFR) Part 921.1(a), the NERR System mission is:

"the establishment and management, through Federal-state cooperation, of a national system of Estuarine Research Reserves representative of the various regions and estuarine types in the United States. Estuarine Research Reserves are established to provide opportunities for long-term research, education, and interpretation."
Federal regulations, 15 CFR Part 921.1(b), provide five specific goals for the NERR System:

1. Ensure a stable environment for research through long-term protection of NERR resources;
2. Address coastal management issues identified as significant through coordinated estuarine research within the System;
3. Enhance public awareness and understanding of estuarine areas and provide suitable opportunities for public education and interpretation;
4. Promote federal, state, public and private use of one or more Reserves within the System when such entities conduct estuarine research; and
5. Conduct and coordinate estuarine research within the System, gathering and making available information necessary for improved understanding and management of estuarine areas.

There are three major elements of the Reserve System:

1. Research on estuarine habitats and processes,
2. Education and interpretation of estuarine processes and
3. Resource stewardship.

These elements are implemented through a variety of national programs summarized below:

NERR System Research and Monitoring Program

The Reserve System provides a mechanism for addressing scientific and technical aspects of coastal management problems through a comprehensive, interdisciplinary, and coordinated approach. Research and monitoring programs, including the development of baseline information, form the basis of this approach. Reserve research and monitoring activities are guided by national plans that identify goals, priorities, and implementation strategies for these programs. This approach, when used in combination with the education and outreach programs, will help ensure the availability of scientific information that has long-term, system-wide, consistency and utility for managers and members of the public to use in protecting or improving natural processes in their estuaries.

NERR System-Wide Monitoring Program (SWMP)

The System-wide Monitoring Program provides standardized data on national estuarine environmental trends while allowing the flexibility to assess coastal management issues of regional or local concern. The principal mission of the monitoring program is to develop quantitative measurements of short-term variability and long-term changes in the integrity and biodiversity of representative estuarine ecosystems and coastal watersheds for the purposes of contributing to effective coastal zone management. The program is designed to enhance the value and vision of the reserves as a system of national reference sites.

NERR System Education Program

The Reserve System provides a vehicle to increase understanding and awareness of estuarine systems and improve decision-making among key audiences to promote stewardship of the nation's coastal resources. Education and interpretation in the reserves incorporate a range of programs and methodologies that are systematically tailored to key audiences around priority coastal resource issues and incorporates science-based content. Reserve staff members work with local communities and regional groups to address coastal resource management issues, such as non-point source pollution, habitat restoration and invasive species. Through integrated research and education programs, the reserves help communities develop strategies to deal successfully with these coastal resource issues.

Formal and non-formal education and training programs in the NERRS target K-12 students, teachers, university and college students and faculty, as well as coastal decision-maker audiences such as environmental groups, professionals involved in coastal resource management, municipal and county zoning boards, planners, elected officials, landscapers, eco-tour operators and professional associations.

K-12 and professional development programs for teachers include the use of established coastal and estuarine science curricula aligned with state and national science education standards and frequently involve both on-site and in-school follow-up activity. Reserve education activities are guided by national plans that identify goals, priorities, and implementation strategies for these programs. Education and training programs, interpretive exhibits and community outreach programs integrate elements of NERRS science, research and monitoring activities and ensure a systematic, multi-faceted, and locally focused approach to fostering stewardship.

NERR System Coastal Training Program

The Coastal Training Program (CTP) provides up-to-date scientific information and skill-building opportunities to coastal decision-makers who are responsible for making decisions that affect coastal resources. Through this program, National Estuarine Research Reserves can ensure that coastal decision-makers have the knowledge and tools they need to address critical resource management issues of concern to local communities.

Coastal training programs offered by reserves relate to coastal habitat conservation and restoration, biodiversity, water quality and sustainable resource management and integrate reserve-based research, monitoring and stewardship activities. Programs target a range of audiences, such as land-use planners, elected officials, regulators, land developers, community groups, environmental non-profits, business and applied scientific groups. These training programs provide opportunities for professionals to network across disciplines and develop new collaborative relationships to solve complex environmental problems.

Additionally, the CTP provides a critical feedback loop to ensure that professional audiences inform local and regional science and research agendas. Programs are developed in a variety of formats ranging from seminars, hands-on skill training, participatory workshops, lectures and technology demonstrations. Participants benefit from opportunities to share experiences and network in a multidisciplinary setting, often with a reserve-based field activity.

Partnerships are important to the success of the Program. Reserves work closely with state coastal programs, Sea Grant College extension and education staff, and a host of local partners in determining key coastal resource issues to address, as well as the identification of target audiences. Partnerships with local agencies and organizations are critical in the exchange and sharing of expertise and resources to deliver relevant and accessible training programs that meet the needs of specific groups.

The Coastal Training Program requires a systematic program development process, involving periodic review of the reserve niche in the training provider market, audience assessments, and development of a three to five year program strategy, a marketing plan and the establishment of an advisory group for guidance, program review and perspective in program development. The CTP implements a performance monitoring system, wherein staff report data in operations progress reports according to a suite of performance indicators related to increases in participant understanding, applications of learning and enhanced networking with peers and experts to inform programs.

Designated in 1999, the Guana Tolomato Matanzas National Estuarine Research Reserve (GTMNERR) is one of three NERRs in Florida. It is a part of this system because of its outstanding representation of the east Florida sub-region of the Carolinian bioregion and its unique combination of natural and cultural resources. The GTMNERR is a federal/state partnership with the Florida Department of Environmental Protection (FDEP) as the state program administrator.

The GTM Research Reserve is managed compatibly with the NERR's Program vision and 2005-2010 Strategic Goals. The issue topic areas of the GTM Research Reserve's management plan (Watershed Landuse, Cultural Resource Preservation and Interpretation, Public Use, Habitat and Species Management and Global Processes) have a direct linkage with the National Program's priority management issues of land use and population growth, habitat loss and alteration, water quality degradation and changes in biological communities.
The GTM Research Reserve and other Reserves share the National Program's 2005- 2010 Strategic Plan**-** guiding Principles (*http://www.nerrs.noaa.gov/Background_StrategicPlan.html*) including:

- Strong partnerships between NOAA, state agencies and universities, and other local partners are critical to the success of the reserve system.
- The reserve system integrates science, education and stewardship on relevant topics to maximize the benefits to coastal management.
- Reserves serve as a catalyst and a focal point for demonstrating and facilitating objective problem solving and best management practices.
- Reserves engage local communities and citizens to improve stewardship of coastal areas.
- Reserves implement an ecosystem-based management approach.

The Florida NERRs are administered on behalf of the State by the FDEP Office of Coastal and Aquatic Managed Areas (CAMA) as part of a network that includes forty-one Aquatic Preserves, three NERRs, a National Marine Sanctuary (NMS), the Coral Reef Conservation Program (CRCP), and the Florida Oceans and Coastal Resources Council. This provides for a system of significant protections to ensure that our most popular and ecologically important underwater ecosystems are cared for in perpetuity. Each of these special places is managed with strategies based on local resources, issues, and conditions.

Reserve Mission and Site Description

The primary role of the GTMNERR is to serve as a platform for research and education and as a clearinghouse for science based information to guide the conservation of natural and cultural resources within the region. This is accomplished by conducting and facilitating scientific studies and symposia which in turn are used to guide the Reserve's environmental education and stewardship programs. This process ensures that the best available information is provided to citizens, coastal managers, scientists and elected officials making decisions affecting coastal habitats. These activities also provide a mechanism for coordinated ecosystem management of lands within the GTMNERR boundary and its watershed.

The Reserve's primary mission is to achieve the conservation of natural biodiversity and cultural resources by using the results of research and monitoring to guide science-based stewardship and education.

The main facility of the GTMNERR is the Environmental Education Center (EEC) located in the northern component of the Reserve ten miles north of St. Augustine, on State Road A1A, in Ponte Vedra Beach. The EEC serves as the administrative, education, research, and stewardship facility for the northern component. The Reserve also maintains an office on State Road A1A in Marineland. This office houses the research, education, and outreach facilities for the southern component of the Reserve.

Community leaders along with state, federal and local governments have preserved extensive areas within the watershed of the Reserve. These preserved areas provide a unique setting for ecosystem level scientific research and monitoring which contribute the information needed for restoring and conserving the natural biodiversity in the region.

Compatible consumptive and nonconsumptive uses of the Reserve's natural resources provide valuable assets for the local community. Ecotourism and recreational uses within and adjacent to the Reserve including boating, picnicking, swimming, sport fishing, cast netting, hunting, camping, hiking, biking, horseback riding, canoeing, kayaking and nature study are outstanding. Wildlife viewing, especially birds, is excellent. Washington Oaks Gardens State Park has an extensive plant garden for viewing along the Matanzas River and a unique coquina rock outcrop, the Anastasia Formation. Fort Matanzas National Monument provides exhibits and tours of historical significance. Faver-Dykes State Park provides for nature study, camping, picnicking and canoeing. Princess Place Preserve has many unique cultural features and is managed by Flagler County for its historical preservation and recreational value. The GRWMA provides outstanding resources for hunters and nature enthusiasts.

Ecological Significance and Designations of the Reserve

NOAA has identified eleven distinct biogeographic regions and 29 subregions in the U.S., each of which contains several types of estuarine ecosystems (15 CFR Part 921, for NERR typology system).

The GTMNERR is within the Carolinian biogeographic region within the east Florida subregion. The location's relatively pristine condition and unique climate and biodiversity are well suited to being designated as a Research Reserve. Community leaders along with state, federal and local governments have preserved extensive areas in the watershed of the GTM Research Reserve resulting in some of the country's most pristine freshwater, tidal creek and estuarine habitats. Consequently, the GTM Research Reserve provides a unique setting to conduct research and monitoring and to set goals for protecting and restoring other estuaries in the region.

Major Reserve Management Priorities

St. Johns County is one of the most rapidly growing counties in Florida. As the population increases as much as 20% by 2015 (Economic and Demographic Research 2009), the demand for new and expanded water dependent use facilities such as marinas and boat ramps will rise as well and is a major issue for the GTMNERR. This potentially massive urban growth will likely impact both the water quality and water resources within the Reserve.

A Water Dependent Uses and Marine Study by St. Johns County (2002) reported the following:

- In 2000/2001, there were a total of 10,073 registered vessels in St. Johns County. That number is predicted to increase to 15,564 vessels by 2015, an increase of nearly 65%.
- There are currently 1,054 wet slips at marinas located within St. Johns County. Based on current boat registration and population trends, an increase of 575 slips will be needed to keep up with the existing level of availability by 2015.
- Based on current permitting trends, it is estimated that an additional 375 private residential docks will be constructed by 2015, bringing the total from approximately 1200 in 2000 to 1575 in the year 2015.

Dock construction, increased boating traffic associated with increases in population, and poor boating practices are impacting benthic resources and shoreline habitat within the Reserve.

Effective mitigation of these issues is necessary to maintain the status quo of natural conditions within the Reserve.

Perhaps the most important all-encompassing management priority is to foster ecosystem-based conservation and restoration of the natural habitats supporting sustainable populations of the diverse array of organisms within the Reserve.

Reserve Protection Efforts

The Reserve encompasses a variety of different local, regional and state regulatory jurisdictional lands, each governed by specific protective rules and regulations. The Reserve has direct jurisdiction over the Guana River Marsh Aquatic Preserve (GRMAP), the upland areas of the former Guana River State Park, and the Pellicer Creek Aquatic Preserve (PCAP). Pellicer Creek itself is designated as a State Canoe Trail, promoting a passive, low-impact form of recreation within the Preserve.

The Florida Fish and Wildlife Conservation Commission (FWC), manages the Guana River Wildlife Management Area (GRWMA).

Deep Creek State Forest and Matanzas State Forest are managed by the Florida Division of Forestry (FDOF) in cooperation with the FWC and St. Johns River Water Management District.

Both Faver-Dykes State Park and Washington Oaks Gardens State Park are managed through FDEP's Division of Recreation and Parks. The mission of the park service is to provide resource-based recreation while preserving, interpreting and restoring natural and cultural resources.

Fort Matanzas National Monument is managed and protected by the US National Park Service. The original national monument site consisted of only the fort on Rattlesnake Island, northwest of the Matanzas Inlet. Through the years, however, the National Park Service has been able to acquire additional land both on Rattlesnake and Anastasia Island and begin to set aside a slice of an intact barrier island ecosystem.

Princess Place Preserve and the River to Sea Preserve at Marineland fall under the jurisdiction of Flagler County. Princess Place Preserve is an important and critical ecological asset protecting saltwater marshes, Pellicer Creek and the Matanzas estuary. The River to Sea Preserve is owned jointly by Flagler County and the Town of Marineland. Beginning at the beach of the Atlantic Ocean and reaching west to the Matanzas River; the River to Sea Preserve protects a rapidly disappearing maritime scrub environment.

The St. Johns River Water Management District has jurisdiction over the Stokes Landing Conservation Area, Moses Creek Conservation Area, and Pellicer Creek Conservation Area. The District management goals for these areas are generally to:

1. Improve water quality, maintain natural hydrological regime, and increase flood protection by preserving important floodplain areas.
2. Restore, maintain, and protect native natural communities and diversity.
3. Provide opportunities for recreation where compatible with the above listed goals.

ENVIRONMENTAL SETTING

Estuarine Geomorphology

The GTMNERR's coastal estuaries are bounded to the west by the Pamlico Terrace (Figure 3), which has an elevation of 1.5 to 7.5 meters above sea level. The topography present today was formed over the last 10,000 years and is composed of remnant beach and dune ridges, swamps, marshes, tidal flats, creeks, rivers, and estuarine lagoon bottoms. The elevation within the GTMNERR ranges from sea level to 12 meters on the dunes at the north end of the Reserve and in the central regions of the Pellicer Creek Conservation Area.

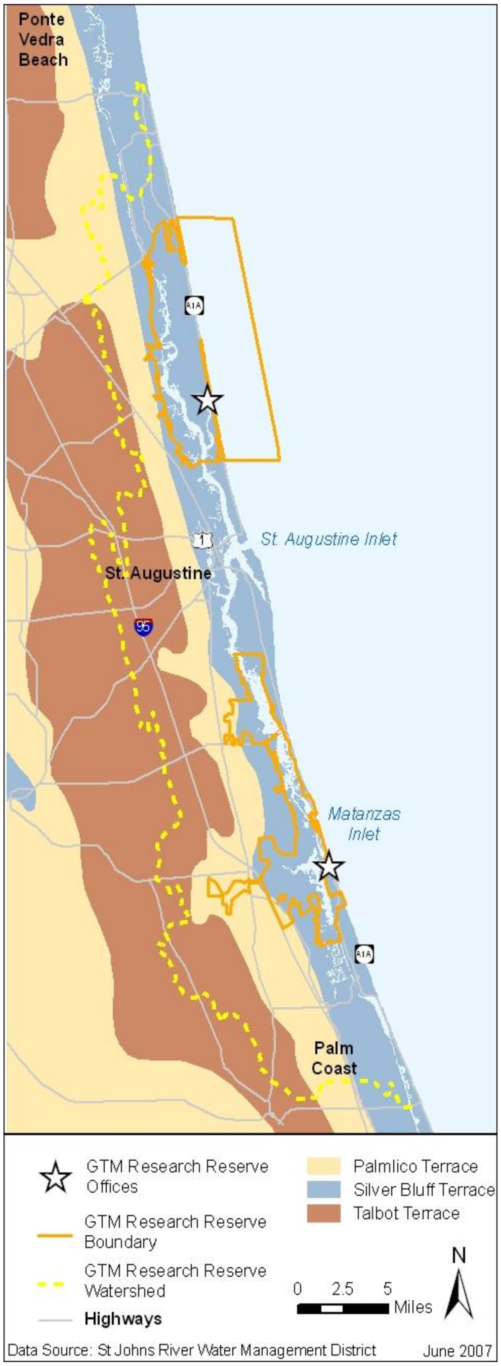


Figure 3. Estuarine geomorphology of the GTMNERR.

The GTMNERR is located in the lower part of the Atlantic Coastal Plain. The coastal region occupies a physiographic division known as the Coastal Lowlands. This region of the Florida Plateau is described by Cooke (1945) as a belt of land along the coast, extending 48 to 96 kilometers inland, that is flat, poorly drained, and characterized by ancient marine terraces and dune ridges.

In St. Johns and Flagler counties, thick limestone beds of the Eocene age underly the area at depths ranging from sea level to more than 90 meters below sea level. Miocene or Pliocene deposits directly overlie the Eocene limestone formations. The surface area is blanketed by Pleistocene and Recent deposits in varying depths.

There are seven or possibly eight marine terraces, each formed at different sea levels during the Pleistocene epoch (White 1970). These terraces were formed prehistorically by waves, currents, and the rise and fall of sea levels. When the sea level remained stationary for long periods, the waves and currents would erode the sea floor to form a fairly level surface. Each time the sea level dropped, a part of the sea floor was exposed as a level plain or terrace. The terraces tend to be parallel to the present Atlantic shoreline and become progressively higher from east to west (Kojima andHunt 1980). Over time the level plains of the terraces were modified or destroyed by stream erosion.

The GTMNERR overlies typical Floridian coastal geologic strata. The ground is covered with Holocene epoch sediments (< 10,000 years old) including sand, clay and shell fragments. Older limestone from the Anastasia formation is exposed on the southern beach in the GRMAP (east of Sombrero Creek). These rocks date from the Pleistocene epoch, which occurred from 1.8 million years ago (MYA) to 10,000 years ago (Florida Geological Survey [FGS] Lithologic Database).

Beneath these surface sediments lies the Hawthorn group (Miocene epoch, 24-5.3 MYA). The Hawthorn group is made up of clays and dolomite, and acts as a semi-confining layer atop the Floridan Aquifer. The Hawthorn group is thickest under the GRMAP ranging in depth from 39 to 90 meters. It is thinner to the south, where it ranges in depth from 33 to 41 meters under the southern portion of the Reserve (FGS Lithologic Database).

There are a total of 42 soil types occurring within the boundaries of the GTMNERR. The varying depth of the water table within the soils at the GTMNERR limits the land use abilities. While the region is relatively flat, the soils types are influenced by surface water flow, waves, currents and tidal forces. Relief is not pronounced, yet a few feet can mean the difference between dry, habitable, cultivable land and freshwater swamp or coastal marsh.

The soils of the uplands within the GTMNERR are primarily derived from sandy marine sediments. There are five general soil map units outlined by the Soil Conservation Service (SCS). The sand ridges, coastal dunes and flatwoods areas of the Guana peninsula consist of the Astatula-Tavares soils. These soils are nearly level to sloping, excessively drained and moderately well-drained soils that are sandy throughout. They are located throughout the hammock-sand ridge and flatwoods areas west of Guana Lake and extend to the estuarine marshes.

The Holopaw-Riviera-Pompano soils are represented in a small area along the north GRWMA boundary west of Guana Lake. They are nearly level and poorly drained; some types are sandy to a depth of 20 to 40 inches or more and loamy below, while others are sandy throughout. They provide fair conditions for growth of grasses, legumes, herbaceous plants, hardwoods and pines.

The coastal dunes along State Road A1A are made up of the Fripp-Satellite-Paola map unit. This unit consists of soils on narrow, rolling sandy ridges interspersed with narrow swales. These soils are excessively drained sandy soils in the primary and secondary dunes and somewhat poorly drained in the swales.

The Riviera-Holopaw-Winder association is found on a small portion of the GRWMA area in the northwest section of the property. These soils are nearly level and poorly drained; some are sandy to a depth of 20 to 40 inches or more and loamy below, while others are sandy to a depth of fewer than 20 inches and loamy below. They are considered "fair" producers of open land, woodland and wetland wildlife habitat, and migratory bird species utilize these areas extensively.

The Pellicer-Tisonia soils are derived from the deposition of estuarine clay sediment and organic detritus, and are found along the boundary of the Tolomato River, the Intracoastal Waterway (IWW) (estuarine tidal marshes), and within the area of the Pellicer Creek Aquatic Preserve. They are nearly level, very poorly drained soils subject to frequent tidal flooding; some are loamy, while others are organic, underlain by clays. These soils are rated as fair producers of wetland wildlife habitat. Resident and migratory bird species utilize these wetlands extensively.

The Reserve's beaches consist of quartz sand, shells, shell fragments, and pebbles derived from exposures of the Anastasia Formation (Tanner 1960). This formation consists of a sandy coquina held together by calcareous cement, and obtained its name from Anastasia Island opposite St. Augustine (Cooke 1945). In the area of the Matanzas Inlet beaches, samples also yielded quartz sand and shell. Offshore samples yielded fine grained sediments (0.055 – 0.516 mm mean diameter), with fine to very coarse sediments on the barrier island, and clay and silt in the lagoon areas (Burnson 1972).

In the upland areas surrounding the Pellicer Creek Aquatic Preserve, sandy soil types are represented in the sand ridge, coastal dune and flatwoods communities. More information on soil types in the Reserve can be found on the USDA Web site at *http://websoilsurvey.nrcs.usda.gov/app/*.

Climate and Weather

The climate of the northeast Florida coastal region is under a pronounced maritime influence (NOAA 1982). The heat of summer and cold of winter are moderated by the close proximity of the Gulf Stream. As a result, this area experiences a humid, subtropical marine climate characterized by long, warm, humid summers with heavy rainfall and mild, dry winters.

Specifically, the annual average minimum and maximum temperatures range from 58 to 81^{o} Fahrenheit (F), respectively. The mean annual temperature is about 70^{o}F near the coast and about 72^{o}F inland. Temperatures are moderated by close proximity to the ocean. Summer afternoon temperatures regularly reach 90°F or higher and nighttime temperatures drop to the low 70s. Average winter temperatures range from morning lows in the 30s to afternoon highs in the 70s. Relative humidity ranges from 40 to 50% in the afternoon to 90 or 95% in the early morning.

The average annual rainfall is about 55 inches, of which 50-60% occurs from June through mid-October as afternoon and evening thundershowers. Ocean breezes tend to retard the movement of rainstorms moving west to east, so the amount of rain falling directly on the coast is less than in the interior regions (Jones and Mehta 1978).

Prevailing winds are easterly, but northwest or southwest winds are common. Summer westerly winds can last for several days, particularly during the early morning hours. Storm events at GTMNERR include thunderstorms, northeasters, tropical storms, and hurricanes. Information collected by Taylor Engineering (2008) showed that on average, northeasters affect the area about five times per year, and tropical storms/hurricanes pass the area about once every three years. With the exception of the September 9, 1964 landfall of category 2 Hurricane Dora in St. Augustine, the areas now comprising the GTMNERR have not experienced a hurricane's eye wall landfall (Winsberg 2003).

During Hurricane Dora surge elevations approached 12 ft. above mean sea level and wave heights reached 20-30 ft along Anastasia Island.In 2001, Tropical Storm Gabrielle moved east across the Florida peninsula exiting just to the south of the Reserve. While maximum winds of only 59 mph were recorded, nearly 12 inches of rain caused localized flooding and a short-term decrease in salinity throughout the Reserve estuaries.

In 2004, St. Johns County experienced three tropical storms (Charley, Frances and Jeanne), all of which were hurricanes but that had slowed to tropical storms by the time they hit the county. The result was extensive shoreline erosion on the coast that essentially eliminated the sand that had previously been deposited as part of a beach renourishment project in the St. Augustine Beach area.

Hydrology

The GTMNERR is located in the Upper East Coast Drainage Basin (part of the Florida East Coast Basin) which covers 467,196 acres. The basin has been further divided into four "planning units", which can be an individual, usually large tributary basin, or a group of small adjacent primary tributary basins with similar characteristics. The Reserve covers three of these planning units, from north to south: Tolomato River, Matanzas River and Pellicer Creek. The fourth planning unit, the Halifax River is south of the GTMNERR boundary.

The natural hydrodynamics of this system have been altered by various water control structures, including dikes, inland wells, drainage ditches and a dam placed across the headwaters of the Guana River Estuary (Figrue 4). The Guana Dam was built in 1957, along with other smaller dams and canals in an attempt to improve hunting and fishing. The system has been further altered by the IWW which bisects the estuary.

The Tolomato, Guana and Matanzas River estuaries form a system of "bar-bounded" estuaries that extend from northern St. Johns County to below Marineland in Flagler County, behind the barrier island system. The Guana River estuary runs parallel to that of the Tolomato River estuary on the seaward side, with the two lagoons joining together six miles north of the St. Augustine Inlet. Oceanic exchange occurs through the St. Augustine Inlet.

The Matanzas River estuary stretches approximately 21 miles southward from the St. Augustine Inlet, with its southernmost section located about seven miles south of the Matanzas Inlet. Moses Creek and Pellicer Creek are the major contributors of freshwater drainage to the Matanzas River in the southern component of the Reserve.

<u>Northern Components</u>

The Tolomato River basin has a drainage area encompassing 84 square miles. The River is a component of the IWW and hence maintained, in part, as a public navigation channel. Dredging has straightened the course of the river at some points and established spoil islands which are now partially or entirely vegetated. Smith Creek, Deep Creek, Sweetwater Creek, Marshall Creek, Stokes Creek, and Casa Cola Creek all drain into the Tolomato River from the west. These six creeks are included in the Reserve boundaries upstream to the extent of tidal influence. Capo Creek, Jones Creek, and Sombrero Creek flow west into the Tolomato River and are entirely within the Reserve boundaries. Smith, Deep, and Sweetwater Creeks drain a large wetland area to the west of the Reserve known as Cabbage Swamp.

Figure 4. Hydrologic features of the northern and southern components of the GTMNERR.

The headwaters of the Guana River originate in the Diego Plains drainage basin north of the Reserve in the city of Ponte Vedra Beach. The Diego Plains drainage basin encompasses approximately 7,800 acres extending from the Lake Ponte Vedra (Guana Lake) dam 17 miles north into Jacksonville Beach. The natural hydrology of the Guana River was significantly altered by the construction of the dam in 1957. Inland wells, water control structures, dikes, and drainage ditches have also altered the natural hydrology of the system. From the dam the river flows south to join the Tolomato River.

Southern Components

Moses Creek and the Matanzas River support extensive undisturbed areas of tidal marsh. Moses Creek drains a large area of wet flatwoods and swamps in western St. Johns County. As the creek forms, it flows east and enters the Moses Creek Conservation Area in the northwestern portion of the property. The creek continues southwest, eventually emptying into the Matanzas River. Moses Creek lies within the Matanzas River Basin, a sub-basin of the Northern Coastal Basin (NCB).

The majority of the watershed in the Pellicer Creek basin is drained by relatively small creeks or branches. The Hulett Branch, Pringle Branch, Stevens Branch, Dave Branch, and Schoolhouse Branch all drain into the PCAP from the west. Styles Creek flows from the south into Pellicer Creek, near the Matanzas River. To the north, Rootan Branch flows southward through Faver-Dykes State Park and drains into Pellicer Creek (DNR 1991). The SJRWMD is responsible for surface and groundwater resources in the watershed of this aquatic preserve as well as adjacent drainage basins.

Pellicer Creek is the only natural drainage feature in the general area that cuts through the marine terraces and ridges to flow east into the Matanzas River. From the Matanzas River lagoonal area the flow of water eventually empties into the Atlantic Ocean by way of the Matanzas Inlet.

Surface water hydrology in this area is influenced by the interaction of the brackish water of the Matanzas River with the freshwater inputs from both tidal branches, and overland flow (DNR 1991)

Physical Processes

St. Augustine Inlet

The shallow estuaries of the Reserve are connected to the Atlantic Ocean by the St. Augustine and Matanzas Inlets that collectively form a barrier island estuarine system. Both inlets are the focal points for oceanic exchange with the estuarine ecosystem. St. Augustine Inlet is an improved tidal inlet connecting the Tolomato and Matanzas Rivers to the Atlantic Ocean. Originally a natural inlet located approximately 120 meters south of its current location; the inlet channel was relocated in 1940 as part of the federal St. Augustine Harbor Navigation Project in response to public interests. Efforts to stabilize the inlet and improve navigation, between 1941 and 1957, resulted in the construction of a north jetty structure approximately 1,880 feet(573 meters) in length and a 3,695 foot (1126 meter) southern structure. The inlet channel and associated structures are maintained by the U. S. Army Corps of Engineers (USACE), as well as the authorized 16 foot (4.8 meter) entrance channel which is maintained at the best natural alignment requiring infrequent dredging. USACE and others have prepared numerous surveys, reports and documents related to the inlet area, including USACE (1965, 1975, 1976, 1998, and 2004a), Taylor Engineering (1989, 1992) and Taylor and McFeteridge (1991). Maintenance dredged material from the navigation channel has typically been disposed of offshore, however, a 1996 dredging event resulted in the placement of suitable material on the downdrift beaches located south of the inlet (Srivinas et al. 1997).

Beginning in 1993, Taylor Engineering of Jacksonville initiated a study to develop a St. Augustine Inlet Management Plan. Part one of the study consisted of an in-depth literature search to identify information relevant to plan development. The resulting document (Abramian et al. 1994) presents information sources on morphologic, hydraulic, and coastal conditions in the inlet and adjacent areas; the influence of the inlet and nearby structures on the adjacent beaches and navigation; characteristics of weather and sea conditions at the inlet; and natural resources at the inlet and adjacent areas. The second part of the study consisted of a comprehensive delineation of inlet physical characteristics. The study provided both an historical bathymetric analysis as well as modeling of inlet hydraulics (Srinivas et al. 1996) from which the final management plan (Srivinas et al. 1997) was developed.

While barrier island estuarine systems like that associated with the Reserve are common along the East and Gulf coasts of Florida, there are very few observational studies of their hydrodynamic properties. Webb et al. (2007) observed hydrography and current velocity at a tidally driven coastline trifurcation, adjacent to the St. Augustine Inlet, over nearly a semidiurnal period on February 2, 2006. The results of the study showed that mean inflow occurs through the central deep channel and mean outflow over the shoals.

Matanzas Inlet

Matanzas Inlet is one of only two unimproved inlets on the east coast of Florida. It is characterized by a significant offshore bar that is transitory in nature, and the presence of appreciable inner shoals (Mehta and Jones 1977). There have historically been tidal channels and shoals at the mouth of the Matanzas Inlet through which there is considerable sediment transport (Gallivan and Davis 1981). The creation of the IWW has changed the dynamics of sediment transport such that reductions in current velocity at the junction of the Matanzas River and the Matanzas Inlet north of Rattlesnake Island cause suspended sediments to settle, necessitating the frequent dredging and removal of spoil to maintain IWW navigational depths. A variety of studies of dynamic processes, sediment transport, and littoral drift of the Matanzas Inlet area have been conducted, including those by Davis and Fox (1980, 1981), Marion and Mehta (1986), Mehta and Shepard (1979), and Gallivan (1979).

Shoreline Erosion

Shoreline erosion and concomitant loss of shoreline habitat is occurring at relatively high rates in many places along the margin of the IWW which runs through the Reserve (Price 2006). GIS analysis of aerial photographs showed essential habitats including oyster bars and salt marshes reduced to intertidal sand flats. Exposure to boat wakes was found to be the causal factor most strongly correlated with the rate of lateral margin movement. Margin movement rates were also found to vary significantly with exposure to wind waves and with the type of channel margin eroded. A reduction in nearshore wave energy appears to be necessary to allow the recovery of impacted ecosystems.

In 2006, GTMNERR completed a shoreline stabilization and restoration project of 300 meters of eroding shoreline on the Guana River adjacent to the Environmental Education Center. Shoreline erosion continues to be a problem in other areas of the GTMNERR, and represents a threat to resources at several locations. Most significantly, shoreline erosion along the eastern shore of the Tolomato River is undermining natural and cultural resources on the western bank of the Guana Peninsula. This shoreline includes 2 significant known archeological sites at Wrights' Landing and Shell Bluff Landing. Rising sea levels and wakes from recreational boat traffic appear to be the primary factors contributing to this erosion. Any stabilization efforts on this shore will be challenging to implement in an environmentally sensitive manner, due to the high wave energy created by boat wakes.

The Summerhaven area south of the Matanzas Inlet has been the site of increased beach erosion as well as actual breaches of the dune system and destruction of paved roadway. The resulting overwash fans have isolated the properties of a number of homeowners in the area.The USACE has deposited material obtained from maintenance dredging of the IWW channel at Matanzas Inlet along this stretch which has the secondary benefit of helping to stabilize the beach (USACE 2004b).

Modeling Efforts

Multiple modeling efforts have been undertaken or are ongoing within the Reserve to evaluate circulation, flushing, water quality conditions, and ecosystem health to meet water quality and habitat protection goals. To meet the data needs for these modeling efforts, SJRWMD completed a bathymetric survey to obtain bottom topography of NCB waterways (SJRWMD 2004a), which included the bathymetry of the Reserve. The project was conducted between 1999 and 2001 with bathymetric transects primarily spaced at 500 or 1000 foot intervals, and depth data obtained at approximately 66 foot intervals along each track line. The survey included both lateral and longitudinal depth transects.

These bathymetric data were used by Camp, Dresser & McKee (CDM) to prepare a two-dimensional finite-difference, curvilinear orthogonal numerical grid model for tidal waters in the NCB (CDM/DHI 2002). This grid is the basis for an ongoing project to estimate land surface runoff and non-point source pollution loading into the IWW and Tolomato-Matanzas estuary using an HSPF (Hydrological Simulation Program FORTRAN) watershed model. The watershed model runs will generate time series of runoff, sediment, and nutrient loads to be used as inputs to the NCB hydrodynamic/water quality model, and hence assist in the determination of the Pollution Load Reduction Goals (PLRGs) and Total Maximum Daily Load (TMDL) criterion (Mao et al. 2007). By coupling the model information with a GIS land use database, the effects of the change of the land use among historical, current and future build-out conditions can be assessed.

GTMNERR has a large coverage (~15 km^2) of tidal flats and tidal marshes which are generally within the tidal range. A study by Tutak and Sheng (2008) used the 3-D hydrodynamic model, CH3D, with non-flooding/drying and flooding/drying versions, to quantify the effects of tidal marshes and tidal flats on the hydrodynamics of the estuarine system. Simulated flow rates at the Matanzas and St. Augustine Inlets were compared with observed data collected using an ADCP for a 12 hour period.

The study showed that using a numerical model capable of flooding/drying improved the tidal simulations for stations located in regions with larger marsh coverage or shallower channels. The simulations of total flow rates through the inlets were also improved. Future work will investigate the overland flow through tidal marshes by using an enhanced vegetation model which incorporates friction introduced by submerged and emerged vegetation. The model may also be useful for studying the effects of tidal marshes and tidal flats on the water level, currents and salinity during extreme events (e.g. hurricanes). The three-dimensional modeling approach can also be used to provide guidance on the development of sampling strategies for biogeochemical studies in the Reserve (Sheng et al. 2008).

Finally, Powell et al. (2006) used the closure of a land barrier breach at Matanzas Inlet as a case study to illustrate the application of morphodynamic relationships between prism, inlet throat area, and sand transport associated with ebb delta volume.

Land Use

The populations of St. Johns County and the adjacent Duval, Flagler, Putnam, and Volusia Counties have grown an average of 23 % between 2000 and 2006 (US Bureau of the Census 2008) and are projected to grow an additional 20 % by 2010 (BEBR, University of Florida 2002). The St. Johns County resident population increased by more than 66% between 2000 and 2006, representing one of the highest growth rates in Florida for that time period. More than 1,660,000 people reside within 50 miles of the Reserve, which includes the cities of Jacksonville, St. Augustine, Palatka, Daytona and New Smyrna (US Bureau of the Census 2008).

Surrounding land use as of 2004 for the watershed of the northern portion of the Reserve is dominated by forest and wetland cover classifications with a continuing increase in urban development from previous land use classifications. The following comprised the watershed land use classifications compiled by the SJRWMD in 2004: forests covered 33.5%, wetlands 47.4%, urban development 19.6%, water 16.1%, agriculture 9.7%, upland non-forested 5.3%, and transportation/communication/utilities 2.0%. Since 2004 several developments of regional impact have begun within the watershed. The town of Nocatee adjoins the Reserve's northwestern boundary along the Tolomato River. Nocatee has a 25-year projected build out totaling 30,000 to 35,000 people and 14,200 homes. Future analyses will reflect the changes in land use, further shifting the forest and agriculture classifications to more urban development.

Within the southern component of the Reserve, the Pellicer Creek planning unit is dominated by forestland (55%), and wetlands (35%), according to SRJWMD land use estimates from 2000. Pellicer Creek itself has been maintained as an aquatic preserve and has been left largely undisturbed. However, there is commercial and residential development to the north and south of the creek. Based on current growth, and the future land use plan for Pellicer Creek, residential developments could potentially increase to 22% of the total area. Most of the western portions of the unit remain under silvicultural use.

Water Use

Potable water can be obtained from either the Floridan Aquifer or from surficial aquifers. These aquifers are primarily shallow lenses of fresh water floating on saline water in near-surface sand

and shell sediments. There is a deeper lens of fresh water (chloride ≤ 250 milligrams per liter [mg/l]) in the surficial sediments of the Guana peninsula, and a shallower lens below the beach dunes. In addition, water flows freely from deep artesian wells at several locations throughout the GTMNERR. The artesian discharge has an average chloride concentration of 120 mg/l.

In the GTMNERR, the depth of the top of the Floridan Aquifer is shallowest in the south (175 ft.(53 meters), PCAP) and gradually deepens towards the north (350 ft. (107 meters), GRMAP) (Scott and Hajishafie 1980). The aquifer has a thickness of approximately 2,000 feet (610 meters) throughout the GTMNERR (Miller 1986). There is a submarine spring off the coast of Crescent Beach that originates from this aquifer (Kinnaman 2006). Groundwater along the coast is subject to a low to high degree of lateral salt intrusion. Barrier island ground water supplies are severely limited in St. Johns County, and increased use is likely to increase salinity intrusion into the shallow aquifer during the next twenty years.

Total fresh groundwater use for St. Johns County and the surrounding counties increased by 23% between 2000 and 2006 (Table 1) and is projected to increase as development in the area expands. This water consumption includes ground, surface water, and reuse water that is used for domestic, commercial and agricultural purposes. The water supply planning program of the SJRWMD addresses future water demands, traditional and alternative water sources, and water supply infrastructure improvements required to meet future water supply needs without causing harm to water resources or water dependent natural systems.

Table 1. Total fresh groundwater use, and change in water use by County for 2000 and 2006 in million gallons per day (mgd)

County	2000 Total Water Use (mgd)*	2006 Total Water Use (mgd)**	Change in Water Use (%)
Duval	154.33	180.19	14%
Flagler	24.55	29.11	16%
Putnam	40.35	63.80	37%
St. Johns	52.55	59.81	12%
Volusia	97.16	106.56	9%
Total	368.94	479.01	23%

*SJRWMD (2004b)
**SJRWMD (2007)

Water Quality

Water quality research and monitoring is conducted in the Reserve on a national level by Reserve scientists and on a state and regional level by FDEP, FDACS, and SJRWMD to facilitate the sustainable protection of water quality.

<u>System-wide Monitoring Program</u>

The GTMNERR participates in the NERR System-wide Monitoring Program (SWMP), established in 1995 to track short-term variability and long-term changes in estuarine environments within the NERR system. The GTMNERR program has three main elements: water quality, weather and nutrient/chlorophyll analyses. The water quality component is comprised of four water quality monitoring stations (listed in Appendix B) at which YSI 6600

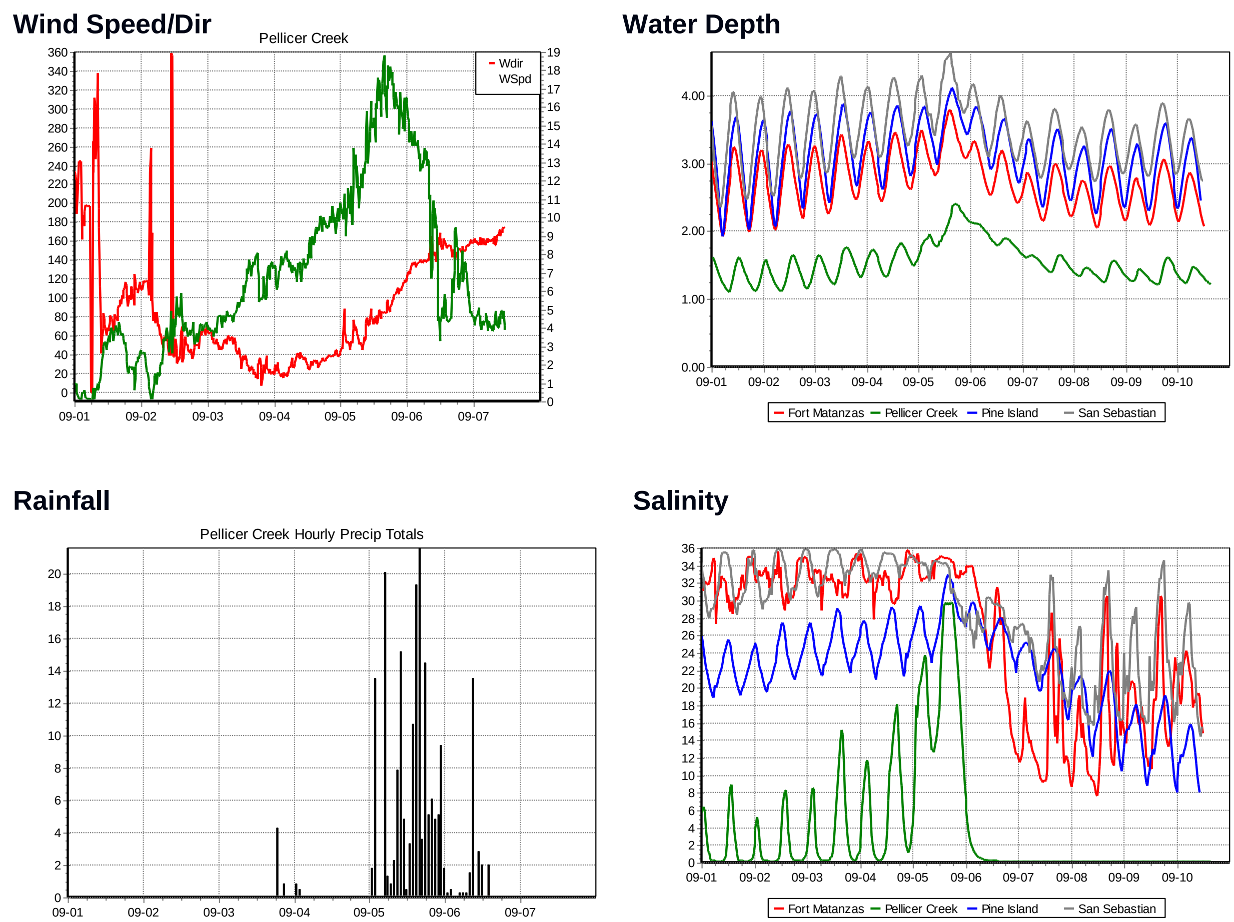
EDS datasondes are deployed. Measures of the water temperature, conductivity/salinity, dissolved oxygen, turbidity, water level, and pH are collected at 15 minute intervals (30 minute intervals prior to 2007). The weather component consists of a weather station located at the mouth of Pellicer Creek from which measures of temperature, relative humidity, atmospheric pressure, rainfall, wind speed and direction, and photosynthetically active radiation (PAR) are collected at 15 minute intervals. Both the weather station and the water quality station at Pellicer Creek have satellite telemetry which provides near real-time data availability. The third SWMP element involves nutrient/chlorophyll analysis of water samples collected monthly at each of the four water quality stations, in addition to a diel sampling regime carried out once a month at the Pellicer Creek site. Water samples collected at each site are analyzed for nitrite, nitrate, ammonium, total nitrogen, total soluble nitrogen, orthophosphate, total phosphorus, total soluble phosphorous, silica, particulate organic carbon, total suspended solids, chlorophyll a, phaeophytin and color.

All SWMP data is housed and served through the NERRS Centralized Data Management Office (CDMO), which provides quality assurance and quality control for the Reserve system. The CDMO is also responsible for maintaining and updating the NERRS standard operating procedures so that all SWMP data are collected in the same way across the nation. Archived and near-real time water quality, weather, and nutrient/chlorophyll data may be accessed directly via an interactive map at: *http://cdmo.baruch.sc.edu/QueryPages/googlemap.cfm*.

SWMP is a backbone component of the Integrated Ocean Observing System (IOOS), a nation-wide organization of ocean and coastal observations, data streams, data management and analysis. The IOOS goal is to bring together these elements from all sources - federal, state, and local - to create synergy across programs. The ultimate purpose is to improve understanding and management of our coastal waters.

Examples of SWMP data generated at each of the water quality stations and from the weather station during the passing of Tropical Storm Frances are illustrated in Figure 5 (from Brucker and Gleeson 2006). Rainfall amounts are shown to increase together with wind speed as the storm approached, followed by a decrease in these parameters as the storm center passed to the southwest of the Reserve. From the sonde data, details of the storm surge generated by the strong northeast winds of the tropical system are reflected in both the increased depth profiles and salinity increases, particularly at the Pellicer Creek station. Passage of the storm is followed by dramatic decreases in salinity at all stations resulting from the heavy rainfall.

Figure 5. Time series of wind speed/direction and rainfall for the Pellicer Creek weather station together with water depth and salinity time series for the Fort Matanzas, Pellicer Creek, Pine Island and San Sebastian water quality stations during the passing of Tropical Storm Frances in 2004.



Close proximity of the weather station and Pellicer Creek water quality station enabled Dix et al. (2008) to document the effects of extreme wind and rainfall conditions associated with tropical storms on physiochemical variability in Pellicer Creek. The passing of four tropical systems in 2004 suppressed tidally induced salinity variations. Strong northeasterly winds associated with the storm events initially prompted salinity spikes, but rainfall over the course of each event ultimately caused strong declines in salinity for extended periods of time. Nitrogen concentrations in Pellicer Creek were significantly elevated following storm events. Since primary production in many coastal environments is nitrogen limited, increases in nitrogen input represent a potential for enhanced algal production and biomass.

Phlips et al. (2004) compared data from the four GTMNERR SWMP water quality sites from May 2002 through August 2003, to four sites in the Indian River Lagoon (IRL) to assess regional differences in physical and chemical characteristics, and phytoplankton abundance. These sites were chosen because they both include estuaries with water residence times ranging from days to months and watersheds with widely differing nutrient load characteristics. The results of the study suggest that spatial and temporal trends in phytoplankton standing crop in much of the GTMNERR and IRL are closely tied to water exchange characteristics and the nutrient-limiting status of the community.

<u>FDEP Surface Water Ambient Monitoring Program (SWAMP)</u>

The SWAMP effort is an interagency collaborative effort that is FDEP’s primary surface water quality monitoring program and central repository for surface water quality data. The intent of the program is to screen water bodies to provide a broad assessment of water quality. Information generated from this program is used to develop total maximum daily loads (TMDLs), identify water bodies for more detailed studies, and potentially identify water bodies for restoration and rehabilitation. Sample locations within proximity of the Reserve are listed in Appendix B.

SWAMP is part of the state’s Integrated Water Resource Monitoring Network (IWRMN). Within this network, the FDEP Ambient Monitoring Program samples freshwater lakes, streams and groundwater and estuaries, although the Inshore Marine Monitoring and Assessment Program (IMAP) discussed below, sampled estuaries between 2000 and 2004.

Data collected through this program are entered into the STORage and RETrieval database (STORET), the central repository for biological, chemical, and physical data for ground and surface waters. The STORET Web site at *http://storet.dep.state.fl.us/WrmSpa/* allows a variety of data.

<u>FWC IMAP</u>

IMAP was a collaborative project between EPA and the FWC Florida Marine Research Institute (FMRI) designed to assess the ecological condition of Florida’s inshore waters using a set of ecological indicators. The indicators chosen for IMAP were divided into two broad categories: physical/chemical and biological.

Physical/chemical indicators chosen for IMAP included the traditional water quality measurements such as temperature, salinity, dissolved oxygen, and pH, in addition to nutrients and chlorophyll *a*. IMAP biological indicators integrate environmental stressors over larger spatial and temporal scales. Fish, crabs and shrimp were sampled with trawls and seines; seagrass community composition (where present) were assessed; and benthic macroinvertebrates were sampled to determine community composition and the occurrence of pollution tolerant or intolerant species. Summary reports of the IMAP program can be found at the Florida Fish and Wildlife Research Institute (FWRI) Web site at *http://research.myfwc.com/features/category_sub.asp?id=3448*. Sample locations are listed in Appendix B.

Florida Department of Agriculture and Consumer Services (FDACS) Division of Aquaculture

The FDACS Division of Aquaculture is responsible for the regulation of aquaculture facilities and the opening or closing of shellfish harvesting waters to protect human health. The Division also ensures the continued productivity of oyster reefs through a restoration program and issues leases of submerged state lands for aquaculture.

The Shellfish Environmental Assessment Section (SEAS) of FDACS monitors water quality in the two conditionally approved shellfish areas within the Reserve boundaries on a quarterly basis to ensure that bacteria levels are safe for shellfish consumption. A conditionally approved area must meet fecal coliform water quality standards and the area must be a sufficient distance from pollution sources for shellfish to be wholesome while the area is open for harvesting.

A management plan developed for these areas uses local rainfall and/or river discharge to predict when the levels of fecal coliform bacteria in the water are unacceptably high. When the rainfall level and/or river level of the management plan is exceeded, the area will be temporarily closed to shellfish until water quality sample results demonstrate that the levels of bacteria have returned to safe levels for shellfishing to resume. Data is collected by the Division (locations listed in Appendix B) and is transmitted to the FDEP for inclusion in the STORET database.

SJRWMD Surface Water Quality Monitoring (SWQM) Program

SJRWMD monitors water quality from 5 primary stations (listed in Appendix B) located either within, or directly adjacent to the GTMNERR. Data on 25 different constituents are derived from samples collected on at least a monthly basis and can be accessed at *http://sjrwmd.com/archydro/factPages*. Using GIS mapping technology, these measurements are evaluated in the context of population density, geology, rainfall, and aquifer recharge. SJRWMD produces a general water quality synopsis from this collected data (SJRWMD 2008) from which the following descriptions are derived.

The northernmost sampling site is located on the Tolomato River, just north of Pine Island in northeastern St. Johns County. When compared to other estuarine sites, conductivity and major ion concentrations are elevated, resulting in very hard water. The median dissolved oxygen concentration is above the FDEP standard for Class 3 surface waters. The water is well-buffered and slightly alkaline. Total organic carbon concentrations are lower than generally found. Total suspended solids and turbidity are both elevated. Total nitrogen and chlorophyll concentrations are lower than in other estuarine areas.

A second station is located at SR312 and the Matanzas River, and is sampled monthly. When compared to other estuarine sites, conductivity is high with correspondingly high major ion concentrations, resulting in very hard water. The median dissolved oxygen concentration is well above the FDEP standard for Class 3 surface waters. The water is well-buffered and slightly alkaline. Concentrations of total organic carbon, color, total nitrogen, chlorophyll, and coliform counts are lower than those found in other estuarine systems.

Moultrie Creek is located in eastern St. Johns County and drains Cowan Swamp to the Matanzas River. The creek is sampled monthly at the SR 207 bridge. Major ion concentrations are high enough to result in moderately hard water. The median dissolved oxygen concentration is just above the FDEP standard for Class 3 surface waters. The water is moderately buffered and slightly acidic. When compared to other streams, total organic carbon concentrations and color are elevated, resulting in lower Secchi depth. Total suspended solids, turbidity, total phosphorus, and chlorophyll concentrations are lower than average.

Pellicer Creek drains Fish Swamp and Pringle Swamp to the Matanzas River. The Pellicer Creek Station is sampled every other month, at U.S. Highway 1. Major ion concentrations vary, but result in moderately hard water. The median dissolved oxygen concentration is below the FDEP standard for Class 3 surface waters. The water is moderately buffered and slightly acidic. When compared to other stream sites, total organic carbon, total phosphorus and total suspended solids concentrations are similar, although color is elevated, and Secchi depth is lower. Estimates of chlorophyll concentration were less than in other areas.

The southernmost SJRWMD station is on the Matanzas River south of Washington Oaks State Park. When compared to other estuarine sites, conductivity and major ion concentrations are high, resulting in very hard water. The median dissolved oxygen concentration is well above the FDEP standard for Class 3 surface waters. The water is well-buffered and slightly alkaline. Color, Secchi depth, and total phosphorus concentrations are typical for estuarine sites, while total organic carbon, total nitrogen, and chlorophyll concentrations are lower than typically found. Total suspended solids and turbidity concentrations are elevated.

A 15-year trend analysis (1990-2004) from these four stations showed total nitrogen, total suspended solids and Chl *a* concentrations to be stable (Ceric et al. 2007).

Pollution Impacts

Point Sources of Pollution

Point source dischargers within or adjacent to NERR waterbodies include domestic and industrial wastewater facilities that are regulated through the NPDES program. In October 2000, the U.S. Environmental Protection Agency (EPA) authorized FDEP to implement the National Pollutant Discharge Elimination System (NPDES) stormwater permitting program in the State of Florida (with the exception of Tribal lands). The program regulates point source discharges of stormwater runoff from urban as well as certain industrial facilities. The operators of regulated industrial facilities must obtain an NPDES stormwater permit and implement appropriate pollution prevention techniques to reduce contamination of stormwater runoff.

There are a number of domestic and industrial wastewater facilities adjacent to the GTMNERR with NPDES permits to discharge to surface waters. The volume of discharges to surface waters from these facilities compared to their permitted capacities varies, with some facilities discharging to surface water only during wet weather conditions and others discharging to surface waters exclusively. While water discharged from the facilities meets water quality standards, these pulses of freshwater themselves may affect the salinity regime in some areas of the GTMNERR.

Municipal Separate Storm Sewer Systems (MS4)
Designated large and medium municipal separate storm sewer systems, or MS4s, are a publicly-owned conveyance or system of conveyances (i.e., ditches, curbs, catch basins, underground pipes) that are designed for the discharge of stormwater to surface waters of the state. An MS4 can drain, and be operated by, municipalities, counties, drainage districts, colleges, military bases, or prisons, to name a few examples. These facilities were previously required by EPA to obtain NPDES permits prior to delegation to the state. In the State of Florida, Phase II permitting was completed in 2003, and the permitted program has been implemented. FDEP's authority to administer the NPDES program is set forth in Section 403.0885, Florida Statutes (*F.S.*). NPDES permit holders adjacent to the GTMNERR are listed in Table 2.

Table 2. Municipalities adjacent to the GTMNERR with MS4 NPDES permits.

Municipality	Permit Number	County
Flagler Beach	FLR04E102	Flagler
FDOT District 2 - St Augustine	FLR04E019	St. Johns
St Augustine	FLR04E101	St. Johns
St Augustine Beach	FLR04E109	St. Johns
St Johns County	FLR04E025	St. Johns

Non-point Sources of Pollution
Non-point sources (NPS) of pollution in the GTMNERR, unlike pollution from industrial and sewage treatment plants, come from many diffuse sources. NPS pollution occurs when rainfall or irrigation runs over land or through the ground, picks up pollutants throughout the watershed, and deposits them into rivers, lakes, and coastal waters or introduces them into ground water within the GTMNERR. NPS pollution is widespread because it can occur any time activities disturb the land or water.

Septic systems, also known as onsite sewage treatment and disposal systems (OSTDS) are prevalent in some areas of the GTMNERR and have been identified as a potential source of nutrients (nitrogen and phosphorus), pathogens and other pollutants that can pose a threat to public health. There are known septic tank problems in the Ponte Vedra area, and on Anastasia Island. In addition, urban runoff from streets and yards, construction, forestry, physical changes to stream channels, and habitat degradation are also potential sources of NPS pollution. Careless or uninformed household waste management also contributes to NPS pollution problems.

The large number of both resident and transient boats operating within the waters of the Reserve is another potential source of NPS pollution and was evaluated as a source of pollution by the Guana Tolomato Matanzas Shellfish and Water Quality Task Force (SJRWMD 1997). Numerous studies have revealed a positive correlation between recreational boat densities and the levels of coliform bacteria in the surrounding water (Rhode Island Sea Grant 1990). Despite a Florida law (327.53 *F.S.*) that generally requires most vessels over 26 feet (8 meters) to have a working toilet on board, there is little if any enforcement. A single overboard discharge of human waste can be detected in up to a one square mile area of shallow enclosed water, and contaminants known from human waste include hepatitis, streptococci, fecal coliform and other bacteria. Marine sanitation devices themselves may contain harmful chemicals in the disinfectants and deodorants that are used, and, if discharged overboard, can negatively impact water quality.

The streams, creeks, ditches and other conveyances within and adjacent to the Reserve transport the majority of agricultural runoff, carrying insecticides, fungicides and other pesticides into the estuary and coastal zone. Pyrethroid insecticides are of particular concern as they can be toxic to aquatic organisms in very small amounts and are used widely. In some cases these chemicals persist in the environment and have an affinity for the sediments of the estuary and are bioaccumulative.

SJRWMD is collaborating with Dr. Valerie Harwood at USF to determine if bacteria in estuarine waters have an anthropogenic component. Water samples from Deep Creek were obtained for analysis. Fecal coliform and *Enterococcus* concentrations are being determined for comparison with Class II water quality standards as well as analysis for two human specific markers, the *esp* gene on *Enterococcus faecium* and the human polyoma virus.

Nutrients and Contaminants

Under Section 303(d) of the Clean Water Act, each state must prepare a list of waters that are not of sufficient quality to meet their designated uses and to establish Total Maximum Daily Loads (TMDLs) for those waters on a prioritized schedule. These lists are required to be submitted to EPA for review and approval every April of even-numbered years; that is, every 2 years. A number of water bodies in the Reserve appear on the 303(d) list that will receive the highest priority for establishment of TMDLs for restoration and protection.

TMDLs establish the maximum amount of pollutants a water body can assimilate without exceeding water quality standards. The Florida Watershed Restoration Act, Chapter 99-223, Laws of Florida, addresses processes for refining the list and for calculating and allocating TMDLs. According to EPA guidelines, waters expected to attain and maintain applicable water quality standards through other Federal, State, or local requirements do not need to be included on the 303(d) list. (*www.dep.state.fl.us/water*). Portions of the GTMNERR are within Group 5 in FDEP’s Northeast District, in the Upper East Coast Basin. Individual waterbodies of waterbody segments are defined by Waterbody Identification (WBID) numbers, which are unique identifiers that offer a convenient, unambiguous method of referencing individual waterbodies within the state.

The status of each WBID that occurs on the Verified List in the GTMNERR is summarized in Table 3. The parameters assessed are those for which exceedances have been verified. This list is the first step in the process of restoring these impaired waters. Once these waters have been adopted by Secretarial Order and approved by EPA, FDEP staff will begin developing TMDLs according to the listed schedule. The final step in this process is the development, by watershed stakeholders and FDEP, of a Basin Management Action Plan (BMAP). The BMAP specifies the activities, schedule, and funding sources that point and nonpoint source dischargers will undertake to restore the water body. The GTMNERR is a stakeholder and will therefore participate in the development of the BMAP.

Table 3. 303(d) Waterbodies Status for the Northern Coastal Basin extracted from the FDEP Revised Draft Verified Lists of Impaired Waters for the Group 5 Basins current as of 9/21/2007*

Planning Unit/ Water Body Segment	Planning Unit	Water Body Identification Number (WBID)	Parameters Assessed	Projected Year for TMDL Development[2]	County
Tolomato/Matanzas					
Guana River	Tolomato River	2320	Coliform (Shellfish harvesting classification), Dissolved Oxygen, Fecal Coliform, Nutrients (Chla)	2012	St. Johns
Sombrero Creek	Tolomato River	2470	Fecal Coliform	2017	St. Johns
Ximanies Creek	Tolomato River	2477	Coliform (Shellfish harvesting classification)	2017	St. Johns
Lake Vedra (Guana Lake)	Tolomato River	2320A	Dissolved Oxygen	2012	St. Johns
Lake Vedra (Guana Lake)	Tolomato River	2320A	Nutrients (Chla)	2012	St. Johns
Tolomato River	Tolomato River	2363I	Arsenic, Coliform (Shellfish harvesting classification), Copper, Iron, Nickel	2017	St. Johns
Red House Branch	Matanzas River	2472	Fecal Coliform	2017	St. Johns
Moultrie Creek	Matanzas River	2493	Fecal Coliform	2017	St. Johns
Matanzas River	Matanzas River	2363G	Iron, Lead	2012	Flagler
Pellicer Creek					
Intracoastal Waterway (IWW)	Pellicer Creek	2363E	Arsenic, Iron	2012	Flagler
IWW	Pellicer Creek	2363F	Coliform (Shellfish harvesting classification)	2017	Flagler
Pellicer Creek	Pellicer Creek	2580B	Fecal Coliform	2011	Flagler

*Complete dataset can be viewed at *http://www.dep.state.fl.us/water/tmdl/verified_gp5R.htm.*

Mussel Watch

Since 1986, the NOAA Center for Coastal Monitoring and Assessment (CCMA) has operated the Mussel Watch Project, monitoring chemical contaminants in oysters and mussels and in sediments. The project analyzes chemical and biological contaminant trends in sediment and bivalve tissue collected at over 280 coastal sites from 1986 to present. Both coastal and estuarine sites are sampled for bivalves biennially and for sediments once every decade. Bivalve and sediment samples are collected from three stations at each site (stations are generally within 100 m of a site center). The concentrations of over 200 different analytes are measured from these samples. The database includes: sediment and bivalve tissue chemistry for over 100 organic and inorganic contaminants; bivalve histology; and *Clostridium perfringens* data.

The Mussel Watch Project determines concentrations of polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyl (PCB) congeners, several pesticides, butyltins, and certain toxic elements in sediment and bivalve samples from the coastal waters of the US. The data are used for determining the extent and temporal trends of chemical contamination on a nationwide basis and identifying which coastal areas are at greater risk in terms of environmental quality (O'Connor 2002; O'Connor and Lauenstein 2006). Data can be compared through rankings of individual constituents for both tissue and sediments based on region, state, or watershed, for individual years or all years combined.

Data trends can also be graphed by year for the selected site and analyte. For example, the trend in lead concentrations in tissue between the Matanzas River site and all other sites in Florida (Figure 6) shows that concentrations in the Matanzas River were lower than other sites in the state in 12 out of the 14 years that samples have been collected. Copper concentrations for all sites in Florida (Figure 7) were more than double those found at the Matanzas River site for the same 14 year sample period (1986-2005).

Figure 6. Trends Comparison of the Matanzas River Site (Selection A) vs All Sites in Florida (Selection B) for Lead (Pb) concentration (µg/dry g) in Oyster Tissue.

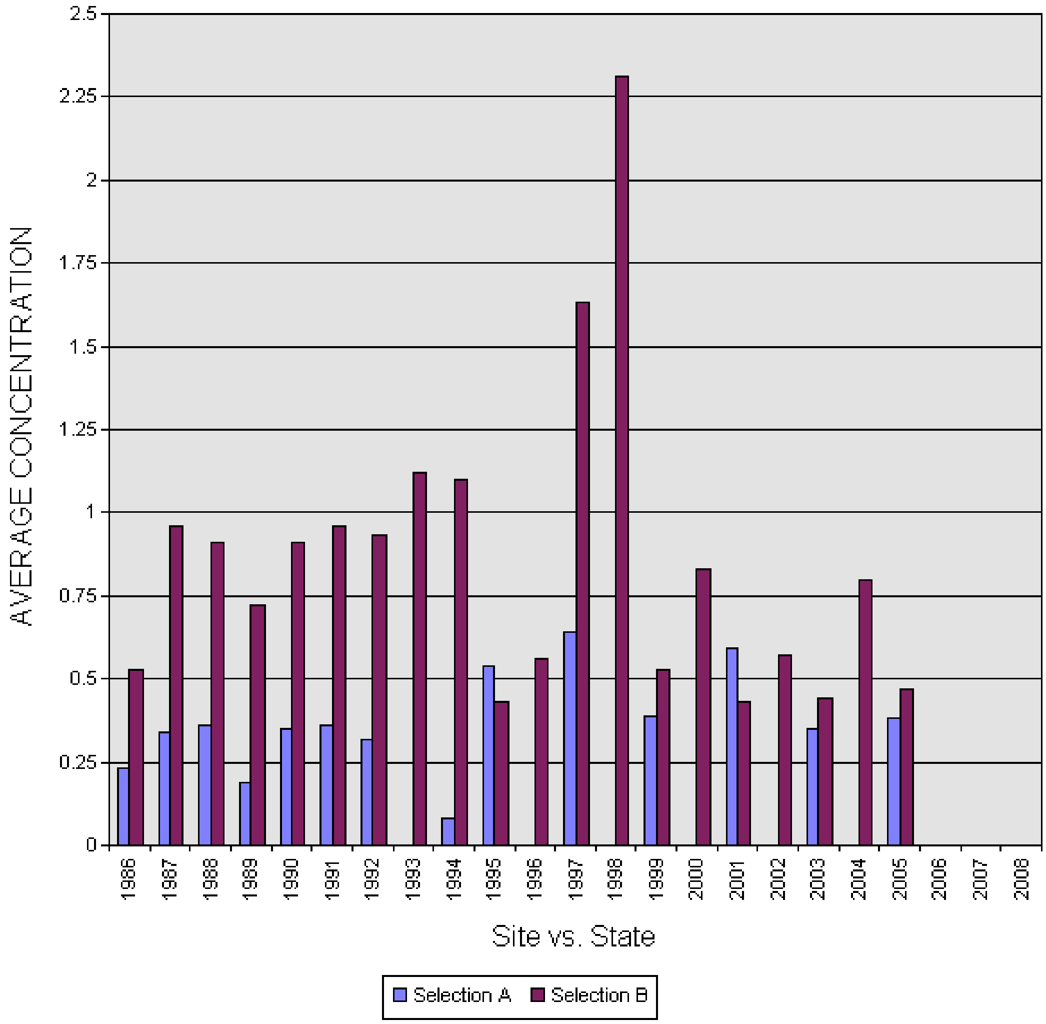
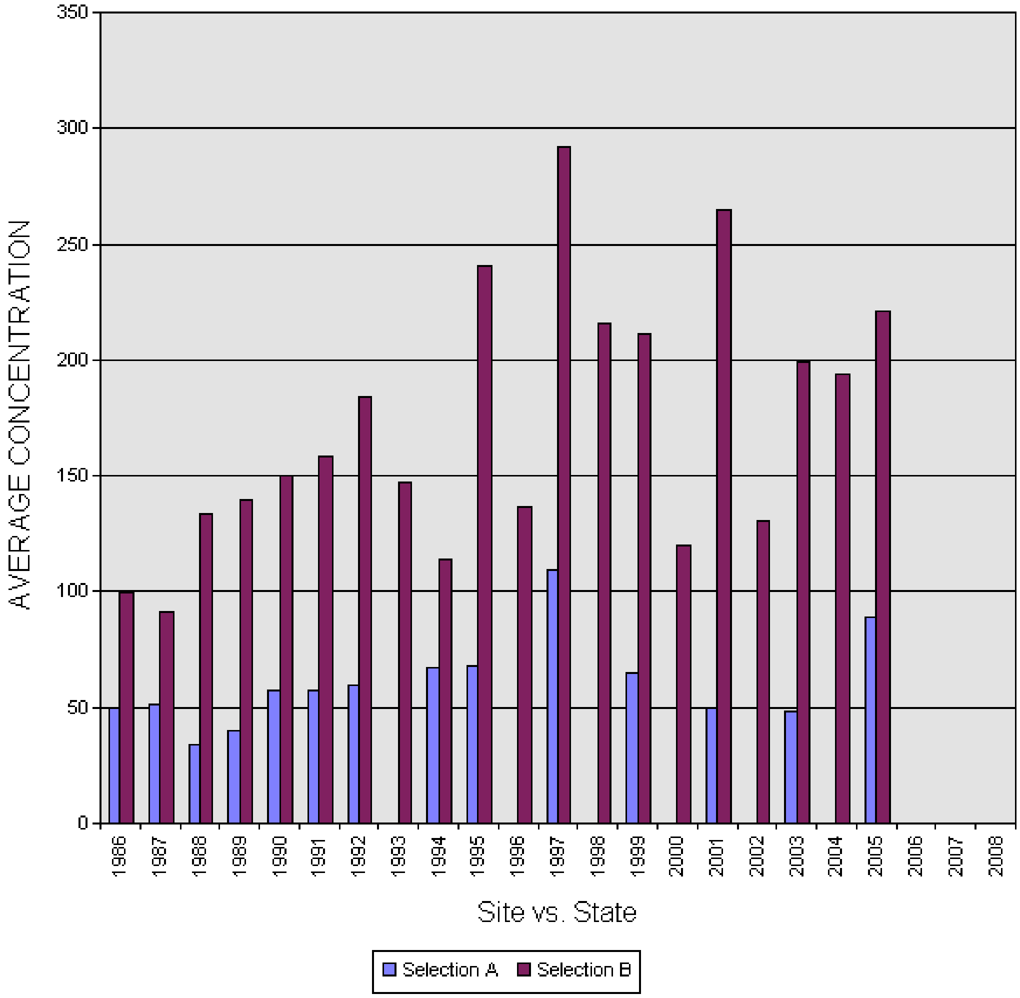


Figure 7. Trends Comparison of the Matanzas River Site (Selection A) vs All Sites in Florida (Selection B) for Copper (Cu) concentration (µg/dry g) in Oyster Tissue.



BIOLOGICAL SETTING

Introduction
The habitat classification system used to describe biotic habitats was developed by the Florida Natural Areas Inventory (FNAI) and the FDEP. The community types are characterized and defined by a combination of physiognomy, vegetation structure and composition, land form, substrate, climate, hydrology, fire regime, topography and soil type. The community types are named for the most characteristic biological or physical feature (FNAI and FDEP 1990). The Reserve contains twenty-three distinct FNAI-classified natural communities (FNAI 1991) as well as open water and ruderal areas. The habitats are roughly organized as a progression from estuarine, to upland, to freshwater aquatic habitats. Each of these biotic habitats is described below. In addition, descriptions of community structure of some of the FNAI habitats have been completed for the CAMA managed units within the Reserve. These have been included in the GTMNERR Management Plan, and relevant sections of those descriptions are also presented below.

Biological community profiles are presented separately, and describe the major biological components and species within the Reserve. Both important species and past and present research (through 2009) associated with each component is presented. Appendix A contains a complete listing of all species known to occur within the Reserve.

Biotic Habitats
Estuarine Tidal Marsh – (synonyms: Saltmarsh, Brackish Marsh, Coastal Wetlands, Coastal Marshes, Tidal Wetlands).
Marine and estuarine tidal marshes are floral based natural communities generally characterized as expanses of grasses, rushes and sedges along coastlines of low wave energy and river mouths. They are most abundant and most extensive in Florida north of the normal freeze line, being largely displaced by and interspersed among tidal swamps below this line.

Estuarine tidal marsh plants live under conditions which would stress most plants. High salt content in the soil, poor soil aeration, frequent submersion and exposure, intense sunlight, and occasional fires make the estuarine tidal marsh community inhospitable to most plants and requires a wide tolerance limit for its inhabitants. The landward extent of estuarine tidal marsh along the shoreline is directly related to the degree of bottom slope; the more gradual the slope the broader the community band. Typical zonation in this community includes smooth cordgrass in the deeper edges, grading to salt tolerant plants such as black needlerush that withstand less inundation.

The vegetation of this marsh community consists of a number of species in the grass (*Poaceae*), sedge (*Cyperaceae*), and rush (*Juncaceae*) families. The marsh area within the Reserve is dominated by smooth cordgrass (*Spartina alterniflora*). Smooth cordgrass is well adapted to sea-strength salinity, 35 parts per thousand (ppt), and occurs in the regularly flooded or low marsh (zone between mean low water (MLW) and mean high water (MHW)). Smooth cordgrass becomes mixed with glasswort (*Salicornia sp*), saltwort (*Batis maritima*), sea purslane (*Sesuvium portulacastrum*), and salt grass (*Distichlis spicata*) on sandy substrates near the high water mark.

Areas of high marsh (zone between MHW and MLW spring tide) occur where tidal flow is restricted and are dominated by black needlerush (*Juncus roemerianus*). Other commonly occurring species in the high marsh include sea oxeye (*Borrichia frutescens*), sea lavender (*Limonium carolinianum*), marsh elder (*Iva frutescens*), and groundsel tree (*Baccharis halimifolia*). Brackish marshes are found in the northern component of the Reserve, and include the managed Diego Pond, and north-central portions of Guana Lake. Brackish marshes have salinity levels of about one-third sea strength. Salinity is strongly influenced by rain water runoff. Vegetation consists mainly of species endemic to the saltmarsh, but includes additional species less tolerant of higher salinity levels. Some representatives are: cattail (*Typha domingensis*), dwarf spikerush (*Eleocharis parvula*), saltmarsh bulrush (*Scirpus robustus*), rush (*Juncus spp.*), and muhly grass (*Muhlenbergia capillaris*).

Tidal fluctuation is one of the most important ecological factors in these communities, cycling nutrients and allowing marine and estuarine fauna access to the marsh. This exchange helps to make estuarine tidal marsh one of the most biologically productive natural communities in the world. In fact, primary productivity surpasses that of most intensive agricultural practices. The former operates at no cost because of free energy subsidies from tides, while the latter requires costly energy subsidies in the form of fuels, chemicals, and labor. A myriad of invertebrates and fish, including most of the commercially and recreationally important species such as shrimp, blue crab, oysters, sharks, grouper, snapper and mullet, also use these marshes throughout part or all of their life cycles.

Estuarine tidal marshes are also extremely important because of their storm buffering capacity and their pollutant filtering actions. The dense roots and stems hold the unstabilized soils together, reducing the impact of storm wave surge. The plants, animals, and soils filter, absorb, and neutralize many pollutants before they can reach adjacent marine and estuarine communities.

Adverse impacts of urban development on estuarine tidal marshes include degradation of water quality, filling of marshes, increased erosion, and other alterations such as bulkheading, and dock construction. Offshore and watershed based pollution from oil spills, litter and polluted storm-water runoff can also have detrimental impacts to estuarine tidal marsh habitats.

Estuarine Unconsolidated Substrate - (synonyms: Beach, Shore, Sand Bottom, Shell Bottom, Sand Bar, Mud Flat, Tidal Flat, Soft Bottom, Coralgal Substrate, Marl, Gravel, Pebble, Calcareous Clay).

In general, estuarine unconsolidated substrate communities are the most widespread communities in the world. However, unconsolidated substrates vary greatly throughout Florida, based on surrounding parent material. Unconsolidated sediments can originate from organic sources, such as decaying plant tissues (e.g., mud) or from calcium carbonate depositions of plants or animals (e.g., coralgal, marl and shell substrates). Marl and coralgal substrates are primarily restricted to the southern portion of the state. The remaining four kinds of unconsolidated substrate, mud, mud/sand, sand, and shell, are found throughout the coastal areas of Florida.

Estuarine unconsolidated substrate exists throughout the Reserve between the extreme spring high and low tide lines. While these areas may seem relatively barren, these habitats may support a large population of infaunal organisms as well as a variety of transient planktonic and pelagic organisms. These flats are inhabited by microscopic benthic algae. Algae-based food webs eliminate the loss of energy associated with trophic intermediates (i.e., bacteria and fungi) in detritus-based food webs. Infaunal organisms in subtidal zones can reach the tens of thousands per square meter, making these areas important feeding grounds for many bottom feeding fish, such as redfish, flounder, spot, and sheepshead. The intertidal and supratidal zones are extremely important feeding grounds for numerous species of birds and invertebrates. Additionally, benthic algae and photosynthetic bacteria have been shown to significantly contribute to the primary productivity of estuaries (Coultas and Hsieh 1997).

Estuarine unconsolidated substrate communities which are composed chiefly of sand (e.g., sand beaches) are the most important recreational areas in Florida, attracting millions of residents and tourists annually. This community is resilient and may recover from recreational disturbances.

This habitat is vulnerable to compaction associated with vehicular traffic on beaches and disturbances from dredge/fill activities and low dissolved oxygen levels, all of which can cause infaunal organisms to be destroyed or to migrate out of the area. Generally these areas are easily recolonized either by the same organisms or a series of organisms which eventually results in the community returning to its original state once the disturbance has ceased. In extreme examples, significant alterations of elevation or sediment grain size distribution can also cause long-term impacts to this habitat.

Estuarine unconsolidated habitat is also susceptible to the accumulation of toxic levels of heavy metals, oils, and pesticides associated with fine-grained sediments and organic matter. Significant amounts of these compounds in the sediments will harm the infaunal organisms, thereby eliminating or contaminating a food source for certain fishes, birds, and other organisms. Such problems primarily occur in some of the major cities, in areas where there is heavy industrial development, near sewage treatment plant outfalls, and along major shipping channels where oil spills are more likely to occur. Improperly treated stormwater runoff from residential areas is becoming a progressively more important source of pollutants as human population densities increase along the coast.

Estuarine Mollusk Reef **- (**synonyms: Oyster Bar, Oyster Reef, Oyster Bed, Oyster Rock, Oyster Grounds, Mussel Reef).
Marine and estuarine mollusk reefs are faunal based natural communities typically characterized as expansive concentrations of sessile mollusks occurring in intertidal and subtidal zones. The most common type of mollusk reef in the GTMNERR, oyster reef, is common in the low-energy, sedimentary environment characteristic of the continuous strands of tidal marsh occurring along the Tolomato, Guana and Matanzas Rivers. It occurs in water salinities from just above fresh water to just below full strength sea water, but develops most frequently in estuarine water with salinities between 15 and 30 ppt. Their absence in marine water is largely attributed to the many predators, parasites, and diseases of oysters that occur in higher salinities. Prolonged exposure to low salinities (less then 2 ppt) is also known to be responsible for massive mortality of oyster reefs. Thus, significant increases or decreases in salinity levels through natural or unnatural alterations of freshwater inflow can be detrimental to oyster mollusk reef communities. The condition of this community provides a valuable performance indicator for restoring natural freshwater inflows to altered estuarine habitats.

The extensive surface area of an oyster reef provides essential habitat for a wide variety of organisms. Every square meter of oyster bed provides up to 50 square meters of hard substrate (Bahr and Lanier 1981). This substrate is colonized by many suspension- and deposit-feeding macrofaunal consumers such as barnacles, polychaetes, amphipods, and mud crabs. These are preyed upon by carnivores, such as the blue crab and black drum. Oyster reefs that are exposed during low tides are frequented by a multitude of shorebirds, wading birds, raccoons, and other vertebrates.

One of the functions of the mollusk reef inhabitants in a tidal marsh ecosystem is to mineralize organic carbon and release nitrogen and phosphorus in forms usable by the primary producers (phytoplankton and benthic algae). Oyster reefs also affect the physiography and hydrology of the estuary by modifying current velocities and changing sedimentation rates and patterns. Oyster reefs trap sediment, stabilize erosional processes, and provide a stable island of hard substrate.

The major threats to mollusk reefs continue to be pollution and substrate degradation due, in large part, to upland development. Mollusks are filter feeders, filtering up to 100 gallons of water a day. In addition to filtering food, they also filter and accumulate toxins from polluted waters. Sources of these pollutants can be from considerably distant areas, but are often more damaging when nearby. Substrate degradation occurs when silts, sludge and dredge spoils cover and bury the mollusk reefs.

Marine Unconsolidated Substrate - (synonyms: Beach, Shore, Sand Bottom, Shell Bottom, Sand Bar, Mud Flat, Tidal Flat, Soft Bottom, Coralgal Substrate, Marl, Gravel, Pebble, Calcareous Clay).
Unconsolidated substrates are marine mineral-based communities found along the shoreline of the Atlantic Ocean. The beach substrate is mainly coquina with white quartz sand. Although the turbulent wave conditions appear to result in an unstable and harsh environment, the surf zone is an important habitat for a variety of animal life. For species adapted to this environment, the wave energy may provide a subsidy by supplying plankton and detritus to secondary filter feeders, exposing prey to fishes, and concentrating plankton along the swash zone (Ross 1983). Swash zones also act as biological purification systems for coastal water.

Organic matter from the ocean, especially macroscopic algae, is acted upon by bacteria in the beach sands. The bacteria are, in turn, eaten by nematodes, flatworms, protozoa, and amphipods. In the high energy zone of the beach, permanent residents are primarily burrowing marine life such as ghost shrimp, polychaetes, and sea cucumbers. At low tide, shore birds actively feed on the many burrowing organisms.

For some fish species, the surf zone is used only by larval stages, with juveniles occurring in other, primarily lower salinity, environments. Other species spawn offshore and utilize the surf zone as a juvenile nursery area. A third group spawns offshore and nearshore and may be found in the surf zone as larvae, juveniles, or even adults.

Marine Consolidated Substrate **-** (synonyms: Hard Bottom, Rock Bottom, Limerock Bottom, Coquina Bottom, Relic Reef).
This community is represented by an outcrop of coquina rock called the Anastasia Formation that is supratidal to subtidal. Zonation of the plants and animals is driven by the tides, with the supratidal zone labeled the black zone, followed by the yellow zone, the green zone, and the red zone. Colors are the result of the dominant alga. Well over 100 species of plants and animals have been identified from this formation in Washington Oaks State Garden. The resilience of this habitat to anthropogenic disturbance requires further study.

Open Water **-** This is a non-FNAI categorized marine habitat consisting of coastal rivers, tidal creeks and estuarine open water areas, as well as the pelagic water areas of marine habitat within state waters that extend three nautical miles off the coast.

Beach Dune **–** (synonyms: Sand Dunes, Pioneer Zone, Upper Beach, Sea Oats Zone, Coastal Strand).

Beach dune is characterized as a wind-deposited, foredune and wave-deposited upper beach that are sparsely to densely vegetated. Dune vegetation consists primarily of sea oats (*Uniola paniculata*), railroad vine (*Ipomoea pes-caprae*) and marshhay cordgrass (*Spartina patens*).

The contour of the beach dune determines the exposure of shoreline communities to ocean winds, salt spray, and temperature and moisture fluctuations. The beach face profile includes the slope of the coquina and sand beach along the oceanfront, a 2-4 foot primary dune westward of the beach, a narrow trough between the primary and secondary dunes, and climaxes in a 20-35+ foot secondary dune.

Plants of the beach dunes are extremely vulnerable to human impacts, particularly soil compaction. A footpath or off-road vehicle trail over the beach dunes damages the vegetation, increasing erosion by wind and water as gaps develop. The sand from the gap moves inland, and rapidly buries vegetation, destabilizing the beach dunes and disturbing adjacent communities. Gaps also increase erosion caused by storms.

The beach dunes are home to the endangered Anastasia Island beach mouse (*Peromyscus polionotus phasma*), cotton rats (*Sigmodon hispidus*), marsh rabbits (*Sylvilagus palustris*), snakes, and owls. Bobcats (*Felis rufus*), and peregrine falcons (*Falco peregrinus*) are also common residents or visitors to these dunes. The northern component of the Reserve contains nearly five miles of virtually undeveloped Atlantic Ocean beach dune habitat.

<u>Coastal strand</u> – (synonyms: Shrub Zone, Maritime Thicket, Coastal Scrub).
Coastal strand is characterized as stabilized, wind-deposited coastal dunes that are vegetated with a dense thicket of salt-tolerant shrubs. The vegetation in this community consists of scrubby oaks

(*Quercus geminata, Q. myrtifolia, Q. chapmanii.*), redbay (*Persea borbonia*), saw palmetto (*Serenoa repens*), yaupon holly (*Ilex vomitoria*), wild olive (*Osmanthus americana*), scattered cabbage palm (*Sabal palmetto*) and southern magnolia (*Magnolia grandiflora*). The overall physical shaping of this community is maintained in part by the shearing effect of salt winds coming across the dunes and sculpturing the oak-dominated vegetation.

Coastal strand dunes are generally quite stable but are susceptible to severe damage if the vegetation is disturbed. Shrubs in the coastal strand are frequently dwarfed and pruned as a result of the salt spray-laden winds that kill twigs on the seaward side, producing a smooth, dense upward-slanting canopy resembling a sheared hedge. Coastal strand is actually an ecotonal community that generally lies between beach dune and maritime hammock. It may also grade into scrub, and it often shares many of the same species that occur in coastal berm. Fire may reduce succession towards maritime hammock. However, maritime influences alone will often suffice to inhibit succession to forest.

Coastal strand is one of the most rapidly disappearing community types in Florida. It is most extensive along the Atlantic Coast where, being elevated and next to the coast, it is prime resort or residential property. Coastal strand originally occurred as a nearly continuous band along the Atlantic shorelines. Now it occurs largely as broken and isolated small stretches. Along with other coastal communities, coastal strand protects inland communities from the severe effects of storms.

This habitat is utilized by migrating birds such as gray catbird (*Dumetella carolinensis*), painted bunting (*Passerina ciris*), wood warblers, and resident species such as northern cardinal (*Cardinalis cardinalis*), northern mockingbird (*Mimus polyglottos*), Carolina wren (*Thryothorus ludovicianus*), marsh rabbit, six-lined racerunner (*Cnemidophorus sexlineatus*), gopher tortoise (*Gopherus polyphemus*) and eastern coachwhip (*Masticophis flagellum*).

<u>Maritime Hammock</u> - (synonyms: Coastal Hammock, Maritime Forest, Tropical Hammock). Maritime hammock is characterized as a narrow band of hardwood forest lying just inland of the coastal strand community.

The maritime hammock community is represented in both barrier island and interior portions of the Reserve and is composed of an over-story of live oak (*Quercus virginiana*), laurel oak (*Q. laurifolia*), pignut hickory (*Carya glabra*), southern magnolia, and redbay. The understory is very open, consisting of saplings of the above mentioned species, yaupon, a variety of sedges, and saw palmetto. White-tailed deer (*Odocoileus virginianus*), bobcats, raccoons (*Procyon lotor*), opossums (*Didelphis virginiana*), gopher tortoises, rattlesnakes and migratory songbirds all use this extensive area.

The generally mesic conditions and insular locations of well-developed maritime hammock communities inhibit natural fires, which occur no more frequently than once every 26 to 100 years. In mature maritime hammock, fire may alter the original appearance, obscuring former beach ridge vegetation patterns and creating a diversity of plant sub-associations. Nutrient recycling is generally accomplished by biological based processes instead of by fire.

Maritime hammock is the terminal stage of succession in coastal areas. Maritime hammock is prime resort and residential property because of its relatively protected location along the coast. Although it originally occurred in virtually continuous bands with coastal strand, maritime hammock is now dissected into fragments by development and is rapidly disappearing. Maritime hammock is reasonably resilient so long as the canopy remains intact and the landform stable.

<u>Xeric Hammock</u> – (synonyms: Xeric Forest, Sand Hammock, Live Oak Forest, Oak Woodland, Oak Hammock).
Xeric hammock is characterized as either a scrubby, dense, low canopy forest with little understory other than palmetto, or a multi-storied forest of tall trees with an open or closed canopy.

Xeric hammock is an advanced successional stage of scrub or sandhill and occurs on sand ridges along former shorelines. The variation in vegetation structure is predominantly due to the original community from which it developed. As with maritime hammocks, an important factor in the development and maintenance of the hammock is the canopy. The species composition is often similar to maritime hammock, composed of an over-story of live oak, sand live oak (*Q. geminata*), laurel oak, pignut hickory, southern magnolia, and redbay. In all cases, however, the soils consist primarily of deep, well-drained sands that were derived from old dune systems. Soils are the best measure to delineate these relict scrubby ridges, and therefore the distribution of this community follows closely to that of Astatula fine sands. The sparsity of herbs and the relatively incombustible oak litter preclude most fires from invading xeric hammock. When fire does occur, it is nearly always catastrophic and may revert xeric hammock into another community type. Xeric hammock only develops on sites that have been protected from fire for 30 or more years.

<u>Scrub</u> – (synonyms: Sand Pine Scrub, Florida Scrub, Sand Scrub, Rosemary Scrub, Oak Scrub).
Scrub occurs in many forms, but is often characterized as a closed to open canopy forest of sand pines with dense clumps or vast thickets of scrub oaks and other shrubs dominating the understory.

Patches of maturing scrub are mixed in with the xeric hammock community. These small patches, which are dominated by sand live oak, myrtle oak (*Q. myrtifolia*), Chapman's oak (*Q. chapmanii*), staggerbush (*Lyonia ferruginea*), fetterbush *(L. lucida*) and several other ericaceous plants, comprise one twelve-acre parcel plus several smaller areas scattered throughout the interior of the Reserve's northern component.

Scrub is essentially a fire maintained community. Ground vegetation is extremely sparse and leaf fall is minimal, thus reducing the chance of frequent ground fires. As the sand pines mature, however, they retain most of their branches and build up large fuel supplies in their crowns. When a fire does occur, this fuel supply, in combination with the resinous needles and high stand density, ensures a hot, fast burning fire. Such fires allow for the regeneration of the Scrub community which might otherwise succeed to xeric hammock. The minerals in the vegetation are deposited on the bare sand as ashes, and the heat of the fire generally facilitates the release of pine seeds. As discerned from the life histories of the dominant plants, scrub probably burns catastrophically once every 20 to 80 years or longer. Scrub is also readily damaged by off-road vehicle traffic or even foot traffic, which destroys the delicate ground cover and allows the loose sand to erode. Once disturbed, ground lichens may require 50 years or more to recover. These scrub areas have been fire excluded long enough that future management will undoubtedly require mechanical treatment to knock back the aging scrub oaks.

Mesic Flatwoods - (synonyms: Pine Flatwoods, Pine Savannahs, Pine Barrens).
Mesic Flatwoods are characterized as an open canopy forest of widely spaced pine trees with little or no understory but a dense ground cover of herbs and shrubs.

Mesic flatwoods occur on relatively flat, moderately to poorly drained terrain. The soils typically consist of 1-3 feet (.3 to 1 meters) of acidic sands generally overlying an organic hardpan or clayey subsoil. The hardpan substantially reduces the percolation of water below and above its surface. During the rainy seasons, water frequently stands on the hardpan's surface and briefly inundates much of the flatwoods; while during the drier seasons, ground water is unobtainable for many plants whose roots fail to penetrate the hardpan. Thus, many plants are under the stress of water saturation during the wet seasons and under the stress of dehydration during the dry seasons.

The mesic flatwood community is dominated by slash pine and pond pine (*Pinus serotina*). The understory consists of saw palmetto, gallberry (*Ilex glabra*), tarflower (*Befaria racemosa*), grasses such as wiregrass (*Aristida beyrichiana*), and a variety of sedges.

As a pyrogenic community, this pineland stand must be prescribed burned on a two-five year rotation in order to control hardwood encroachment and to prevent accumulation of excessive fuel loads. Nearly all plants and animals inhabiting this community are adapted to periodic fires; several species depend on fire for their continued existence. Without relatively frequent fires, mesic flatwoods succeed into hardwood-dominated forests whose closed canopy can essentially eliminate the ground cover herbs and shrubs. Additionally, the dense layer of litter that accumulates on unburned sites can eliminate the reproduction of pines which require a mineral soil substrate for proper germination. Conversely fires that are too frequent or too hot would eliminate pine recruitment and eventually transform mesic flatwoods into dry prairie.

Shell Mound **-** (synonyms: Midden, Indian Mound, Tropical Hammock, Maritime Hammock, Coastal Hammock).
Shell mound is unusual among the biological communities in that it is largely a result of the activities of Native Americans, instead of natural physical factors. Shell mounds are small hills, usually in coastal locations, composed entirely of shells (clams, oysters, whelks) which support an assemblage of calciphilic plant species. A rich calcareous soil develops on the deposited shells which supports a diverse hardwood, closed-canopy forest habitat on undisturbed mounds.

The unique shell mound hardwood forest habitat is located at Shell Bluff and several other areas along much of the perimeter of the Guana peninsula (e.g., Wright’s Landing). Shell Bluff was homesteaded in the past and was devoid of vegetation until recently. Today, it is covered almost exclusively by southern red cedar (*Juniperus silicicola*), scattered slash pine (*Pinus elliottii*) and an understory of grasses and sedges.

The greatest threat to this habitat is erosion by tidal currents (Baker 1988), wave action from boats along the IWW, and sea level rise. A restoration project, completed in 1992 prior to Reserve designation, attempted to stabilize the Shell Bluff shoreline using coquina rocks. A recent engineering evaluation (Taylor Engineering, 2007) indicates that inappropriate placement, size and density of these rocks have worsened the situation. Erosion also continues to be a major threat to the Shell Mound at the Wright's Landing area to the south, where large trees, including slash pines and some mature sand pines (*Pinus clausa*) are washing into the Tolomato River.

<u>Coastal Interdunal Swale</u>
This is a habitat that occurs where 1) dune and swale topography has developed within the past 5000 years, 2) a lens of groundwater intersects the bottom of the swales, and 3) extensive flooding by saltwater is infrequent. Critical to the existence of this habitat is a subsurface hydraulic connection with the barrier island's water table. The water levels in the interdunal wetlands are strongly tied to local rainfall events. Consequently, the community varies from flooded to completely dry depending on rainfall, as well as area and elevation of the surrounding dunes.

A large expanse of this community type is located within the northern portion of the Reserve. For all practical purposes, it is the southern portion of an adjacent wetland system managed as Big Savannah Pond by the Florida Fish and Wildlife Conservation Commission (FWC). Both wetlands currently function reciprocally because of the hydrologic connection between them and a large ditch that bisects them. In addition, similar depressional wetlands exist throughout the barrier island within the coastal strand community; although they are much smaller in size. Two known sites are located just north of the Reserve's central and northern parking areas.

Coastal interdunal swale wetlands are dominated by sand cordgrass (*Spartina bakeri*), maidencane (*Panicum hemitomon*), cinnamon fern (*Osmunda cinnamomea*), royal fern (*O. regalis*) and a rich variety of other herbaceous plants. It is also particularly rich in wildlife, possessing large numbers of macroinvertebrates, fish, amphibians such as the mole salamander (*Ambystoma talpoideum*), snakes, turtles, alligator (*Alligator mississippiensis*), rodents, river otter (*Lutra canadensis*), waterfowl and wading birds like wood stork (*Mycteria americana*), roseate spoonbill (*Ajaia ajaja*), and raptors like American kestrel (*Falco sparverius*). Striped newts also use this wetland, usually just following drought conditions when ephemeral pools begin filling with rainfall. This species has a complex life cycle (Johnson 2002) and appears to only reproduce in ponds where predatory fish are absent (Moler and Franz 1987).

Little in the way of active management is required for this habitat other than to prevent disruption by vehicles or excessive foot traffic or disruption of natural hydrology. Fires occasionally burn through the swales but the dominant factor in this community's development and maintenance is hydrology.

<u>Sandhill</u> **-** Sandhill - (synonyms: Longleaf Pine, Turkey Oak, Xerophytic Oak, Deciduous Oak, High Pine).
Sandhill habitats are characterized as a forest of widely spaced pine trees with a sparse understory of deciduous oaks and a fairly dense ground cover of grasses and herbs on rolling hills of sand.

Fire is a dominant factor in the ecology of this community. Sandhills are a fire climax community, being dependent on frequent ground fires to reduce hardwood competition and to perpetuate pines and grasses. The natural fire frequency appears to be every 2 to 5 years. Without frequent fires, sandhills may eventually succeed to xeric hammock. Unburned sandhills may be dominated by turkey oak.

Coastal Berm – (synonyms: Shell Ridge, Coastal Levee, Coastal Forest, Buttonwood Embankment, Mangrove Hammock).
Coastal berm applies to a variety of plant associations that develop on ridges of storm deposited sand, shells, and debris. These associations include dense thickets of large shrubs and small trees, hammocks, or sparse shrubby vegetation with spiny xerophytic plants. Coastal berm habitats are similar to coastal strand habitats in their physiography and resilience.

Scrubby Flatwood **-** (synonyms: Xeric Flatwoods, Dry Flatwoods).
Scrubby Flatwoods are characterized as an open canopy forest of widely scattered pine trees with a sparse shrubby understory and numerous areas of barren white sand. The vegetation is a combination of scrub and mesic flatwoods species; scrubby flatwoods often occupy broad transitions or ecotones between these communities.

Scrubby flatwoods generally occur intermingled with mesic flatwoods along slightly elevated relictual sandbars and dunes. The white sandy soil is several feet deep and drains rapidly. However, the water table is unlikely to be very deep. Scrubby flatwoods normally do not flood even under extremely wet conditions. The temperature and humidity of air and soil in scrubby flatwoods fluctuates substantially more than in most other communities because the scattered overstory, sparse understory, and barren sands of scrubby flatwoods do not buffer daily and seasonal changes very well.

Although the elevated, deeper sandy soils of scrubby flatwoods engender a drier environment than the surrounding mesic flatwoods, the general sparsity of ground vegetation and the greater proportion of relatively incombustible scrub-oak leaf litter reduce the frequency of naturally occurring fires. Only after a long absence of fire and during periods of drought does the leaf litter become sufficiently combustible and concentrated enough to support an ecological burn. Several species of plants in scrubby flatwoods are typical scrub plants which endure only when long intervals between fires occur. Thus, a periodicity of approximately 8 to 25 years between fires appears to be natural for this community.

Upland Mixed Forest **-** Upland Hardwood Forest and Upland Mixed Forest - (synonyms: Mesic Hammock, Climax Hardwoods, Upland Hardwoods, Beech-Magnolia Climax, Oak-Magnolia Climax, Pine-Oak Hickory Association, Southern Mixed Hardwoods, Clay Hills Hammocks, Piedmont Forest).
Upland mixed forests are characterized as well-developed, closed canopy forests of upland hardwoods on rolling hills

Soils of upland mixed forests are generally sandy-clays or clayey sands with substantial organic and often calcareous components. The topography and clayey soils increase surface water runoff, although this is counterbalanced by the moisture retention properties of clays and by the often thick layer of leaf mulch which helps conserve soil moisture and create mesic conditions. Furthermore, the canopy is densely closed, except during winter in areas where deciduous trees predominate. Thus, air movement and light penetration are generally low, making the humidity high and relatively constant. Because of these conditions upland mixed forests rarely burn.

Upland mixed forests are climax communities for their respective geographic locations. They are often associated with and grade into upland pine forest, slope forest or xeric hammock. Occasionally, upland mixed forests may also grade into maritime hammock or prairie hammock. During early stages of succession, upland mixed forest may be difficult to distinguish from upland pine forests that have not been burned for several years. Disturbed sites may require hundreds of years to reach full development with species compositions representative of climax conditions.

Depression Marsh – (synonyms: Isolated Wetland, Flatwoods Pond, St. John's Wort Pond, Pineland Depression, Ephemeral Pond, Seasonal Marsh).
Depression marsh is characterized as a shallow, usually rounded depression in sand substrate with herbaceous vegetation often in concentric bands. A number of small isolated wetlands are scattered throughout the interior portion of the northern component. These wetlands are dominated by sand cordgrass, maidencane, and a rich variety of other herbaceous plants. As with swale wetlands, these depressional marshes possess a rich diversity of associated animals. One listed species found here is the striped newt (*Notophthalmus perstriatus*).

Depression marshes occur where sand has slumped and created a conical depression subsequently filled by direct rain fall, runoff, or seepage from surrounding uplands. The substrate is usually acid sand with deepening peat toward the center. Some depressions may have developed or be maintained by a subsurface hardpan. Hydrological conditions vary, with most depression marshes drying in most years. Hydroperiods range widely from as few as 50 days or less to more than 200 days per year.

Fire is important to maintaining this community type by restricting invasion of shrubs and trees and the formation of peat. Fire frequency is often greatest around the periphery of the marsh and least toward the center. Severe peat fire can lower the ground surface and create a pond at the center of the marsh. Hydrologic conditions and species composition must be monitored and used to assess ecological targets to guide fire management.

Dome Swamp - (synonyms: Isolated Wetland Cypress Dome, Cypress Pond, Gum Pond, Bayhead, Cypress Gall, Pine Barrens Pond).
Dome swamps are characterized as shallow, forested, usually circular depressions that generally present a domed profile because smaller trees grow in the shallower waters at the outer edge, while bigger trees grow in the deeper water in the interior. Pond cypress, swamp tupelo, and slash pine are common plants.

Dome swamps typically develop in sandy flatwoods areas where sand has slumped creating a conical depression. Soils are composed of peat, which becomes thickest toward the center of the dome, and are generally underlain with acidic sands and then limestone, although other subsoils may also occur. Some domes have a clay lens that helps retain water levels.

Dome swamps often derive much of their water through runoff from surrounding uplands, but they may also be connected with underground channels, in which case subterranean flows would dominate the hydrological regime. Dome swamps generally function as reservoirs that recharge the aquifer. The normal hydroperiod for Dome swamps is 200 to 300 days per year with water being deepest and remaining longest near the center of the dome.

Fire is essential for the maintenance of a cypress dome community. Without periodic fires, hardwood invasion and peat accumulation would convert the dome to Bottomland Forest or Bog. Dome swamps dominated by bays are close to this transition. Fire frequency is greatest at the dryer periphery of the dome and least in the interior where long hydroperiods and deep peat maintain high moisture levels for most of the year. The normal fire cycle might be as short as 3 to 5 years along the outer edge and as long as 100 to 150 years towards the center. The profile of a Dome swamp (i.e., smaller trees at the periphery and largest trees near the center) is largely attributable to this fire regime. The shorter hydroperiods along the periphery permit fires to burn into the edge more often, occasionally killing the outer trees. Cypress is very tolerant of light surface fires, but muck fires burning into the peat can kill them, lower the ground surface, and transform the dome into a pond.

Floodplain Swamp - (synonyms: River Swamp, Bottomland Hardwoods, Seasonally Flooded Basins or Flats, Oak-Gum-Cypress, Cypress-Tupelo, Slough, Oxbow, Back Swamp).
Floodplain swamps occur on flooded soils along stream channels and in low spots and oxbows within river floodplains.

Soils of floodplain swamps are highly variable mixtures of sand, organic, and alluvial materials, although some sites, especially within sloughs or on smaller streams, may have considerable peat accumulation. Floodplain swamps are flooded for most of the year, with sites along channels inundated by aerobic flowing water while those of sloughs and backswamps are naturally flooded with anaerobic water for extensive periods of time. Soils and hydroperiods determine species composition and community structure. Seasonal and often prolonged inundations restrict the growth of most shrubs and herbs, leaving most of the ground surface open or thinly mantled with leaf litter. Floods redistribute detritus to other portions of the floodplain or into the main river channel. This rich organic debris is essential to the functional integrity of downriver ecosystems such as estuaries. These swamps are usually too wet to support fire.

Flatwoods/Prairie/Marsh Lake - (synonyms: Flatwoods Pond, Ephemeral Pond, Grass Pond, St. John's Wort Pond, Freshwater Lake, Pineland Depression, Swale, Prairie Pond).
The distinctions between these communities, and from depression marsh, are often quite subtle, because of their successional interrelationships.

Water for this habitat is derived mostly from runoff from the immediately surrounding uplands. This habitat functions as aquifer recharge areas by acting as reservoirs. Water generally remains throughout the year in a flatwoods/prairie lake or a marsh lake, although water levels may fluctuate substantially. Alterations in natural hydrologic conditions and water quality are the primary disturbances to this habitat.

<u>Blackwater Stream</u> - (synonyms: Blackwater River, Blackwater Creek).
Blackwater streams are characterized as perennial or intermittent seasonal watercourses originating deep in sandy lowlands where extensive wetlands with organic soils function as reservoirs, collecting rainfall and discharging it slowly to the stream. The tea-colored waters of blackwater streams are laden with tannins, particulates, dissolved organic matter and iron derived from drainage through swamps and marshes.

Blackwater streams are the most widely distributed and numerous riverine systems in the southeast coastal plain. Very few, however, have escaped major disturbances and alteration. Clearcutting adjacent forested lands and disruptions to natural hydrology are two of the more devastating alterations for this community. Additionally, limited buffering of blackwater streams from development intensifies the detrimental impacts of agricultural, residential and industrial polluted runoff.

<u>Ruderal</u>
This habitat consists of areas where natural ground cover is severely disturbed by human influence. Developed land within the Reserve consists of the maintenance and office facilities, parking lots, trails, roads, nature centers, restrooms and other structures found within the boundary. To minimize the environmental impact of these structures, careful planning is needed to limit impervious surfaces, select environmentally friendly landscaping, construction and maintenance materials and monitor the surrounding natural environment for unintentional harm.

Biological Community Profiles

Plankton
Little research has been done on plankton communities within the GTMNERR up to this point. However, Dr. Edward Phlips (University of Florida) has investigated phytoplankton structure, and phytoplankton bloom density and spread, an important issue related to animal and human health. Though the focus of this research is on phytoplankton dynamics, whole samples for phytoplankton and zooplankton enumeration and identification have been collected and preserved.

Karenia brevis, the ‘red tide’ organism, is a common, unarmored, photosynthetic dinoflagellate found year-round throughout the Gulf of Mexico at background concentrations of 1,000 cells per liter or less and is occasionally found in Atlantic coastal waters. *K. brevis* produces brevetoxins that are capable of killing fish, birds, and other marine animals. Bottom-dwellers such as groupers and grunts are usually the first fish to die in a Florida red tide, although most fish are probably susceptible. Mortality, in terms of numbers killed and species affected, can be severe and is dependent upon factors such as bloom density and the length of time animals are exposed to the toxins.

There are periodic blooms on the east coast of Florida, with a bloom recently occurring in October 2007 within the waters of the GTMNERR. The bloom began in the coastal waters between the mouths of the St. Johns and Nassau Rivers. The bloom persisted, moving south along the coast and entering both the St. Augustine and Matanzas Inlets. Cell counts as high as 5 million cells/L were recorded in the Matanzas River south of the 206 bridge (Hitchcock and Frazel, unpublished raw data). Net community production and respiration rates from 'light-dark' bottle incubations of *K. brevis* populations revealed the 'red tide' along Florida's northeast coast was predominantly autotrophic (Production > Respiration) (Hitchcock and Frazel, unpublished raw data).

Dr. James Fourqurean, with Florida International University (FIU), and Dr. Gary Hitchcock from the University of Miami (UM), have assessed red tide toxins in sediments and epiphyte communities, including marsh grasses and seagrasses throughout the state. Several sample sites within the Reserve were included in the survey. The joint FIU/UM project, co-sponsored by the National Science Foundation and the National Institutes of Health, has investigated ecological linkages between epiphytes and *K. brevis* through DNA analysis.

Vegetation

There are currently 580 plant species identified within the GTMNERR (Appendix A). The diverse plant community covers marine, littoral, estuarine, wetland and upland habitats.

Listed Species

The following plant species are those that are listed by the USFWS as endangered, threatened or of special concern within the Reserve.

- The sand-dune spurge (*Chamaesyce cumulicola*), also known as the coastal dune sandmat, is fairly common in areas where the groundcover is discontinuous. It is low growing, as opposed to other more erect species. It blooms in spring, summer, and fall, and is found in dune and scrub habitat.

- Coastal vervain (*Glandularia maritima*) is designated as an endangered species by the State of Florida. It is a small, lavender-flowered member of the Verbenaceae family. It inhabits dunes and coastal ridges.

- Crested coralroot (*Hexalectris spicata*) is a small, ground-dwelling member of the orchid family. Crested coralroot is known to inhabit calcareous hammocks and shell middens, and it blooms in the spring and summer.

- Angle pod (*Matelea gonocarpa*) is a perennial, twisting vine that is found in hammocks. Angle pod flowers have yellow or greenish-brown petals, when it blooms during the spring and summer.

- Pygmy-pipes (*Monotropsis odorata*) are small perennial herbs that are conspicuous for their lack of chlorophyll. They compensate by being parasitic on underground fungi associated with tree roots.

- Prickly pear cactus (*Opuntia stricta*) is abundant where it can be found in undeveloped back dune areas. It blooms throughout the year, and the dark purple fruits are edible.

- The giant orchid (*Pteroglossapsis ecristata*) inhabits dry habitats throughout much of Florida. It is a perennial herb that may reach heights of nearly 2 meters when blooming.

<u>Research</u>

- A survey of the vascular flora of Guana Tolomato Matanzas National Estuarine Research Reserve was completed and revised by volunteer botanist Jerry Harrison in September of 2005. This survey documented the presence of 489 species of vascular flora at the Reserve. Of this number, 58 species that are non-native (exotic) to North Florida were recorded.

- St. Johns River Water Management District (SJRWMD) has collaborated with the GTMNERR in the development of a guide for the GIS based photointerpretation and coding of coastal wetland communities associated with the GTMNERR. The guide is divided into three sections. The first describes the aerial photography resources, the mapping process and conventions, and the vegetation classification. The second gives an overview of community types, including illustrations, descriptions, and diagnostic characteristics for each major vegetation community type. The third section is a guide to the dominant and common plant species of the coastal wetlands, including photographs, drawings, and distribution maps (Kinser et al. 2008)

- The ecology of early successional maritime forests on dredged spoil islands within the Reserve is the focus of study for Ph.D. student John Baker, from the University of Florida. The spoil islands were created between 1928 and 1970 from dredge material deposited during construction of the IWW. Observational studies (which were still underway at time of publication) are focusing on the vegetation, soils and water resources of these islands. The composition and abundance of the herbaceous subcanopy, and canopy vegetative communities are being sampled. Experiments are exploring the ability of spoil islands to support maritime forests and determine what environmental factors are preventing trees from growing in spoil fields.

- Ho et al. (2005) tested the biogeographic theory predicting that plant-herbivore interactions are more intense at low versus high latitudes, using a site within the Reserve as one of the low-latitude sites. Results from the testing of hypotheses demonstrated that herbivore density is indeed higher at low versus high latitudes; and that damage to plants by herbivores is greater at low versus high latitudes. More details of the study, funded through the Reserve's Graduate Research Fellowship Program are given in the description of that program under the Section on *Research and Monitoring Activities*.

- The northern extent of both the red mangrove (*Rhizophora mangle*) and black mangrove (*Avicennia germinans*) occurs within the GTMNERR. However, changes in climate may in turn alter the distribution of the red mangrove. Leitholf and Weishampel (2007) were testing the hypothesis that increasing temperatures and a reduction in the freeze frequency, will result in a northward expansion of mangroves into the salt marsh zone in the GTMNERR. The goals of the project were to determine the importance of abiotic processes such as temperature and salinity on mangrove demography, and to create a computer model simulating mangrove dynamics under different climate changes and invasion scenarios.

- A study by Leitholf (2008) documented the phenology of the mangroves and the invasive Brazilian pepper (*Schinus terebinthifolius)* along the northern ecotone of the species and determined that temperature was a correlating factor in the growth and distribution *S. terebinthifolius*.

  A simulation model was also developed which focused on the establishment and competition among the three mangrove species and the invading *S. terebinthifolius*. This model was run under various invasion and/or climate change scenarios to determine possible outcomes under global climate change with or without the presence of *S. terebinthifolius*. It was concluded that under all scenarios of invasion, other than sea level rise as part of global climate change, *S. terebinthifolius* would dominate the landscape if allowed to invade and establish in areas in which it is not currently present.

- It is generally believed that tidal marshes are nitrogen limited systems and that marsh plants solely utilize the inorganic forms of nitrogen, ammonium and nitrate. Recent research has demonstrated the ability of *S. alterniflora* to take up dissolved organic nitrogen (DON) directly; however, DON has been neglected by scientists and is poorly characterized in temperate salt marshes. To evaluate the existence of latitudinal gradients in the availability of dissolved organic nitrogen in *S. alterniflora* salt marshes along the Atlantic coast, Mozdzer et al. (2007) sampled porewater from 8 field sites from Maine to Florida, with the Florida site being located within the GTMNERR. By combining information on the availability and utilization of DON, Mozdzer and colleagues from the

University of Virginia hope to create a better understanding of nutrient utilization within salt marshes of the North American Atlantic coast.

- The vascular flora of five Florida shell middens, including the Shell Ring at the former Guana River State Park showed that over 95% of the flora was native species (Stalter and Kincaid (2004). Calcareous soils were determined to be a major influence on species distribution at such upland shell midden sites.

- Reserve scientists, along with Jacksonville University researchers are assessing the effects of coastal strand habitat management on existing and future invasive plant populations in the GTMNERR. The size and extent of invasive populations of exotic species such as tropical soda apple (*Solanum viarium*), Brazilian pepper (*Schinus terebinthifolius*), and Chinese tallow (*Sapium sebiferum*) is unknown and will be evaluated through vegetation surveys. The team will also assess the impact of management activities/techniques on the suppression and eradication of invasive plants, as well as the impact of vegetation control on wildlife.

- A study of plant colonization on dead margins in the GTM estuaries was initiated in 2008 by University of Central Florida graduate student, Shannon Segelsky (Dr. Linda Walters, advisor). Dead margins are piles of disarticulated oyster shells that result from boat and wind wakes. The study is examining at what elevation/tidal range dead margins are colonized by saltmarsh vegetation. Vertical profiles of reefs with and without dead margins have been carried out together with mapping/marking the associated vegetation. This mapping will be redone periodically and all data compared to results of similar studies in Mosquito Lagoon.

- A project initiated in 2009 within the GTMNERR by Christy Crace, graduate student at the University of North Florida (Dr. Daniel Moon, advisor), is examining how different insect feeding guilds react to salt-stressed coastal plants. The project has both ecological and molecular components. The responses of six coastal plant species to induced salt-stress are being assessed by measuring growth, leaf production, and flowering. Herbivore responses are determined by visual herbivore counts, indirect visual evidence of insects (e.g., stem boring), and sweep netting. The molecular component of the project will aid in quantifying plant stress by measuring foliar nitrogen as well as the activity of certain stress enzymes; particularly catalase and superoxide dismutase. With rising sea levels, understanding the effects of salt stress in salt marsh food webs should provide information for future management of these complex systems.

- Reserve staff initiated a collaboration with Dr. Nisse Goldberg (Jacksonville University) in 2009 to pilot a mangrove-mapping strategy in the GTMNERR. The project utilizes a GIS-based algorithm developed by NOAA's Coastal Services Center for fine-scale delineation of mangrove habitat using a supervised-classification mapping approach. If the strategy proves successful, information generated from the project will provide important baseline maps for subsequent change analyses and ecological studies of mangrove.

Invertebrates

More than 95% of the Earth's animal species are invertebrates, and representative phyla can be found in some form or another in all of the habitats within the Reserve. More than 500 different invertebrates have been identified within the Reserve; they are listed in Appendix A. As integrators of environmental condition, the abundance, diversity, biomass and species composition of invertebrates can be useful metrics for assessing estuarine health. (USEPA 2009)

Some of the more prominent invertebrate species are discussed below.

American oyster (*Crassostrea virginica*)

The American oyster occupies estuarine habitats throughout the eastern and Gulf of Mexico coasts of the United States. The remains of shell middens in the Reserve show that this animal has supported a subsistence fishery for inhabitants well before the establishment of St. Augustine. In addition to its direct economic importance, the oyster also provides important habitat for many estuarine fish and invertebrate species. In the Reserve, oysters occur along the full length of the estuary.

Limited recreational oyster and hard clam harvesting occurs within two delineated shellfish harvest areas in the GTMNERR. In addition, there are currently four aquaculture leases within the Reserve for oysters and two aquaculture leases for hard clams totaling 42 acres. A brief description and maps of each of the shellfish areas, including the management status is available online at *http://www.floridaaquaculture.com/pdfmaps*.

Shellfish harvesting is managed through the Department of Agriculture and Consumer Services (FDACS) Division of Aquaculture. The Department routinely monitors fecal coliform and water quality parameters at established stations in each of Florida's shellfish harvesting areas. Sub-surface water samples are collected and shipped overnight to a certified laboratory. The analysis for fecal coliform takes 24 hours, and numbers of bacteria are expressed in the units of Most Probable Number (MPN) per 100 milliliters (ml). FDACS Division of Aquaculture (*http://www.floridaaquaculture.com/seas/seas_intro.htm*).

White and brown shrimp (*Penaeus setiferus* and *Penaeus aztecus*)

The white shrimp and brown shrimp are both commercially harvested in northeast Florida and spend part of their lifecycles within the estuaries of the Reserve. Both species are important in estuarine and saltmarsh environments as they convert detritus, plant material, microorganisms, macroinvertebrates, and fish parts into useful protein for higher trophic level organisms.

The white shrimp is generally found in waters that are turbid, shallower, and more brackish than those in which brown shrimp are found. The white shrimp was the first species of commercial importance in the U.S., with the fishery for this species dating back to 1709 (Muncy 1984). Shrimp are also the most economically important fishery in Florida (Seaman 1985).

Blue crab (*Callinectes sapidus*)

Blue crabs are harvested both recreationally and commercially within the Reserve using crab traps or pots as the primary method of harvest. Blue crabs spend most of their life cycle within estuarine habitats, although the larval stages develop in the open ocean. Young crabs will move within estuaries to mid and low salinity waters and grow quickly. Blue crabs reach maturity and the five inch legal harvest size in one to two years.

Blue crabs play an important role in the marine and estuarine trophic system, as prey and predators. Florida pompano and other large fish and planktivores (Steele1991) consume larval blue crabs (Murphy et al. 2001), while juvenile blue crabs are eaten by larger fish such as spotted seatrout and red drum. The primary predators of adults include raccoons and large wading birds.

Fiddler crabs *(Uca sp)*

Fiddler crabs are found in the intertidal zone and within salt marshes and are recognized by their square body and marked difference in size between the right and left claws of males. Two common species of fiddler crab occur within the GTMNERR; the Atlantic mud fiddler, *Uca pugnax*, and the sand fiddler, *Uca pugilator*. Mud fiddlers are a brownish-yellowish color, and prefer muddy areas, whereas sand fiddlers inhabit sandy habitats. Fiddler crabs have no directly quantifiable commercial value but constitute an important food source for marsh birds, blue crabs and many other species (NOAA 2008).

Marsh periwinkle (*Littorina irrorata*)

The marsh periwinkle is a small gastropod that can range in color from dark brown to an almost bleached white. It is an important component of the intertidal salt marsh community. Periwinkles may be a major participant in the decomposition of cordgrass, *Spartina alterniflora*, leaves through a mutualistic association with leaf fungi (Silliman and Newell 2003). Marsh periwinkles can serve as an indicator species of the health of salt marsh, a habitat that is critical for many species.

The marsh periwinkle is an obligate salt marsh resident for which cordgrass may be considered a critical habitat. Individuals can be found inhabiting high-marsh areas around freshwater seeps and low-marsh stems submerged in full strength seawater (greater than 25 parts per thousand). Marsh periwinkles feed on microalgae and detritus; they may also garden and consume fungal decomposers found on the surface of marsh plants (Silliman and Newell 2003).

Research

- The bacteria *Vibrio vulnificus* is an opportunistic pathogen now recognized as the leading cause of food-associated deaths in Florida. Infections are most frequently contracted after raw oyster consumption. Gordon et al. (2005) enumerated *V. vulnificus* in oysters and waters of the GTMNERR from a series of more than 300 isolates obtained during warm months. Gordon et al. (2008) have since been able to develop real-time PCR assays that were sensitive, specific, and quantitative in water samples and could also differentiate the *Vibrio* strains in oysters without requiring isolation of *V. vulnificus.* The assay may therefore be useful for rapid detection of the pathogens in shellfish and water, as well as for further investigation of its population dynamics.

- Hare (2008) performed genetic analyses on adult and newly-settled oysters collected within lagoons and near ocean inlets along the Florida coast in 2007 to assess the oyster as a bioindicator of population connectivity among Florida lagoons. The northernmost inlet sample site was at the Whitney Lab, south of Matanzas Inlet. Genetic differentiation among reproductive adult populations enabled the inference of source populations and migration routes for juvenile oysters during one recruitment season. Preliminary results from the study showed patterns of connectivity between oyster population in Matanzas Inlet and Ponce Inlet, as well as connectivity between Matanzas Inlet populations and populations in Fort Pierce.

- Research conducted on grazing by the marsh periwinkle, by Dr. Brian Silliman (University of Florida) (Kilheffer et al. 2006) has revealed that southeastern marshes are the product of a simple trophic cascade, where marine predators, such as the commercially harvested blue crab, facilitate marsh plant persistence and productivity by controlling densities of plant-grazing snails (marsh periwinkle). When released from top-down control, snail numbers increase and grazing by high densities of snails (whose radular activity facilitates invasion of growth-suppressing fungi) converts lush intertidal grasslands to mudflats. These findings have major conservation implications, as they potentially link the health and function of southeast marshes to the management of crab fisheries.

- Studies from 2003-2007 indicate that blue crab densities have declined precipitously (40-80%) in southeast estuaries (Silliman et al. 2009). Concomitant with this crab decline has been unprecedented marsh die-back. Surveys from many die-off areas have found 300m long fronts of snails (2000 ind./m^2) consuming marsh grass at up to 100m^2/ month. Given these findings, it is possible that the cascading consumer effects shown in small-scale experiments may already be at work in southern marshes (Silliman et al. 2009).

- The invasive Asian green mussel (*Perna viridis*) has been documented to occur in several locations in the Matanzas and Tolomato Rivers near St. Augustine Inlet (Baker et al. 2007). This invasive bivalve competes with oysters and other native shellfish for habitat, and presents the threat of significantly reducing populations of these commercially valuable resources.

- Dr. Matthew Gilg and other researchers at the University of North Florida are examining the larval green mussel distribution in the GTM estuary and attempting to genetically track the source of the adult populations. Related to this work is the joint development of a tool by Peter Sheng's group at UF's Civil and Coastal Engineering Department, along with the UF Advanced Computing and Information Systems Lab and SJRWMD's Peter Sucsy and Tim Cera, that can be used to examine how green mussel larvae would be distributed from particular spawning points in the estuary. The tool is a cyber-infrastructure system which essentially accesses appropriate data sets and computing assets over the internet through a user-friendly interface to run a 3-D hydrodynamic model of the GTMNERR.

- The utility of dactyls for inferring evolutionary patterns were evaluated by Agnew (2007) as part of his dissertation project at Louisiana State University. Dactyls are the moveable part of the claw of the crab. Because of their high preservation potential and uses in foraging and defense, crab dactyls are potentially excellent test subjects for an ongoing debate concerning the relative importance of top-down (predators) and bottom-up (prey) controls on morphologic diversification and evolution. Both living and subfossil xanthoid crabs were sampled from the southeast U.S. Atlantic and Gulf of Mexico coasts, including intertidal locations within the GTMNERR. Statistically significant differences in the wear patterns between live collected crabs and those from death assemblages, indicating more wear in the death assemblage than the living assemblage. It was suggested that the wear patterns are caused by shell crushing and that there may have been a fairly recent shift in the diet of the mud cab (*Panopeus sp*.). Wear patterns on modern *Panopeus* on either side of the Florida peninsula were also different.

  This research demonstrated that the relative influence of top-down and bottom-up controls on dactyl evolution can be identified by correlating dactyl morphologies with evidence of predation either by crabs (wear patterns) or on crabs (handedness reversals and predatory fractures) using the most commonly preserved remains of living and/or fossil taxa.

- The Golden apple snail (*Pomacea sp*.) is an invasive species that has only recently been documented in the Reserve. Live specimens and photographs of adults and eggs in a retention pond have been collected near Moultrie Creek. The proximity of this population to Pellicer Creek Aquatic Preserve presents a serious threat to the aquatic ecosystem there. They consume almost every submerged aquatic plant species in the Preserve and have a high reproductive rate. This species has become well established throughout much of south and central Florida in recent years.

- Pristine Florida wildlife habitats are being lost to development and ecosystems are being threatened more than ever by human encroachment. Published accounts of Florida non-marine molluscan communities are few in number, brief, not based on strategized sampling protocol, and scattered in the scientific literature. The relatively intact natural ecosystems present within the boundaries of the northern component of the GTMNERR undoubtedly support most of the species of land, aquatic, and estuarine mollusks known to occur in northeastern Florida. No systematic survey of the non-marine mollusks of the GTMNERR has ever been undertaken. Harry G. Lee, M.D., Field Associate, Florida Museum of Natural History initiated such a survey in 2008. A total of 65 species, including 56 native, and 9 introduced species have been identified as of Januay 2009. (*http://www.jaxshells.org/northeas.htm*).

- Ethan Nash, a graduate student at the University of Central Florida (Dr. Linda Walters, advisor) commenced research in 2008 to examine the associations of three non-native species [charru mussel (*Mytella charruana*), green mussel (*Perna viridis*), and pink barnacle (*Megabalanus coccopoma*)] with different oyster reef types in both Mosquito Lagoon and the GTM estuarine system. These studies will be complemented by field and laboratory studies of air exposure and thermal tolerance for *Mytella/Perna* as this relates to the ability of the mussels to invade intertidal oyster reefs.

Fishes

The fish communities within the Reserve are a mixed assemblage with freshwater, estuarine and coastal marine species often coexisting together depending on salinity, temperature, and time of year. A total of 303 fish species have been identified in GTMNERR habitats including freshwater, brackish and marine waters. Recreational and commercial fishing are major activities within the GTMNERR with most effort focused on edible game fishes. Descriptions of some of the major species are listed below.

<u>Red drum (*Sciaenops ocellatus)*</u>

Red drum are popular recreational game and food fish found in estuarine areas and nearshore waters of the Reserve. Red drum prefer shallow waters (0.5-1 meters deep) and are found over all bottom types. These fish are also commonly found around oyster reefs, though breaks in continuity of shorelines such as coves, points, jetties, and old pier pilings attract them. During cold spells large numbers of red drum can be found in tidal creeks and rivers. They can live in fresh water and have been found well up Pellicer Creek.

Spawning occurs in nearshore waters from August to November. Young red drum feed on small crabs, shrimp, and marine worms. Adults tend to feed on larger crabs, shrimp, and small fish. A stock assessment of Red Drum in Florida through 2003, showed that angling success, as measured by total catch rates increased in 2003, reversing a downward trend seen since the mid to late 1990's (Murphy 2005).

<u>Black drum (*Pogonias cromis*)</u>

The black drum is a member of the croaker family and is related to both, red drum, and spotted seatrout. A characteristic of this family of fish is the ability to produce croaking or drumming sounds with the air bladder, which is the reason for the common names croaker and drum. This ability is most developed in the black drum and anglers can sometimes hear sounds from schools passing near their boats. Black drum, the largest members of the family Sciaenidae, can reach over 46 inches (116 cm) and 120 pounds (54 kg). Long-lived fish, black drum can reach almost 60 years of age (FWC 2006a).

Drum are found in a wide range of habitats in the Reserve, from right at the water's edge along the coast, to the deepest holes (>21 m) in the IWW near St. Augustine. Young drum feed on marine worms, small shrimp, crabs and small fish. Larger drum eat small crabs, worms, algae, small fish and mollusks. Barbels under the lower jaw are used to find food by feel and smell.

Drum often dig or root out buried mollusks and worms while feeding in a head-down position. The black drum has no canine teeth like those of the spotted seatrout, but does have highly developed pharyngeal teeth, which are used to crush mollusks and crabs before swallowing (Texas Wildlife and Parks Department (TWPD 2007)).

Spotted seatrout (*Cynoscion nebulosus)*

Spotted seatrout range throughout Florida's bays and coastal waters. In northeast Florida adult spotted seatrout are found over a wide range of estuarine habitats. They are common around oyster reefs, in deep holes, on sand bottom, and in areas where structure exists.

Maximum ages reached in Florida are 9 years for males and 8 years for females. Spotted seatrout first spawn between 0 and 2 years old and 11.8–15.7 inches (5.34-7.11 cm) total length (TL). Spawning occurs within estuaries and in nearshore waters during spring, summer, and fall. The diet of juvenile seatrout (< 1.2 inches (0.54 cm) TL) includes amphipods and other small crustaceans. Larger juveniles and adults feed primarily on shrimp and a variety of finfishes, including other young spotted seatrout (FWC 2007a).

Flounder (*Paralichthys sp*.)

Nearly all flounders landed by anglers in Florida are one of three species in the genus *Paralichthys*: gulf flounder *P. albigutta;* southern flounder, *P. lethostigma*; or summer flounder, *P. dentatus*. All three species occur within the waters of the GTMNERR. The distributions of gulf and southern flounder appear to be substrate-related. Southern flounder are found on silt and mud, and gulf flounder are found mostly on sand. Female southern flounder mature at age 3 or 4, and female gulf flounder mature at age 1. Both species spawn in offshore waters during late fall–winter (65 ft–200 ft) (20-60m). Gulf flounders are benthic carnivores. Large juveniles feed primarily on small fish and crustaceans (shrimp and crabs). Adults feed on schooling fish such as menhaden, bay anchovy, pinfish, grunts, pigfish, Atlantic croaker, and mullet (FWC 2006b)

Striped mullet (*Mugil cephalus*)

Striped mullet, are perhaps the most widespread and abundant inshore teleost (Odum 1970). They are an ecologically important component in the flow of energy through estuarine communities and occur in both the estuaries and nearshore coastal waters of the Reserve.

Diet and feeding behavior of juvenile and adult striped mullet may vary by location, but they primarily feed on epiphytic and benthic microalgae, macrophyte detritus, or inorganic sediment particles. Sediment particles function as a grinding paste in the gizzard-like pyloric portion of the stomach (Odum 1970). Larval and post-larval mullet feed on zooplankton (Nash et al. 1974). The major predators of juvenile and adult mullet are fishes and birds (Thomson 1963). Among fishes, spotted seatrout, red drum, hardhead catfish, and southern flounder will prey on mullet in the Reserve. Wading birds also prey on mullet

Striped mullet is one of the most important inshore finfish fisheries in Florida as both a food fish and for roe exported overseas. In 2004, commercial landings of striped mullet (7.6 million pounds) (3.4 million kg) constituted fourteen percent of total finfish landings (53 million pounds) (24 million kg) and eight percent of total commercial finfish dockside dollar value (Mahmoudi 2005).

Sheepshead (*Archosargus probatocephalus*)
Sheepshead range from Nova Scotia south to Mexico's Campeche Bank and are found in estuarine waters throughout the Reserve. They are often found around oyster bars, seawalls, docks and in tidal creeks. Sheepshead move offshore in schools to spawn following the onset of cool weather. They return to inshore waters in the spring after spawning.

Adult sheepshead typically feed on algae, blue crab, young oysters, clams, crustaceans, and small fish. Florida landings of sheepshead were 3.3 million pounds (1.5 million kg) in 2005, out of which the recreational fishery represented about 90% (FWC 2006c).

Mummichog (*Fundulus heteroclitus*)
The mummichog or killifish is an abundant Atlantic Coast fish ranging from the Matanzas River to Newfoundland, Canada. They are particularly important in marsh food chains because of their distribution and abundance (Abraham 1985). Mummichogs are considerd to be instrumental in the movement of organic material within and out of saltmarsh ecosystems (Knieb et al. 1980).

For over 100 years the mummichog has been a popular experimental organism for a wide array of scientific studies (Feder 1987). Mummichogs from the Matanzas River have been used extensively as a model organism for reproductive and other physiological studies by researchers at UF's Whitney Lab, including the studies of Lin et al. (2004), Petrino and Wallace (1992), and Calman et al. (2001).

Research

- Monthly fisheries surveys, initiated in 2001, were conducted to establish baseline data on juvenile estuarine fish spatial and temporal distribution patterns. The study area included the bar-built estuaries ranging from just north of St. Augustine within the Reserve, south to Ponce Inlet (Turtora and Schotman 2006).

  The study has provided thorough baseline information on the species of fish associated with different estuarine habitats in the area throughout the year, and hence has yielded crucial data for more effectively managing coastal fisheries. Specifically, the work completed thus far indicates that the Tomoka area and areas north of the St. Augustine Inlet are the mainstem IWW nursery areas. Both areas are characterized by low salinity, low current velocity, and small substrate grain-size. The Matanzas River was not shown to be a nursery area due to the proximity of inlets. October was typically the beginning of juvenile recruitment for *Micropogonias undulatus* as they were collected throughout the basin

"all at once" (Turtora 2008).

- Studies by Clarke (2006) and (Juanes et al. 2007) of the winter ecology of young-of-the-year (YOY) bluefish *(Pomatomus saltatrix)* evaluated recruitment in the Matanzas River Estuary during the winters of 2002-2004. Three distinct intra-annual cohorts of YOY fish were shown to be present. An analysis of first year sampling data indicated higher bluefish abundance in sand habitats where an abundance of mullet were present. Second year results were more variable. Results from the study demonstrate the use of the Matanzas River estuary by bluefish during the winter. This may be a mechanism for maximizing survival and increasing the overall stock biomass.

- A related project is now underway using experimental fish trawls offshore at selective depth strata. This new project is being completed by graduate student David Stormer, under the direction of Dr. Francis Juanes at the University of Massachusetts.

- The ovaries of female *Fundulus heteroclitus* living in the northeastern Florida saltmarsh (within the GTMNERR) recrudesce in January and the fish initially spawn heavily during the subsequent full moons (a lunar pattern); they later spawn with less intensity during both the new and full moons (a semilunar pattern), and then regress in late September. In studying the reproductive cycling in female *Fundulus heteroclitus* in the laboratory, researchers at UF's Whitney Laboratory discovered that these fish apparently select the higher of the two semidiurnal tides for spawning, regardless of the daily light-dark cycle (Hsiao et al. 1994).

Reptiles and Amphibians

An array of reptile and amphibian communities exists in the Reserve, the location and distribution of which are primarily controlled by habitat type and proximity to water. The survey of species in the Reserve (Appendix A) lists eighteen species of turtles and tortoises, twenty snakes, eight lizards, eighteen different frogs and toads, two salamanders, the greater siren (*Sirenia lacertina*), the endangered striped newt (*Notophthalmus perstriatus*), and the American alligator (*Alligator mississippiensis*). Four of the twenty listed snake species are venomous, including the Florida cottonmouth (*Agkistrodon piscivorus conant*), Eastern diamondback rattlesnake (*Crotalus adamentius*), pygmy rattlesnake (*Sistrurus miliarius barbouri*), and the coral snake (*Micrurus fulvius*).

The Reserve has several listed and/or endangered species of reptiles and amphibians that are discussed below.

Sea turtles
Three listed species of sea turtles: the loggerhead (*Caretta caretta*), the leatherback (*Dermochelys coriacea*) and the green turtle (*Chelonia mydas*) utilize the sandy beach between the high tide line and the base of the Reserve's beach dunes for nesting. The nesting season generally occurs between May and October. Florida statewide nesting beach survey data for the 2006 season (FWRI: *http://research.myfwc.com/features/view_article.asp?id=11812*) shows 205 loggerhead nests and 10 green turtle nests in St. Johns County. Of those, a total of 101 nests occurred within the Reserve. There were no reported leatherback nests in 2006.

An updated analysis of Florida's long-term loggerhead sea turtle nesting data, carried out as part of the FWC Index Nesting Beach Survey, reveals a continuing decline in loggerhead nest numbers around the state. Nest counts have decreased nearly 50 % from 1998 to 2007. In contrast, nest counts for green turtles and leatherbacks are increasing. A record number of nests of these two species were recorded during the 2007 season (*http://research.myfwc.com/features/view_article.asp?id=27537*).

Gopher tortoise
The gopher tortoise (*Gopherus polyphemus*), a keystone species and a species listed as threatened, lives in sandy habitats in the Reserve. A keystone species is one whose very presence contributes to a diversity of life and whose extinction would consequently lead to impacts on other forms of life. They have been designated a keystone species because its burrows provide refuge to hundreds of other species, including opossums, rabbits, gopher frogs, Florida mice, eastern diamondback rattlesnakes and gopher crickets (FWC 2007b).

The prime sandhill habitats within the Reserve are open areas with abundant food and relatively deep, sandy soils for burrowing, and sunny spots for laying eggs. The long, burrows they dig offer refuge from cold, heat, drought, forest fires and predators. The record burrow was over 47 feet (14 meters) long. They feed on low-growing plants like wiregrass, broadleaf grasses, and legumes. They also eat prickly pear cactus, blackberries, and other seasonal fruits.

In 2006, the Florida Fish and Wildlife Commission agreed that reclassification of the gopher tortoise from Species of Special Concern to Threatened is warranted. The change in status is pending (*http://myfwc.com/imperiledspecies/petitions/gopher-tortoise.htm*). Reserve volunteers conduct biennial Gopher Tortoise Burrow Surveys which are described in detail in Section V.

Indigo snake
The Eastern indigo snake (*Drymarchon corais couperi*) is listed as threatened by both FWC and USFWS. It is the largest nonvenomous snake in North America. Individuals have been measured from six to eight and half feet (1.8 to 2.6 meters) long. Unlike the color indigo or indigo buntings, this snake is much more black than blue. It has smooth, shiny scales and a reddish chin and throat. The young are lighter in color and have a faint banded pattern. It readily moves through a variety of habitats, especially those that border marshes and swamps, in search of prey such as birds, young turtles, frogs, and other snakes, including rattlesnakes. The indigo has been reported in the area of the GRMAP.

Striped newt

The striped newt (*Notophthalmus perstriatus*) in Florida is reported to reside in xeric hammocks, scrubby flatwoods, sandhills, and scrub habitats and breed in isolated wetlands (Christman and Means 1992). A unique coastal population of striped newt occurs within the depression marsh and interdunal swale wetlands of the Reserve's interior. This population is the only barrier island assemblage known throughout its range (Johnson and Owen, in preparation). Reserve staff members have established a striped newt monitoring program which is discussed in Section 5. During the 2007 survey one newt was identified in the GRWMA.

Research

- There are two concurrent sea turtle nesting survey programs currently operating in Florida; the State Survey Nesting Beach and the Index Nesting Beach Programs. The goal of the Index Beach program is to use identical protocols for gathering detailed information to assess trends and to compare beaches. The State Survey Nesting Beaches program maximizes temporal and geographic surveillance of nesting activities but the effort varies among years and among beaches, and there is variation in survey frequency.

- GTMNERR Stewardship Staff are the primary permit holders for Marine Turtle Permit #140, in cooperation with the Florida Fish and Wildlife Conservation Commission for the northern area of the Reserve. The permit authorizes specific GTMNERR staff and volunteers to conduct daily activities related to nest monitoring, stranding and salvage incidents of sea turtles on these beaches. Surveys are conducted at sunrise from May 15th through August 31st.

- An initial comprehensive gopher tortoise survey of the Guana Peninsula was completed by GTMNERR staff and volunteers during April to July 2005. The survey identified more 260 active burrows.

- A study of gopher tortoises on small islands near St. Augustine was conducted by Dana Ehret (University of Florida) that could reveal whether displaced colonies can be successfully relocated to similar sites in Florida and other states. The UF study focuses on gopher tortoise populations on five small islands along the IWW.

Birds

The varied habitats of the Reserve support over 250 species of birds, ranging from hummingbirds to wild turkeys. The Reserve also serves as an important habitat for migrating species of birds and serves as a critical feeding and resting location along the North American Atlantic flyway.

Listed bird species found in the GTMNERR, include the brown pelican (*Pelecanus occidentalis*), little blue heron (*Egretta caerulea*), Louisiana heron (*Egretta tricolor*), snowy egret (*Egretta thula*), reddish egret (*Egretta rufescens*), limpkin (*Aramus guarauna*), American oystercatcher (*Haematopus palliates*), least tern (*Sterna antillarum*), bald eagle (*Haliaeetus leucocephalus*), wood stork (*Mycteria americana*), peregrine falcon (Falco peregrinus), American kestrel (*Falco sparverius*) and roseate spoonbill (*Ajaja ajaja*).

The USFWS is the principal Federal agency charged with protecting and enhancing the populations and habitat of more than 800 species of birds that spend all or part of their lives in the United States. Brief descriptions of the listed species within the Reserve, provided below, are extracted from species accounts provided on the USFWS Web site at *http://www.fws.gov/species/#birds*, and from the FWC Web site at *http://myfwc.com/Viewing/species*/.

Brown pelican (*Pelecanus occidentalis*)
The brown pelican, also called American brown pelican or common pelican, inhabits the Atlantic, Pacific, and Gulf Coasts of North and South America. Brown pelicans can be seen both in the estuaries, as well as along the Atlantic shoreline throughout the Reserve. Pelicans are primarily fish-eaters, with a diet consisting mainly of small fish such as menhaden and silversides.

Egg-laying in eastern brown pelicans generally happens from December through February. Brown pelicans breed in colonies, mostly on small islands along the Intracoastal Waterway. Pelicans pair up for one year, and both help brood and rear the young, which fledge in about 76 days. In 2002 the estimated population of eastern brown pelicans in Florida was 25,600 - 32,000.

Little blue heron (*Egretta caerulea*)
Little blue herons stand roughly 2 feet (0.6 meters) tall and appear dark bluish overall. They feed in the estuaries and saltwater and freshwater marshes throughout the Reserve. Herons feed on small amphibians, small fish, crustaceans, and insects.

Louisiana heron (*Egretta tricolor*
The Louisiana heron, also called the tricolored heron, stand about twenty-six inches (0.6 meters) tall. They are long, slim, with notably long legs, neck, and bill. Louisiana herons prefer wetlands with low vegetation and shallow water, as deep as seven inches (17 centimeters), suitable for wading up to their chests. They feed on small fish like topminnows, which together comprise almost 90% of the diet (Hancock and Elliot 1978).

Snowy egret (*Egretta thula*)
The snowy egret is one of the most familiar herons, delicately built, with snowy white feathers, black legs, and bright yellow feet. The snowy egret's diet is composed primarily of fish and crustaceans, but also includes snails, snakes, and both aquatic and terrestrial insects.

Reddish egret (*Egretta rufescens*)
The reddish egret is the rarest and least well-known of the North American herons and is only rarely seen within the Reserve. Small fish such as minnows make up the bulk of this wading bird's diet.

Limpkin (*Aramus guarauna*)
The limpkin resembles a rail but stands taller, has a longer neck and is distinguished by its dark brown feathers flecked with white, which give it a spotted appearance. Limpkins occur throughout the Reserve and can be observed walking through shallow water, where it uses sight

and touch to search for apple snails, mussels, worms and insects. The sharp and twisted end of its curved bill fits perfectly into a snail shell, allowing the limpkin to deftly extract the mollusk.

American oystercatcher (*Haematopus palliates*)
The American oystercatcher is one of the largest and heaviest of American shorebirds, easily identified by dark-brown wings, and black head, with a bright red bill. Oystercatchers get their name from their habit of snatching oysters from slightly open shells. They also use their powerful bills to open mollusks and to sort through heavy shells in search of food.

Oystercatchers are periodically seen on sandbars and mudflats within the Reserve estuaries, as well as along the beaches.

Least tern (*Sterna antillarum*)
The least tern is a migratory bird that returns to the Reserve from wintering grounds in Latin America during April and May. The least tern has long, pointed wings and a deeply forked tail. It is the smallest of our terns, and bears outer wing feathers that edge the light-gray wings in black. The breeding adult is gray above, white below, with a black cap.

The Reserve's beach habitats provide nesting sites for the threatened least tern. The shorebirds nest in very shallow depressions on broad expanses of bare sand, which camouflage the eggs. Nesting areas along the Reserve's beaches are posted to alert people using the beach of this important habitat.

Data collected for 2005 from volunteer monitoring (discussed in Section V) identified an average of 63 least tern adults at the nesting site, with a peak of 82 adults during the height if the nesting season. The nest site was located on the beach approximately three quarters of a mile south of the GTMNERR south parking area. The survey group counted 30 actual nesting pairs during the season.

Bald eagle (*Haliaeetus leucocephalus*)
Bald eagles, officially declared the National Emblem of the United States by the Second Continental Congress in 1782, are distinctive large dark brown birds with a white head and tail, and yellow eyes, bill and feet. Southern bald eagles, which occur in the Reserve, are considerably smaller than their northern counterparts. Juvenile eagles are chocolate brown, but with varying degrees of mottled white on their tails, bellies and wing linings. It is not until their fourth year that the birds acquire the white head and tail feathers identifying them as adults. The principal food for bald eagles is fish, which the birds seize by using their strong talons to take their prey from the water. Ducks, coots and other water birds also are major food sources for eagles, as well as small animals, reptiles and carrion.

Once bald eagles mate, they form long-term pair bonds that can persist for many years. If one member of the pair dies the surviving partner will select a new mate. In Florida, eagles mate in the winter, laying their eggs between late November and early February.

There are several active bald eagle nests within the Reserve. One active bald eagle nest across the Guana River from the EEC has been monitored by Reserve volunteers since 2005. Two chicks were successfully fledged in 2006, and one chick was fledged in 2007. Bald eagle monitoring throughout the Reserve is discussed in the Section on *Monitoring Activities*.

Wood stork (*Mycteria americana*)
The wood stork is the largest wading bird native to America. It is white with black flight feathers, distinctive because of its dark, featherless head (down to the upper neck) and thick, down-curved bill. Wood storks fly with neck and legs extended, interrupting strong wing beats with brief glides.

Wood storks forage, or feed in drying wetlands, which concentrate prey. They usually feed within 16 miles of their colony but often fly great distances in search of feeding grounds, sometimes as much as 60-80 miles. One breeding colony occurs at the St. Augustine Alligator Farm, from which individuals fly throughout the Reserve in search of prey.

Peregrine falcon (*Falco peregrinus*)
Peregrine falcons don't breed in Florida, but are regularly spotted along the coastal shorelines and wetlands of the Reserve during spring and fall migrations as they move between northern breeding grounds and wintering areas in Central and South America.

The peregrine falcon is distinguished by its typical falcon silhouette - long, pointed wings and long thin tail - and by the dark feathers on its head and nape, which resemble a hood or helmet. A distinctive black wedge extends below the eye. Falcons prey on doves, shorebirds and ducks.

American kestrel (*Falco sparverius*)
The kestrel is the smallest and most common of the falcons. Two subspecies of American kestrel (*Falco sparverius*) occur in Florida: a northern subspecies (*Falco sparverius sparverius*) that winters here between September and April, and a resident, non-migratory subspecies, the southeastern American kestrel (*Falco sparverius paulus*). Kestrels seen in Florida during May-June are resident southeastern American kestrels.

American kestrels often perch on telephone wires at the edge of a field or other open area. From this vantage they hunt for insects (especially grass-hoppers and dragonflies), lizards and small mammals.

Roseate spoonbill (*Ajaja ajaja*)
The roseate spoonbill is easily identified by the luminous pale pink plumage with red highlights and the long bill with the spoon shaped tip. The spoon-shaped (spatulate) bill of this species has sensitive nerve endings that help the spoonbill detect prey. As it sweeps the bill from side to side through shallow water, the spoonbill encounters, captures and swallows small fish, shrimp, crayfish, fiddler crabs and aquatic insects.

Mammals
Mammals fill a wide range of ecological roles within the terrestrial, freshwater and marine habitats of the Reserve. A total of forty-five species of mammals have been identified within the Reserve (Appendix A), five of which are non-native species. Terrestrial herbivores such as

rodents and deer are prey to raccoons, foxes and bobcats. Omnivores such as moles, shrews, opossums, and bears feed on a wide variety of plant and animal matter and some can function as both predator and prey. The endangered West Indian manatee is the largest herbivore as well as the largest mammal found in the estuarine and freshwater areas of the Reserve.

Below are descriptions of listed mammal species within the Reserve.

North Atlantic right whale (*Eubalaena glacialis*)
The right whale is the most endangered of the world's large whales, with between 300 and 350 animals known to exist (American Cetacean Society 2009). The right whale winter calving area in Florida's coastal waters is officially recognized as part of a critical habitat. Due to their coastal nature, right whales are often visible from the beach, and are often seen seaward of the Reserve.

Identifying characteristics of right whales include no dorsal fin, and a V-shaped blow when it exhales. They typically have white, raised patches of skin on the head called callosities. They have short black flippers on both sides of the body and a triangular tail with a deep notch in the middle. Adult whales can be 50-60 feet (15-18 meters) in length and weigh 55 tons (50,000 kg). Both the Marine Resource Council and FWRI maintain monitoring and research programs on the right whale. The FWRI right whale research program is discussed under the Research section below.

Humpback whale (*Megaptera novaeanglinae*)
The endangered humpback whale also migrates through northeast Florida coastal waters and is periodically observed offshore of the Reserve. The humpback has a bulky head with bumpy

protuberances (tubercles), each with a bristle. The name humpback describes the motion it makes as it arches its back out of the water in preparation for a dive. Humpbacks also have huge, mottled white flippers with rough edges that are up to one-third of its body length; these are the largest flippers of any whale.

Humpbacks have a small dorsal fin toward the flukes and grow to be about 52 feet (17 meters) long, weighing 35-50 tons (31,000-45,000 kg) (Marine Mammal Center 2002).

Anastasia Island beach mouse (*Peromyscus polionotus phasma*)
The Anastasia Island beach mouse is listed as an endangered species, and is restricted to Anastasia Island and an introduced population within the beach dunes of the northern component of the Reserve. This subspecies historically occupied about 50 linear miles of beach habitat. In 1992, the USFWS funded the translocation of 28 males and 27 females from Anastasia Island to the Reserve (USFWS 1993). However, the population numbers at the Reserve's beach dunes remain very low. Quarterly monitoring at both Anastasia State Park and GTMNERR are discussed in the Section on *Monitoring Activities*.

West Indian manatee (*Trichechus manatus latirostris*)
Manatees are large, somewhat seal-shaped gray to brown mammals with flat, rounded tails. Adults are typically about 9 to 10 feet (3-3.5 meters) long and weigh around 1,000 pounds (453 kg). They are herbivores, spending up to eight hours a day grazing on seagrasses and other aquatic plants. A manatee can consume up to 20% of its body weight in aquatic vegetation daily (Zieman 1982). The manatee uses its muscular lips to tear plants much like an elephant uses its trunk.

Manatees are occasionally observed in the vicinity of both Guana River and Pellicer Creek during their seasonal migrations along the IWW. They also use the Tolomato and Matanzas River estuaries, and seem to congregate on the mainland side of the estuary.

Florida black bear (*Ursus americanus floridanus*)
The black bear is the largest native terrestrial animal in Florida, and is in danger of becoming extinct because of extensive habitat loss (FNAI 2001). They prefer forested areas with dense understory vegetation and swampy areas, such as within the Twelve Mile Swamp and Snowden Bay drainage basins, within the Reserve. Florida black bears are one of three distinct subspecies of the American black bear recognized in the southeastern United States. They are large, powerful mammals weighting up to 600 pounds (182 kg), with rounded ears, short tails, five-toed feet, and large canine teeth. Though they travel with a slow-shuffling gait, they can run up to 30 miles an hour (48 km/hr), and with their stout, heavily-curved claws, climb trees exceptionally well.

Black bears are omnivorous, mostly consuming tubers, bulbs, berries, nuts, and young shoots. The food items eaten most often and in the greatest volumes are seasonally available fruits and colonial insects (Schaefer and Sargent 1990).

Research

- From December through March, Fish and Wildlife Research Institute (FWRI) researchers fly aerial surveys to locate right whale mothers as they migrate to the warm protected waters off Florida and Georgia to have their calves. Approximately 60 surveys are flown each calving season; each survey lasts approximately six hours. Surveys are flown in a small, twin-engine plane at an altitude of 1000 feet (300 meters) to distances of up to 30 miles (48 km) offshore. The primary mission of these surveys is to locate right whales within and adjacent to the Southeast Critical Habitat and pass that information on to mariners.

  Researchers at FWRI use the following methods to keep track of whales:
    - Each right whale that is located is photographed by the aerial survey team.
    - The photo is then compared to the photo catalog of right whales. Each right whale has a page with a collection of photographs and a unique number or name.
    - The photo is then matched to a whale in the photo catalog.
    - The information is added to the individual sighting history.

  The ability to identify individual whales allows researchers to collect an entire life history of each right whale and to track their movements and associations with other whales. In the 1980s, photo-ID allowed researchers to determine that the whales sighted in northern areas, such as Cape Cod Bay, the Bay of Fundy, and the Great South Channel, were the same whales migrating to the waters of Florida to have their offspring. *(http://research.myfwc.com/features/view_article.asp?id=7511)*

  The Marineland Right Whale Project begun in 2001 includes about 200 volunteers that search for and sight right whales along the coastline from the St. Augustine to Ponce Inlets. The purpose of the project is to supplement the observational capabilities of aerial surveys. The Project also utilizes an AirCam, a twin-engine, slow-flight aircraft developed for National Geographic wildlife surveys, for both aerial surveys and sighting/photo responses. The monitoring effort is coordinated by Dr. Jim Hain (Associated Scientists of Woods Hole) and Joy Hampp (Marineland).

RESEARCH AND MONITORING ACTIVITIES

One of the primary objectives of the ecosystem science program at the GTMNERR is to promote research and monitoring within and adjacent to the Reserve. To date, much of this has been accomplished by both Reserve staff and by facilitating and/or collaborating with outside investigators from universities, government agencies, and private institutions. The benefits of encouraging outside investigations include high quality research, a broad range of expertise, interdisciplinary approaches, potential participation of graduate and undergraduate students and volunteers and a wide range of funding sources that may otherwise be unavailable through NOAA or the FDEP. Hence, the work has included a very diverse array of studies (e.g., ranging from the development of molecular probes to hydrodynamic modeling) that have significantly contributed to our baseline information and insights on the complex structure and dynamics of natural processes in the GTM estuarine system. These studies have provided an important foundation for the development of the current GTM Research Reserve's Management plan, through which future research and monitoring efforts will be guided.

Research facilities

The main facility is the Environmental Education Center (EEC), located off State Road A1A in Ponte Vedra Beach. The 21, 282 square foot building contains a 250 person auditorium, office space, classrooms, a 30 student teaching laboratory designed for hands-on study of the environment, as well as a separate laboratory prep area. The facility also houses 2,000 sq ft of static and interactive environmental exhibits, interpretive exhibits, aquariums, a nature store and an outdoor amphitheater overlooking the Guana River.

The EEC houses a Geographic Information Systems (GIS) resource center with ArcInfo access. A Hewlett Packard Model 800 plotter is available for mapping needs. There is a separate working lab for visiting scientists and Reserve staff, as well as a locker room and shower facilities. A separate aquarium room is available for research purposes, although running seawater is not available.

The GTM Research Reserve's office in Marineland includes a classroom/meeting room with full audio/visual equipment, a resource library, a 23 foot Carolina Skiff for research and educational use, and an adjoining field station. The field station includes a small laboratory used to support research and monitoring efforts by Reserve staff and visiting investigators. In addition to the work and storage space of the laboratory, lockers and a restroom/shower are also part of this facility. Adjacent sleeping quarters with a restroom/shower, small refrigerator and a microwave are available for researchers, students and educators. The Reserve's office at Marineland is in close proximity to the Marineland Oceanarium, River to Sea Preserve and the University of Florida's Whitney Laboratory for Marine Bioscience.

The laboratory facilities at both Reserve offices have dissecting scopes, refrigeration, freezers, and fume hoods. Both facilities also have networked PC computers linked to the internet via an FDEP server.

Ancillary Facilities
The Reserve estuaries are easily accessible to several universities and community colleges in the region including the University of North Florida, Jacksonville University, and Community College of Jacksonville in Jacksonville, the University of Florida (UF) in Gainesville, Flagler College in St. Augustine, St. Johns River Community College in Palatka and Daytona Beach Community College in Daytona Beach. The institutons having facilities and programs of direct relevance to the GTMNERR are described below.

Jacksonville University (JU) is a co-educational, private institution located on 198 acres adjacent to the St. Johns River. In addition to laboratories and classrooms, the university houses an extensive vertebrate and invertebrate collection, the Maggie Wheldon Shell Collection, a fossil collection and herbarium concentrating on the flora of the southeast. Analytical laboratory computer facilities and small vessels for research are available.

JU has also established a new Marine Science Research Institute (MSRI) on the banks of the St. Johns River. The completed MSRI will house the St. Johns Riverkeeper office, along with the FWC, Northeast Florida Fisheries Laboratory, the JU Sailing Program and a new high school marine education program in conjunction with Duval County Public Schools.

The University of North Florida is a four-year college in the State University System. Several faculty and students in the Department of Biology have conducted research within the GTMNERR, and this activity should be further advanced by the department's recently established Master's Degree Program in Biology. Laboratory facilities, several small research vessels and field equipment are available for research. Faculty from the University of North Florida's College of Computing, Engineering and Construction have also been active in the Reserve, developing experimental telemetry systems for transmitting environmental data. Environmental research is expanding at the University as reflected by the recent establishment of a flagship Coastal Biology Program and the Taylor Engineering Research Institute.

The University of Florida (UF), located in Gainesville, has many collegiate, departmental and interdisciplinary programs in education and research in oceanography and marine related fields. Special marine-related facilities include; the Coastal Engineering Laboratory with wind and wave tank, model slabs, wave generators, automatic tide level generator, sand tracer laboratory and extensive field and remote sensing equipment; The Florida Museum of Natural History with research collections of fish, birds, mollusks and mammals; the Coastal Engineering Archives, which provides information on beach erosion, coastal protection and historical shoreline changes in Florida. UF operates a fully certified QA/QC Nutrient Lab, under the direction of Dr. Edward Phlips, through which nutrient samples from both the GTMNERR and the Appalachicola NERR are processed.

UF also maintains an extensive research program through the Whitney Laboratory for Marine Bioscience located at Marineland. Located near the Matanzas Inlet on the border of St. Johns and Flagler Counties, the laboratory presently occupies five acres, with over 20,500 square feet of laboratory and office space. Extensive aquaria, holding tanks and an excellent sea water system can support a variety of marine life studies. Housing is available for visiting scientists and graduate students. Whitney Laboratory facilities were recently expanded with the opening of a 17,000 square foot Center for Marine Studies.

SJRWMD provides the scientific, technical, and regulatory support required to identify and assess habitat and biological resources deemed critical to the ecological integrity of the NCB system which includes the GTMNERR. The District's laboratory support services, headquartered in Palatka, Florida include in-house water quality analysis, logistical support for field sample and data collection, and quality assurance.

The District maintains an extensive GIS database, containing districtwide data layers that are managed by staff in the Department of Information Resources (IR), and project-specific data layers managed jointly by project and IR staff.

GTMNERR Monitoring Activities

Water Quality Monitoring
The GTMNERR participates in the System-wide Monitoring Program (SWMP), described previously in the section on *Water Quality* which provides standardized data on national estuarine environmental trends while allowing the flexibility to assess coastal management issues of regional or local concern. The principal mission of the SWMP is to develop quantitative measurements of short-term variability and long-term changes in the integrity and biodiversity of representative estuarine ecosystems and coastal watersheds for the purposes of contributing to effective coastal zone management. The program is designed to enhance the value and vision of the Reserves as a system of national references sites.

Coastal Strand Transect Monitoring
Coastal strand is found on storm deposited ridges of sand, shell, and debris that parallel the shore behind the dune ridge. This community exists only on the east coast of Florida, and the northern component of the GTMNERR contains 595 acres of this habitat. The goal of the monitoring program is to utilize vegetation surveys to monitor changes through time of species occurrence, dominance, and composition. A series of 4 transects located just north of the GTMNERR Guana River entrance are sampled every April by Reserve volunteers. The transects are located in the field of view of permanent photopoints to provide supplemental data to the transect survey. Data recorded along each transect include species occurrence, percent cover of each species, and average height of the canopy and midstory species.

Vegetation Plot Monitoring
The vegetation plot monitoring program is intended to provide quantitative data to monitor the effects of the prescribed fire program at the Reserve. The monitoring program is designed to document the response of vegetation to prescribed fire through the analysis of species composition and species percent cover. The goal is to understand the vegetative composition changes of each community when fire is re-introduced to each of 4 target areas. The general schedule of monitoring is for Reserve volunteers to sample each plot during April. Data recorded within each plot include species occurrence, percent cover of each species, and average height of shrub and tree species.

Dune Transect Monitoring
Dune vegetation on the Reserve beaches is defined as those plant communities found on the stretch of land between the Atlantic Ocean and U.S. Highway A1A. The goal of this program is to monitor changes through time of species occurrence, dominance, and composition. The schedule of monitoring is for Reserve volunteers to sample six line transects during April. Data recorded within each plot include species occurrence, percent cover of each species, and average height of shrub and tree species using the line intercept method. The transects are permanently located concurrent with survey areas for the Anastasia Island beach mouse.

Prickly Pear (*Opuntia sp*.) Population Monitoring
Reserve staff are monitoring the population of prickly pear cactus and assessing the impacts of the exotic invasive cactus moth (*Cactoblastis cactorum*) on the population contained in the beach dune strand. Goals of the monitoring are to quantify the numbers of active and previously infested plants, assess the ecological impact to other species in the beach dune system if the majority of cacti are destroyed, and to consider the implementation of control eradication measures.

Laurel Wilt Monitoring
Laurel wilt is a deadly disease of redbay (*Persea borbonia*) and other tree species in the Laurel family (Lauraceae). The disease is caused by a fungus (*Raffaelea* sp.) that is introduced into host trees by a non-native insect, the redbay ambrosia beetle *(Xyleborus glabratus*). The fungus plugs the water-conducting cells of an affected tree and causes it to wilt. Laurel wilt has caused widespread and severe levels of redbay mortality in the Southeastern coastal plain. Reserve staff members are monitoring the rate of spread of the disease and will be assessing the impacts on the Reserve ecosystem if the species disappears. Reserve staff are also monitoring for possible genetic resistance to the effects of the fungus (*Raffaelea* sp.) with UF and FDOF researchers.

Prescribed Burning Photo-point Monitoring
Permanent photo-points have been established at each of the burn units within the northern component of the Reserve to monitor the progress of the Reserve's prescribed fire program. Images at each unit are acquired every six months and analyzed to track the community response to the prescribed burn cycle for each unit. Five photo-points have been established to date.

Butterfly Biodiversity Census
Reserve volunteers undertake the annual butterfly biodiversity census in conjunction with the Florida Butterfly Monitoring Network. Butterflies are excellent indicators of biodiversity and ecosystem health. The monitoring of adult butterflies is possible as adults of most species are relatively easy to identify and species may be observed in a variety of habitats. Except for some migrant species, the presence of adult butterflies also shows that all other life stages were successfully achieved in the area.

Exotic Crab Monitoring
The GTMNERR was one of nine NERRs involved in a pilot study to detect exotic (non-indigenous) crabs in local waters. The GTM estuary has been invaded by at least two exotic crab species, including the Indo-Pacific swimming crab, *Charybdis hellerii*, and the porcelain crab,

Petrolisthes armatus. The project was designed to have both spatial and seasonal components that allow for early detection of the arrival of exotic species; tracking and predicting the direction and likelihood of invasive range expansion by those species; and monitoring the abundance and diversity of native crabs before, during, and after the invasion process. Monitoring at the GTMNERR has continued since the study was initiated. Crabs are obtained using experimental habitat trays filled with oyster shell and deployed in patchy mud and oyster habitat. The trays are collected quarterly and all crabs identified, measured and sexed. *Charybdis hellerii* has not been

detected in the habitat trays but has been found in experimental trawls and by commercial crab fisherman. *Petrolisthes armatus* is found in abundance in the habitat trays. Samples collected since 2002 show it to be at least as abundant as the native common mud crab (*Panopeus herbstii*) and the flat mud crab (*Eurypanopeus depressus*).

<u>Invasive Mussel and Barnacle Monitoring</u>
Invasive species monitoring also includes mapping and monitoring of the green mussel (*Perna viridis*) and a large acorn barnacle (*Megabalanus sp*.). Study of green mussel distribution is complemented by research at the University of North Florida, previously discussed under the research section on *Invertebrates*.

<u>American Eel (*Anguilla rostrata)* Monitoring</u>
FWC is mandated by the Atlantic States Marine Fisheries Commission (ASMFC) to monitor young-of-year (also known as glass) eels and adult eels in Florida. In 1999, the ASMFC developed a Fishery Management Plan for American eel, which is an interstate cooperative effort to protect and enhance the Atlantic stock of American eel in the United States while providing

for a sustainable harvest of the species. As part of this requirement, FWC and University of Florida personnel conduct routine monitoring of glass eels at the Guana River Dam (St. Johns County) and juvenile eels at Rodman Reservoir or Kirkpatrick Dam (Putnam County), from January to March. Over an eight-week period in January and February, dip-net sweeps are made twice every half-hour during flood tide at the Guana River Dam site on four randomly selected nights each week. During February and March, lift nets are used to sample juvenile eels twice per week at Rodman Reservoir Dam during randomly selected periods at night. In addition to obtaining catch data, the eels' length, weight, and pigmentation stage are recorded. These data have been collected since 2001 and, along with data from the other participating states, were used in the 2005 coast-wide stock assessment (Bonvechio 2008). However, the most current published report is that detailing the 2003-2004 assessment years (Bonvechio et al. 2004)

FWC biologists also conducted a pilot study at three locations along Pellicer Creek to determine if and when glass eels migrate into this freshwater system. Attempts to collect eels were made using a special fyke (or hoop) net, that was set overnight for at least two separate nights each week during January and February of 2005. The method, however, yielded very few eels.

Sea Turtle Monitoring

The Reserve staff monitors sea turtle nesting activity, previously discussed in the section on *Reptiles.* The Reserve's beach habitat is an active nesting beach that is part of the statewide Index Nesting Beach Survey compiled annually by the FWC. Most of the nests are deposited by loggerhead sea turtles, but nests of the endangered green and leatherback sea turtles have also been documented.

Gopher Tortoise Population Surveying

The Reserve has established a biennial gopher tortoise survey program to assess the current population status of the tortoise within the Guana peninsula. The survey data is also used to document trends in population status in response to management activities. Volunteer-led surveys were completed in 2005 and 2007 in which borrows were identified, classified as active or inactive, and geographically located using a differential GPS unit.

Striped Newt Surveying

The striped newt survey is an annual survey conducted by volunteers during April. Survey areas include a number of pond sites within the northern component of the Reserve.

Bald Eagle (*Haliaeetus leucocephalus*) Monitoring

The bald eagle is a threatened species both in Florida and nationally and expanding development is decreasing suitable habitat. There are several nests within the Reserve boundaries, most prominently an active nest located southwest across the Guana River from the EEC. This nest has been monitored by onsite staff since 2005. The goals of the monitoring program are to encourage public interest in the conservation of bald eagles; participation in a statewide program monitoring nest disturbance and success; documentation of eagle nest locations to avoid disrupting nesting; and collection of data on mated pairs and their nest success each year. Monitoring by volunteers begins in October and continues until eaglets are completely fledged, as late as May. Data on the nest site at the EEC is collected at the beginning of each season and adult and eaglet behavior is recorded at least bi-weekly for twenty minutes.

Least Tern Nesting Surveys

A Reserve volunteer conducts weekly surveys throughout the nesting season (weather permitting) from April-August. The surveys are conducted using an all terrain vehicle (ATV) during low tides and usually in the morning, and are conducted in conjunction with the shorebird surveys discussed below.

Other Shorebird Monitoring

Numerous species of listed shorebirds are known to frequent the relatively undisturbed beaches of the Reserve. Regular shorebird surveys began at the Reserve in 2006 and are conducted weekly throughout the year. Volunteer or staff members use an ATV to traverse the 4.1 miles of beach to observe shorebird activity. Surveys are usually performed in the morning during low tides and are conducted in conjunction with the least tern nesting survey during nesting season. All species and numbers are recorded. Unusual birds are photographed and identified later. Beginning in 2007, data is also collected for the International Shorebird Survey which provides data to national and international agencies.

Marsh Bird Monitoring

The monitoring of both short-term variation and long-term trends in marsh bird populations throughout the Reserve is being accomplished with volunteers following the protocol outlined in the Standardized North American Marsh Bird Monitoring Program (Conway 2005). The primary bird groups addressed through this monitoring effort include rails, bitterns, grebes, gallinules, moorhens, wrens, and sparrows.

This standardized monitoring protocol, which uses broadcast calls to elicit vocalizations, is designed to address a series of issues relating to the monitoring and conservation of marsh birds. Specifically, the goals of this program are:

1. Determine the population status and breeding distribution of marsh birds;
2. Determine species-habitat associations of marsh birds;
3. Determine population trends of marsh birds at local (e.g., NERR Site), regional (e.g., Gulf Coast), and national geographic scales as well as various temporal scales;
4. Determine the environmental factors that influence the distribution of marsh birds;
5. Increase local volunteer (birders or bird-watchers) participation in research and monitoring programs.

Understanding marsh bird populations within the Reserve is important because they: (1) may be affected by the accumulation of environmental contaminants in wetland substrates; (2) are vulnerable to invasive plants; (3) potentially serve as “indicator species” for assessing wetland ecosystem quality; (4) can be used to evaluate the success of wetland restoration efforts; (5) have high recreational value (many species are highly sought-after by recreational birders); and (6) several rails are game species in many states (NERRS 2007).

St. Johns Audubon Fall Migration Peregrine Falcon Count

Peregrines from northern North America migrate in the fall to Central and South America. They often hunt along the barrier islands on the Atlantic and Gulf of Mexico coasts during this time. The goal of the Audubon monitoring effort is to document the population trends of fall migrating peregrine falcons and merlins. Audubon Society volunteers have been counting peregrines, merlins, and kestrels during the fall migration period extending from September 27 – October 12th, since 1997. The location of the count is at the north beach access overlook of the Reserve. Data are submitted by Audubon to *www.hawkcount.org* and *www.hawkwatch.org* for national and international coordination.

Anastasia Island Beach Mouse Monitoring

Monitoring of the Anastasia Island Beach Mouse by the Reserve is intended to ascertain the population viability and recovery. The population located at the Reserve is one of only 3 populations of this sub-species. Mouse populations are monitored quarterly in conjunction with the monitoring program at Anastasia Island State Park. Trapping is conducted for two nights each quarter. Three transects are set with 2 traps every 15m for a total of 40 traps per transect. Volunteers record general weather conditions and captured mouse condition. Mouse data collected includes sex, pelage condition, weight, reproductive condition, ear tag number, and tail clip for genetic analysis. Unmarked mice receive ear tags placed in the left ear for subsequent re-identification.

National Water Level Observing Network

The National Water Level Observation Network (NWLON) is the fundamental observational component of the National Water Level Program (NWLP). The NWLON is a network of 175 long-term, continuously operating water-level stations throughout the USA. There are additional stations within the GTMNERR boundaries that are not currently operating but for which archived data and predicted tide data are available. The data continuity, the vertical stability and careful referencing of NWLON stations have enabled the data to be used to estimate relative sea-level trends for the Nation. Both current and historical tide data can be accessed from the NWLON Web site at *http://tidesandcurrents.noaa.gov/nwlon.html*.

National Data Buoy Center

The NOAA National Data Buoy Center (NDBC), designs, develops, operates, and maintains a network of data collecting buoys and coastal stations. NDBC provides hourly observations from a network of about 90 buoys and 60 Coastal Marine Automated Network (C-MAN) stations to help meet these needs. All stations measure wind speed, direction, and gust; barometric pressure; and air temperature. In addition, all buoy stations, and some C-MAN stations, measure sea surface temperature and wave height and period. Conductivity and water current are measured at selected stations.

There are two NDBC stations in proximity to the Reserve; one is on the St. Augustine Beach Pier, with near real-time data available at *http://seaboard.ndbc.noaa.gov/station_page.php?station=sauf1*. The other station is a weather buoy 40 nautical miles ENE of the St. Augustine Inlet, with near real-time data available at *http://www.ndbc.noaa.gov/station_page.php?station=41012*. The NDBC also carries the data generated from the GTMNERR's Pellicer Creek stations at *http://www.ndbc.noaa.gov/station_page.php?station=gtqf1* and *http://www.ndbc.noaa.gov/station_page.php?station=gtxf1*.

The NERR Graduate Research Fellowship Program

The National Estuarine Research Reserve System's (NERRS) Graduate Research Fellowship Program was established in 1997 to support graduate students interested in coastal and estuarine sciences. By providing stipends, a living laboratory and a broad network of fellow scientists, the reserve system aims to encourage and enable talented young scientists to contribute to the knowledge base, provide the science to support coastal decision- making and train future coastal scientists and policy-makers.

The Graduate Research Fellowship Program provides master's degree students and Ph.D. candidates with an opportunity to conduct research of local and national significance that focuses on enhancing coastal zone management. Fellows conduct their research within a National Estuarine Research Reserve and gain hands-on experience by participating in their host reserve's research and monitoring programs.

Graduate Research Fellowship projects are based on the reserves' local needs, the reserve system's national priorities and the students' interest. A majority of the projects funded to date have addressed the pressing issues of non-point source pollution and habitat conservation and restoration. All fellowship projects address issues important to coastal zone management and enhance our understanding of estuarine ecosystems. National Estuarine Research Reserve Fellows are the leaders for the next generation of estuarine scientists; they are influencing the decisions made today for a better coast tomorrow.

GRF projects support the reserve system by studying pressing estuarine management topics with local, regional and/or national significance. Fellows also engage with reserve staff members to contribute to their host reserves' research and monitoring programs, while gaining hands-on skills to complement their academic studies.

As of August 2009, 8 research projects have been completed or were currently underway within the GTMNERR. One of the projects was funded through the ACE Basin NERR, with portions of the research being conducted in the GTMNERR.

Summaries of the abstracts of the research projects, as well as the name of the researcher, fellowship date, and academic affiliation are given below. More details of the fellowship program can be found on the NERR Web site at *http://www.nerrs.noaa.gov/Fellowship/welcome.html*.

- **Describing human uses, evaluating existing management and delineating ecological resources, the formulation of an estuarine planning strategy: A case study of the GTMNERR**
  Ashley Murphy (Johnson), Graduate Research Fellow 2001-2004
  University of Florida

  The research combined the best of land use zoning and protection strategies to create an estuary plan that identifies areas for natural resource protection, while enhancing water-dependent uses. This research has resulted in a scientifically defensible method for creating estuarine zones based on resource presence and human use patterns, integrating the ecological, sociological, and political components of a coastal area to create zones of marine use and space.

  Estuary planning in particular is needed in the GTMNERR as this coastal area is under development pressure. The results of this research contribute to coastal and marine resource management through the development of a methodology for inventorying important coastal and estuarine resources, subsequently leading to a better understanding of how humans interact with the coastal and marine environment.

- **How estuaries respond to nutrient load: the Guana Tolomato Matanzas National Estuarine Research Reserve as a model case**
  Nicole Dix, Graduate Research Fellow 2006-2009
  University of Florida

  Predicting the consequences of eutrophication in coastal ecosystems has become a major priority for marine researchers. Estuaries are difficult to empirically model, however, due to their highly dynamic nature. This three-year research project is using the Reserve as a model system for comparing the effects of different nutrient load scenarios in highly flushed estuaries. The objective of the research effort is to determine the differences in the response of selected components of the benthic and attached biota to the nutrient load scenarios in the San Sebastian and Matanzas regions of the GTMNERR. Water quality analyses will provide spatial and temporal nutrient gradients, which can be related to benthic macroinvertebrate community structure and periphyton colonization rates. In addition, the results will add to the baseline knowledge of the GTMNERR and can ultimately be used to create more effective management plans for the conservation of estuarine systems around the world.

- **Winter recruitment of young-of-the-year bluefish, Pomatomus saltatrix, into Northeast Florida estuaries: Aspects of distribution, essential habitat, diet and condition**
  Peter Clarke, Graduate Research Fellow 2004-2005
  University of Massachusetts

  Juvenile bluefish, *Pomatomus saltatrix*, spend their first summer in Mid-Atlantic Bight estuaries and coastal waters. A southerly fall migration takes places in coastal waters in the western Atlantic during the fall to over wintering grounds in the Southern Atlantic Bight. Very little is known about the wintertime distribution and trophic dynamics of juvenile bluefish in southern waters at the edge of their geographical range.

The collection of bluefish and their potential prey during the winter in Northeast Florida was focused around estuarine and coastal waters from two sites. The Matanzas Inlet which is unique in Northeast Florida as one of the last remaining natural and least environmentally impacted inlets within Florida, and St. Augustine Inlet which suffers from results of human land development. The comparison of two disparate sampling locations with similar habitat and species assemblage within the same geographical location provided an opportunity to examine dependent variables responsible for bluefish winter recruitment. Further discussion of this project is included in the research section on *Fishes*.

- **Assessing and modeling mangrove forest dynamics along the temperate-subtropical ecotone in eastern Florida**
  Susan E. Leitholf, Graduate Research Fellow 2004-2008
  University of Central Florida

  Mangrove communities are adapted to intertidal flooding regimes and have historically been found along the entire east coast of Florida. Mangroves are freeze intolerant and hence are restricted to subtropical environments. The Reserve is home to the northernmost extent of mangroves along the Atlantic coast, which have been recovering from a series of freezes in the 1970s and 80s. This research hypothesized that increasing temperatures and a reduction in the freeze frequency and intensity would result in a northward expansion of mangrove into the salt marsh zones in the GTMNERR. Such an expansion represents a major landscape change that will have significant impacts on birds, fish, and other species relying on coastal vegetation. In addition to mangrove spreading into its historic range, Brazilian pepper (*Schinus terebinthifolius*), an exotic species that competes with mangrove in nearby estuaries will benefit under a warming trend. The vagility of this bird-dispersed exotic may permit it to establish more rapidly than mangrove.

  The dynamics of these species along this ecotone were investigated by mapping the current and historic distributions of mangrove in the GTMNERR using field surveys, GPS, GIS, aerial photography and satellite imagery. To understand the growth patterns of the three native mangrove species and Brazilian pepper, the growth and demography of leaf and reproductive tissues was monitored for two years across the ecotone. With these and related environmental measures, a forest gap succession (FORMAN) model was developed to simulate mangrove recruitment, growth and competition in the GTMNERR. The model was coupled to a dispersal model to make predictions of rate and location of spread of these species in the Reserve under different climate and sea level rise scenarios.

- **Estuarine Response to Extreme Events – The GTMNERR Case Study**
  Bilge Tutak, Graduate Research Fellow 2007-2009
  University of Florida

  This project will assess the response of the Reserve, a representative estuary in the Southeastern US, to extreme events (e.g., tropical cyclones, strong coastal upwelling events, and Northeasters). Extreme events bring sharp changes in environmental conditions (e.g., salinity, water temperature, and wave-induce sediment resuspension), which adversely affect estuarine resources (e.g., habitat and benthos). In the summer of 2003, the GTMNERR experienced a rapid and persistent water temperature drop (>7^{o}C) due to a persistent coastal upwelling event in the South Atlantic Bight (SAB). In August through October, 2004, the Reserve experienced an extreme salinity drop (>20 PSU) due to four major hurricanes in August and September. It is hypothesized that the extended low salinity period in the Reserve was due to the heavy rainfall and poor exchange in the St. Augustine and Matanzas Inlets which prevented the saline ocean water from entering the estuary during the hurricanes. This project will quantify the exchange patterns at the two inlets and within the Reserve during non-extreme and extreme events. In-situ and satellite data during past and subsequent extreme events will be gathered, and numerical models of estuarine hydrodynamics will be used to synthesize the data and to assess the system-wide response of the GTM to extreme events. Validated numerical models will be used to simulate synoptic-scale environmental conditions and to identify regions of sharp changes and gradients, where appreciable impact on habitat and benthos are expected.

- **The effect of salt spray, freshwater supply and forest seed source on ecological succession on dredge spoil islands along the intracoastal waterway in northeastern Florida**
  John Baker, Graduate Research Fellow 2001-2004
  University of Florida

  In this study, the effect of salt spray, freshwater supply and forest seed source on ecological succession on different aged dredge spoil islands along the IWW in Northeastern Florida was determined. The study provided basic knowledge about spoil island habitat, evaluated the presence of patterns in the primary succession of maritime forests and spoil islands, provided information on the ability of spoil islands to support tree growth and provided information on how size, shape and location of spoil islands determine specific vegetation patterns. The study, when published, will contribute to developing methods for estuarine ecosystem restoration and provide information on mechanisms for sustaining resources. It will help determine how quickly maritime forest can be restored through primary succession and natural seed dispersal mechanisms given certain environmental and spatial variables. Soil characteristics measurements included organic matter content, soil moisture and soil particle size. The Point-Centered Quarter Method and the Braun-Blanquet Scale was used to measure abundance and cover for plant species on randomly located east-west transects. Soil moisture and relative elevation were estimated at each vegetation sampling point. Soil cores for percent organic matter determination and salt spray were sampled on one-east-west transect for each spoil island. Maritime forest tree seeds and seedlings were planted in different vegetation zones. Tree growth and survivorship was measured.

- **Using the reserve system to explore plant-herbivore interactions: Latitudinal variation and impacts of climate change**
  Chuan-Kai Ho, Graduate Research Fellow 2004-2007 (with ACE Basin)
  University of Houston

  This project focused on biodiversity, one of the research focus areas for the NERR system. This project used an existing suite of 13 reserves and 3 Long Term Ecological Research (LTER) sites along the Atlantic Coast as a network to examine latitudinal variation in plant-herbivore interactions. This geographic variation is driven in part by different traits of populations in different geographic locations. In addition, this project tested the potential impacts of climate change on plant-herbivore interactions by examining the importance of differing shifts in plant and herbivore population ranges.

  Using a combination of greenhouse experiments (focusing on growth of herbivores from different geographic regions feeding on plants from different geographic regions) and field sampling (of herbivore abundances, size and damage to plants), the project focused on four plant species and their most common 6 herbivores. All of the species are widely distributed along the Atlantic Coast of the U.S. Working with multiple species ensured that the results are general and not idiosyncratic to a single plant or herbivore species. The ACE Basin Reserve was the host reserve.

- **Do grazers and drought stress interact to drive die-off and foundation plant species shifts in Florida marshes?**
  Schuyler van Montfrans, Graduate Researh Fellow, 2009
  Universitry of Florida

  Evidence from salt marshes along the eastern coast of the U.S. suggests that grazers in salt marshes have been substantially overlooked as important drivers of changes in community structure, as well as large-scale die-off of *Spartina*, and that these effects are exacerbated by drought stress. Droughts have increased in both frequency and intensity, and may be acting to accelerate the effects of increasing grazer populations.

  This project focuses on the role of the purple marsh crab, *Sesarma reticulatum*, and its role as a consumer in driving foundation species shifts (specifically from *Spartina alterniflora* to the succulent plant, *Salicornia virginica*). The goal of this research is to determine the singular and relative (vs snails and simulated drought stress) impacts of *S. reticulatum* grazing on marsh productivity, marsh die off expansion and shifts in marsh plant species dominance. To test how grazing by *S.reticulatum* impacts *S. alterniflora* and the shift in foundation species to the succulent *S. virginica,* crab exclusion cages will be deployed in both healthy and heavily-grazed marsh areas, as well as along the borders of *S. alterniflora* and *S. virginica*. To test whether physical stress and marsh periwinkle grazing exacerbate the effects of *S. reticulatum* grazing, caging experiments will be conducted to manipulate densities of *S. reticulatum* and snails, as well as the salt content of the soil. This study will be the first to quantify these effects, and will be vital to the long-term monitoring and management of these habitats.

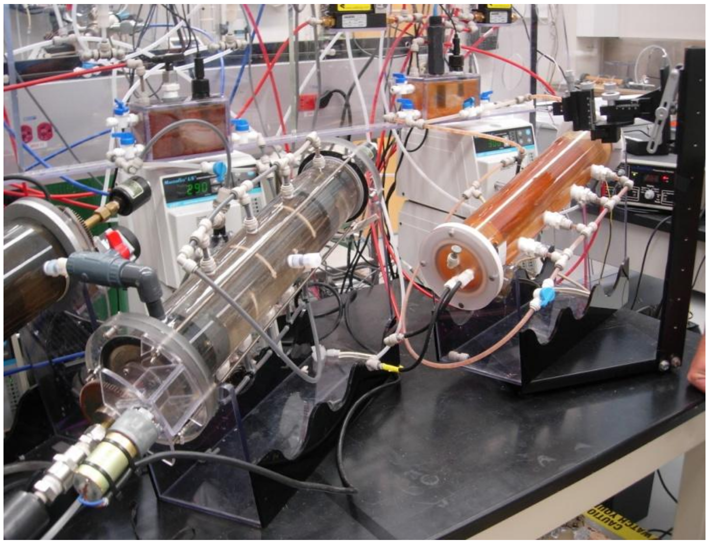
Cooperative Institute for Coastal and Estuarine Environmental Technology (CICEET) Program

The Cooperative Institute for Coastal and Estuarine Environmental Technology (CICEET) is a research funding partnership of NOAA and the University of New Hampshire (UNH), established to transform the best available science into practical, innovative tools that coastal managers need to address their priority challenges. CICEET uses the capabilities of UNH, the private sector, academic and public research institutions throughout the U.S., as well as the 27 NERRS in the reserve system, to develop and apply new environmental technologies and techniques. Since its inception in 1997, CICEET has invested in more than 170 environmental technology development, demonstration, and application projects. The CICEET toolkit contains dozens of field ready tools to address a range of environmental challenges along the nation's coasts. Listed below are the projects within the GTMNERR that have been funded or have been proposed through the CICEET program.

- **Redox Control Bioreactor for Enhanced Nitrogen Removal from Septic Tank Effluent**

  Coordinator: Dr. Jay L. Garland, jay.l.garland@nasa.gov

  Nitrogen pollution of coastal waters from on-site septic systems is a widespread problem. Advanced onsite treatment based on traditional nitrification/denitrification approaches are inherently limited; the low carbon/nitrogen ratio of the waste stream limits denitrification, leading to significant levels of residual nitrate which can readily contaminate ground water. Introducing hydrogen to on-site waste treatment represents an inexpensive, clean means of reducing residual nitrate via the stimulation of hydrogenotrophic denitrification, a microbial process which converts nitrate to N_2 without the need for organic carbon (i.e., autotrophic process). Hollow fiber membranes are an effective means of delivering relatively insoluble gaseous substrates to biological reactors, relying on diffusion rather than sparging to provide gases to biofilms growing directly on the fiber surfaces. Hollow fiber membrane reactors based on either O_2 or H_2 delivery have been evaluated for aerobic (i.e., nitrification) or hydrogenotrophic processes.



  The work involved an innovative membrane reactor design in which juxtaposed fibers receiving O_2 and H_2 allow for simultaneous nitrification and hydrogenotrophic denitrification within a single reactor. The basic concept of the redox control reactor (RCB) was validated in tests with a synthetic, ammonia-rich waste stream, allowing the proposed work to focus on its application to septic tank effluent (STE) processing. STE treatment in the RCB will require pretreatment to remove organic material so that fast growing heterotrophs will not out compete the slowly growing nitrifiers for space on the hollow fibers within the RCB.

The major product of the work is conclusive results of the system performance under actual field conditions, allowing for a clear decision regarding the potential development of a commercial unit.

Start Date: 2006-07-15
End date: 2008-09-15
Funding Amount: $339,059
Status: Final report submitted 2009 (Garland and Smith 2009)

- **Real-Time Detection of Specific Pathogens with a Fiber Optic Biosensor and Determination of the Source of Bacterial Contamination Using Antibiotic Resistance Analysis and Ribotyping of *E. coli* in the GTMNERR**

Coordinator: Dr. Valerie (Jody) Harwood, vharwood@cas.usf.edu

As coastal areas are increasingly impacted by development and pollution from stormwater runoff and sewer discharges, there is an increasing need to rapidly and specifically identify microbial pathogens that can affect human health. An ideal water test should be able to: (1) detect specific disease-causing human pathogens (not simply indicator organisms) in real time (within a few minutes or few hours of sampling), (2) quantitate and differentiate between viable and nonviable microorganisms, (3) be performed on a compact portable platform that can be operated by minimally trained field personnel, and (4) be automated or adapted to process numerous samples for multiple target pathogens simultaneously. An innovative fiber optic biosensor system developed in our laboratory has these capabilities. The national significance of rapid detection of pathogens is difficult to overestimate, and will have a positive impact on our ability to forestall incidences of human illness related to the use of Florida water resources.

The project objectives were as follows:
- Develop biosensor assays for representative waterborne pathogens *Vibrio vulnificus* and indicator organisms (*Enterococcus spp*) for use in marine and estuarine waters.
- Evaluate the use of the Analyte 2000 biosensor for real-time detection of pathogens and indicator organisms (*Enterococcus spp.*) in marine and estuarine waters of the GTMNERR. Sample sites included San Sebastian Creek, a watershed that is heavily impacted by the shipping industry, Marshall Creek, which empties into the Tolomato River and which is the site of a large housing development, and the relatively pristine Pellicer Creek, which empties into Matanzas inlet. As many as five sites per watershed were sampled on a monthly basis over twelve months.

Start Date: 2001-09-01
End Date: 2004-09-01
Funding Amount: $198,433
Status: Final Report 2005

This work suggests that fiber optic biosensors/immunosensors with the sensitivity and specificity needed to detect low numbers of target bacteria in environmental samples may eventually be developed; however, the instrument used in this study could not achieve that goal given the antibodies and fluorophores available. Sample enrichment improved the sensitivity of detection for *V. vulnificus*, and ultimately 100 CFU could be detected in saltwater in one working day. The differences between the assays conducted with enterococci vs. *V. vulnificus* illustrate the necessity of a high-affinity antibody preparation for success of immunosensors. Because antisera are a biological product, they are generally a less reproducible ligand or identifier than other types such as oligonucleotides. Furthermore, as proteins, they are subject to degradation over time, and may not be ideal for use in remote platforms. However, in many instances high-affinity antiserum preparations have proven useful in the medical field, and the goal of optimization of biological ligands for use in sensor technology remains worthwhile. (Harwood and Lim 2005).

- **Multichannel Handheld Sensor for Microbial Contaminants**

  Coordinator: Dr. John Paul, jpaul@marine.usf.edu

  Harmful algal blooms (HABs) such as red tide threaten human and ecological health, and are responsible for an estimated $50 million in medical expenses and losses in the shellfish, finfish, recreation, and tourist industries. Current red tide monitoring methods are labor-, skill-, and equipment-intensive, and sometimes inaccurate. This project's investigators have already developed a faster, more sensitive method of detecting Florida's red tide microbe. Working with the State of Florida's Bureau of Aquaculture Environmental Services, investigators adapted this costly, sophisticated technology into a field-ready, fast acting, handheld sensor for use by non-technical personnel. The objectives of the research were to develop a multichannel handheld analyzer to detect microbial contaminants based upon Nucleic Acid Sequence Based Maplification (NASBA), and to develop a simple method for field nucleic acid extraction from environmental samples.

  Start Date: 2005-09-01
  End Date: 2008-09-01
  Funding Amount: $300,956
  Status: Final Report 2009 (Paul and Fries 2009)

Other research activities
The Reserve also sponsors or supports a variety of other research activities. Listed below are brief descriptions of other research that is either completed or underway within the Reserve.

- **Investigation of Sympatric Speciation by Host-Race Formation in the Gall Midge *Asphondylia borrichae* (Rossi & Strong)**
  Keith Stokes from the UNF's Department of Biology is using the gall midge (*Asphondylia borrichiae*) to investigate sympatric speciation. The gall midge oviposits in the shoot apical meristem of three species of coastal plants with overlapping ranges. Ovipositing results in the formation of galls, nearly sphericalgrowths of plant tissues surrounding the eggs. He will be collecting galls from three geographically disparate sites, one of which is within the

GTMNERR. The galls will be held in vials while the flies complete their development. DNA analysis of the flies will be used to evaluate relationships between the flies and the different host species.

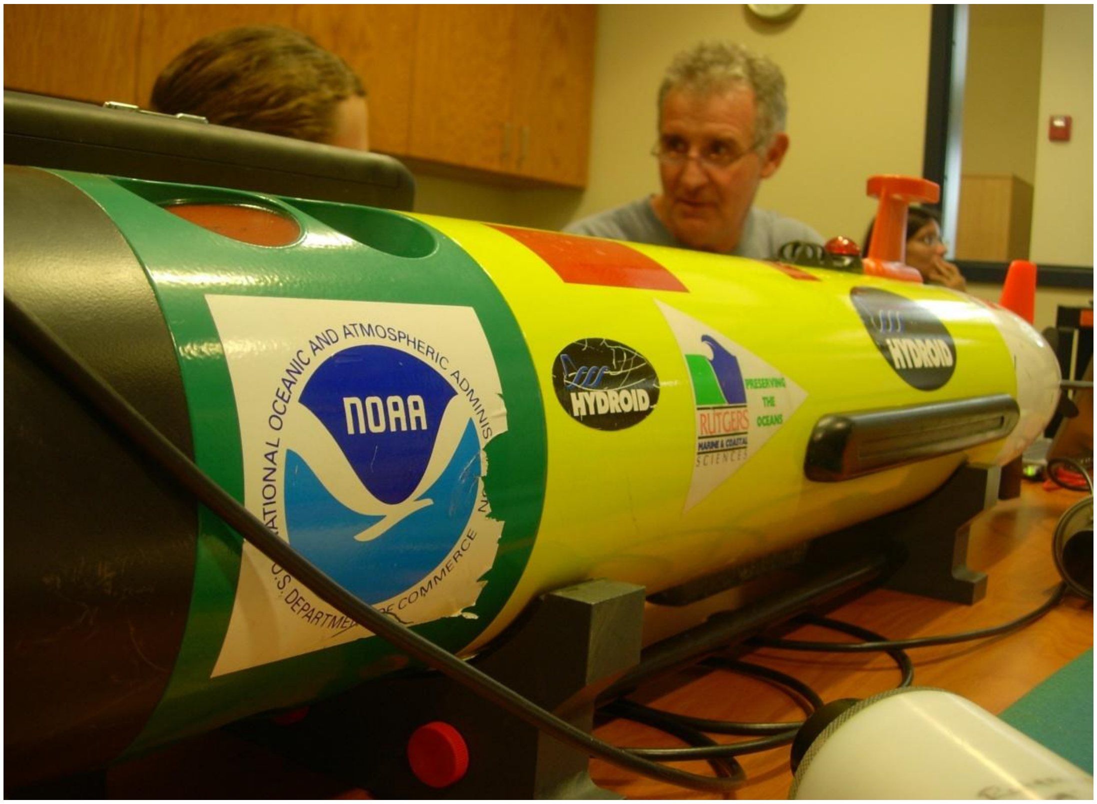
- **Ecology of Tick-borne Pathogens in the Southeastern USA**
  Lyme disease is caused by several species of spirochete bacteria within the *Borrelia burgdorferi* genogroup but very little is known about their ecologyin the Southeast. Dr. Kerry Clark with UNF's Department of Public Health has proposed to gain a more thorough understanding of the unique ecology of *Borrelia* in the southeast to clarify ecologcial determinants of the presence, geographic distribution, genetic variability, reservoir hosts, tick vectors, and human disease transmission risk for this pathogen. The sampling protocol includes the collection of organisms within the GTMNERR.

- **Assessment of Water Quality in the Guana-Tolomato-Matanzas Estuary: A first application of the ACES workbench (Fox et al. 2007)**
  To better assess water quality at estuarine sites, the Surface Water Quality Monitoring Program at the St. Johns River Water Management District (Florida) created a new approach using the Analytical Framework for Coastal and Estuarine Study (ACES), a GIS-based toolset and geodatabase schema (presented by Bourne et al. 2007; at ERF 2007). The methodology focuses on first-principles-analysis of the estuary. First, the relative importance of tidal versus terrestrial flow on estuarine hydrodynamics is assessed using bulk parameters derived from geomorphology and measured flows in the estuary. Then, a control volume is defined by intersecting the tidal-plane and estuary bathymetry. Boundaries of the control volume are user-defined through qualitative knowledge of the flow field. Regression or other model approaches aimed at finding the correlative relationships between the influential factors of upstream riverine drainage, coastal drainage, and estuarine non-point source pollution are subsequently derived.

  A case study applying the methodology to the GTM estuary indicates that while the estuary is heavily affected by tide, there is significant correlation between land-based pollutants and water quality. The ACES tool has been designed to augment the successful ArcHydro data model that falters in coastal applications, by creating an environment where data from diverse sources can be synthesized.

- **Northern Coastal Basin 2006 Oyster Mapping**
  SJRWMD's NCB SWIM Plan (Haydt and Frazel 2003) identified the mapping of the extent of oyster habitat as an important data need for developing habitat protection and restoration in the basin. Spatial data regarding the extent of intertidal oyster habitat and subsequent GIS mapping of oyster habitat within the NCB, including the GTMNERR, was completed by Linda Walters and Paul Sacks from UCF. The GIS-based oyster coverage and maps were created by analyzing aerial imagery taken at low tides. The final product also included ground truthing and an assessment of accuracy. SJRWMD staff members are continuing to ground truth the existing map in order to expand the coverage.

- **Mapping GTMNERR Offshore Habitats**
  During October of 2008 Reserve staff coordinated with Rutgers University scientists from the NOAA Undersea Research Program for a side-scan sonar and current-profiling survey within the northern oceanic region of the GTMNERR using REMUS, a multifunctional autonomous underwater vehicle (AUV). REMUS was programmed to run a series of transects in a zig-zag pattern at a fixed speed and three meters above the bottom from the north to south end of the offshore section of the Reserve. Information on bottom topography and current profiles in addition to temperature, salinity and turbidity along the course of each transect was generated. This mission provided an important first look at the habitat characteristics of the oceanic portion of the Reserve's northern component.



- **Quantification, Analysis, and Management of Intracoastal Waterway Channel Margin Erosion in the Guana Tolomato Matanzas National Estuarine Research Reserve, Florida (Price 2006)**
  A GIS based study implicated and quantified the extent of marsh shoreline erosion brought about by boat wakes along the IWW in the southern component of the Reserve. Analyses of aerial photographs of the southern half of the Reserve showed high rates of erosion along the margin of the IWW. From 1970/1971 to 2002 nearly 70 hectares (approximately 170 acres) of shoreline habitat were degraded by erosion along the 64.8 kilometers of channel margin analyzed. Essential habitats including oyster bars and salt marshes were reduced to intertidal sand flats.

  Exposure to boat wakes was found to be the causal factor most strongly correlated with the rate of lateral margin movement. Margin movement rates were also found to vary significantly with exposure to wind waves and with the type of channel margin eroded. A reduction in nearshore wave energy appears to be necessary to allow the recovery of impacted ecosystems.

- **Linking Atmospheric Mercury Deposition to Methylmercury Bioaccumulation in Estuarine Fish at Atlantic NERR Sites**
  The transport and transformation processes connecting atmospheric deposition of mercury to its bioaccumulation in fish are many, complex and uncertain. In 2009 a collaborative study with the Center for Coastal Fisheries and Habitat Research in Beaufort, NC [one of NOAA's National Centers for Coastal Ocean Science (NCCOS)] was initiated to investigate links between atmospheric mercury deposition and bioaccumulation of methylmercury in estuarine biota at selected east coast NERR sites. GTM staff are collecting oysters (*Crassostrea virginica*) and fish (*Fundulus heteroclitus*) at strategic locations within tidal creeks of the Reserve for subsequent chemical analyses at the NCCOS laboratory in Beaufort. The project will examine whether or not a latitudinal gradient in mercury concentration in estuarine sentinel organisms parallels the latitudinal gradient in atmospheric mercury deposition.

ASSESSMENT OF RESEARCH AND MONITORING NEEDS

Interviews with Reserve staff, academic scientists, outside agency personnel, and other interested parties have identified the following research facility needs, research gaps, monitoring priorities and needs, and research priorities and needs for the GTMNERR.

Research Facility Needs

- Several investigators have indicated the desire for an additional water quality sampling station in the vicinity of the SR 206 bridge that crosses the IWW. This region of theMatanzas estuary is tidally influenced by both the St. Augustine and Matanzas Inlets and is reltively narrow by virtue of the causeway and bridge structure. It therefore representing an interesting choke point in the estuary worthy of water quality monitoring; moreover, this area is one of the NOAA sites for the Mussel Watch program. Ideally, this station would be equipped with the same SWMP water quality sampling devices as the Pellicer Creek station.

- An expansion of sleeping accommodations at both Reserve locations will enable larger groups of researchers to work in close proximity to the Reserve.

- The installation of an auxiliary sampling platform at the Pellicer Creek site would provide space for additional sampling equipment such as an ISCO sampler and periphyton samples.

Research Gaps

- Ideally, biological monitoring should focus on multiple trophic levels (e.g., phytoplankton, zooplankton, macroinvertebrates, fishes, and marine mammals) and habitats incorporating measures of both species/habitat biodiversity and condition. This multiple trophic level monitoring is not yet in place. It will complement the expansion of the national SWMP effort to include assessments of habitat changes in biodiversity, population structure, and productivity in coastal communities related to anthropogenic and climate change impacts.

- The GTMNERR submerged habitats are not well characterized. An up-to-date baseline inventory of habitats and species together with the development of protocols for conducting change analyses and predictive modeling is needed. In addition, mapping of submerged habitat sediment grain size, bathymetry and hard-bottom resources to serve as baseline for future change analyses and habitat suitability modeling efforts is needed.

- There is a need for information concerning the status and trends in recreational and commercial fisheries within the Reserves boundary.

- Storms are often the cause of major coastal shoreline changes, exacerbating the impact of anthropogenic influences, such as sea level rise, inlet management, beach renourishment and channel dredging, on natural sediment dynamics (Michener 1997). Sediment transport modeling is necessary to quantify these processes and predict the outcome of anthropogenic and natural events.

- Our understanding of coastal circulation in the nearshore and offshore waters of the Reserve is lacking due to very few observations, except at NDBC buoy 41012 approximately 40 nautical miles offshore, and NDBC 41009 at about 20 nautical miles offshore of Cape Canaveral. The proximity of these waters to estuarine outflows from St. Augustine Inlet and the Matanzas Inlet heightens the potential for serious impacts to the integrity of all elements of the coastal environment, including plankton, invertebrate and fish communities, as well as the quality of recreational resources, such as beaches. Installation of a chain of offshore buoys and associated sampling equipment would enable researchers to begin to develop a hydrodynamic understanding of the offshore environment. This basic research could then be used to study the effects of nutrient flows from the estuary and offshore, as well as the bio-physical interactions between the two environments.

- Previous analysis of erosive trends of shoreline suggests that increased nearshore wave energy caused by boat wakes is the primary cause; however, further research may be necessary to accurately relate wake energy to erosion rates. Such work should be followed by the development and implementation of a plan intended to address the problem of erosion in the Reserve.

Monitoring Priorities and Needs

- There is an immediate need to evaluate existing ecosystem science information to establish baseline conditions in order to evaluate and prioritize future management activities. Long-term systematic monitoring of pollutants, habitats, and estuarine species has not been initiated throughout the GTMNERR, and in particular in the Reserve’s CAMA managed boundaries.

- Long-term standardized monitoring is needed to assess trends in the condition of the Reserve’s water quality and biological resources. Monitoring has been initiated through the SWMP but data collected from other entities needs to be collated and analyzed. Analysis and monitoring of the composition of estuarine and oceanic species is needed to track short-term variability and long-term trends.

- The initial GRMAP and PCAP management plans include habitat and species inventories (DNR 1991) that should be updated, or a general GTMNERR inventory should be conducted using standardized methods to facilitate change detection.

- Basic biological monitoring of phytoplankton, zooplankton, and macroinvertebrate communities is needed to develop an understanding of the basic trophic status of the estuarine ecosystem.

- Establishing long-term baseline mapping of the Reserve's upland habitats is necessary to track short-term variability and long-term trends. Habitat change monitoring is necessary to set management priorities and to assess the resiliency of the Reserve's habitats.

- The influence of long-term climate change, particularly global warming and sea level rise, on the Reserve's habitat and species composition will need to be monitored closely to guide future long-term management strategies.

- Consolidating research and monitoring information from a variety of local, state and national programs is needed to produce a comprehensive watershed plan for sustainable protection of the water quality and coastal habitats of the Reserve.

Research Priorities and Needs

- There is aneed for continued coordination with the GTM Research Reserve's CTP and Education programs to facilitate translation and communication of the Reserve's research results. The GTM Research Reserve's Management Plan emphasizes such educational linkages and particularly the use of research and monitoring information in guiding adaptive management decisions.

- Climate change is predicted to strongly affect coastal areas due to sea level rise, increase in storm frequency, and changes in weather patterns. Since human populations are increasingly drawn to coastal areas, the continued interactions of human activities with the natural environment need to be understood, especially in light of a changing climate, which may alter these interactions (NERR 2007).

  As the national effort develops, the SWMP program is being expanded to include assessments of habitat loss and changes in biodiversity, population structure, and productivity in coastal communities as a result of climate change impacts. One of the main objectives of the climate change assessment will be to establish a surface elevation table (SET) network within wetland habitats (e.g. marsh, mangroves, etc.) of the Reserves to support long-term monitoring and research of factors affecting the elevation of coastal wetlands with respect to sea level. SET data will be analyzed to develop surface elevation trajectories which will allow the evaluation of whether the wetland surfaces are keeping pace with sea level. Coupled with other components of SWMP, this information could be used to investigate processes resulting in elevation change, and community responses to this change.

- Primary production, respiration and the balance between the two, or net ecosystem metabolism (NEM), has been assessed for many of the NERR estuaries (Caffrey 2003). The GTMNERR was not included as sufficient data for the system had not been acquired. Sufficient data is now available such that the NEM for the GTMNERR can be assessed. This assessment is consistent with the NERR SWMP goal to examine short-term variability and long-term changes in representative estuarine ecosystems (Wenner et al. 2001).

- Habitat suitability modeling or similar efforts should be implemented as a predictive tool to guide management decisions affecting natural biodiversity.

- The influence of anthropogenic water diversions from aquifers for drinking water, irrigation and lake management on the Reserve's natural resources requires further study

- Researchers from UF have numerous biological samples collected in conjunction with ongoing projects that have been archived, but have yet to be analyzed. Analysis and characterization of the samples would greatly expand the knowledge base of basic biological information in the Reserve. A catalog of samples collected is included in Appendix C.

- More in-depth work aimed at establishing a stronger causal correlation to shoreline erosion and boat wakes could involve field measurement of wave energy and an attempt to correlate wave energy with fetch, nearshore bathymetric profile, local sediment type, and erosion rates. Such a study could develop a comparison of the net volumes of sediment transported by relatively small but frequent wind waves and larger but less frequent boat wakes.

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APPENDIX A. LIST OF SPECIES

Common Name	Scientific Name
Kingdom Plantae	
Phylum Pterophyta (ferns)	
Carolina Mosquito Fern	*Azolla caroliniana*
Cinnamon Fern	*Osmunda cinnamomea*
Royal Fern	*Osmunda regalis*
Golden Polypody	*Phlebodium aureum*
Resurrection Fern	*Pleopeltis polypodioides var. michauxiana*
Lacy Bracken	*Pteridium aquilinum var. caudatum*
Water fern	*Salvinia auriculata*
Southern Shield Fern	*Thelypteris kunthii*
Shoestring Fern	*Vittaria lineata*
Netted Chain Fern	*Woodwardia areolata*
Virginia Chain Fern	*Woodwardia virginica*
Phylum Pinophyta (cone-bearing plants)	
Red Cedar	*Juniperus virginiana*
Sand Pine	*Pinus clausa*
Slash Pine	*Pinus elliottii*
Longleaf pine	*Pinus palustris*
Pond Pine	*Pinus serotina*
Loblolly Pine	*Pinus taeda*
Pond cypress	*Taxodium ascendens*
Phylum Magnoliophyta (flowering plants)	
Blue Maidencane	*Amphicarpum muhlenbergianum*
Florida Bluestem	*Andropogon floridanus*
Purple Bluestem	*Andropogon glomeratus var. glaucopsis*
Bushy Bluestem	*Andropogon glomeratus var. pumilus*
Broomsedge	*Andropogon longiberbis*
Splitbeard Bluestem	*Andropogon ternarius*
Broomsedge Bluestem	*Andropogon virginicus var. virginicus*
Green Dragon	*Arisaema dracontium*
Wiregrass	*Aristida beyrichiana*
Woollysheath Three-awn	*Aristida lanosa*
Bottlebrush Three-awn	*Aristida spiciformis*
Switchcane	*Arundinaria gigantea*
Switch cane	*Arundinaria tecta*
Common Oat	*Avena fatua*
Bamboo	*Bambusa spp.*
Capillary Hairsedge	*Bulbostylis ciliatifolia*
Sandyfield Hairsedge	*Bulbostylis stenophylla*
Greenwhite sedge	*Carex albolutescens*
Sandywoods Sedge	*Carex dasycarpa*
Hammock Sedge	*Carex fissa var. aristata*
Long's Sedge	*Carex longii*

Common Name	Scientific Name
Blackedge Sedge	*Carex nigromarginata*
Southern Sandspur	*Cenchrus echinatus*
Coastal Sandspur	*Cenchrus incertus*
Sanddune Sandspur	*Cenchrus tribuloides*
Class Magnoliopsida (woody flowering plants)	
Slender Woodoats	*Chasmanthium laxum var. laxum*
Spanglegrass	*Chasmanthium laxum var. sessiliflorum*
Sawgrass	*Cladium jamaicense*
Whitemouth Dayflower	*Commelina erecta*
Spring Coralroot	*Corallorhiza wisteriana*
Bermudagrass	*Cynodon dactylon*
	Cyperus brevifolius
Baldwin's Flatsedge	*Cyperus croceus*
Swamp Flatsedge	*Cyperus distinctus*
Yellow Nutgrass	*Cyperus esculentus*
Umbrella sedge	*Cyperus filicinus*
Globe sedge	*Cyperus globulosus*
Haspan Flatsedge	*Cyperus haspan*
Fragrant Flatsedge	*Cyperus odoratus*
Manyspike Flatsedge	*Cyperus polystachyos*
Pinebarren Flatsedge	*Cyperus retrorsus*
Nutgrass	*Cyperus rotundus*
Strawcolored Flatsedge	*Cyperus strigosus*
Tropical Flatsedge	*Cyperus surinamensis*
Fourangle Flatsedge	*Cyperus tetragonus*
Crowfootgrass	*Dactyloctenium aegyptium*
Panicum	*Dicanthelium erectifolium*
Variable Witchgrass	*Dichanthelium commutatum*
Forked Witchgrass	*Dichanthelium dichotomum*
Hemlock Witchgrass	*Dichanthelium portoricense*
	Dichanthelium sabulorum
Southern Crabgrass	*Digitaria ciliaris*
Slender Crabgrass	*Digitaria filiformis var. filiformis*
Shaggy crabgrass	*Digitaria villosa*
Saltgrass	*Distichlis spicata*
Coast Cockspur	*Echinochloa walteri*
Baldwin's Spikerush	*Eleocharis baldwinii*
Yellow Spikerush	*Eleocharis flavescens*
Sand Spikerush	*Eleocharis montevidensis*
Viviparous Spikerush	*Eleocharis vivipara*
Indian Goosegrass	*Eleusine indica*
Green-fly Orchid	*Epidendrum magnoliae var. magnoliae*
Purple Lovegrass	*Eragrostis spectabilis*

Common Name	**Scientific Name**
Coastal Lovegrass	*Eragrostis virginica*
Centipedegrass	*Eremochloa ophiuroides*
Pinewoods Fingergrass	*Eustachys petraea*
Slender Fimbry	*Fimbristylis autumnalis*
Carolina Fimbry	*Fimbristylis caroliniana*
Chesnut sedge	*Fimbristylis castanea*
Marsh Fimbry	*Fimbristylis spadicea*
Fringe rush	*Fimbristylis vahlii*
Dwarf Umbrellasedge	*Fuirena pumila*
Southern Umbrellasedge	*Fuirena scirpoidea*
Waterspider Orchid	*Habenaria repens*
Watergrass	*Hydrochloa carliniensis*
Fringed Yellow Stargrass	*Hypoxis juncea*
Blue flag	*Iris virginica*
Tapertip Rush	*Juncus acuminatus*
Leathery Rush	*Juncus coriaceus*
Forked Rush	*Juncus dichotomus*
Soft Rush	*Juncus effusus*
Bog Rush	*Juncus elliottii*
Shore Rush	*Juncus marginatus*
Bighead Rush	*Juncus megacephalus*
Manyhead Rush	*Juncus polycephalus*
Creeping Rush	*Juncus repens*
Black Needle Rush	*Juncus roemerianus*
Shortleaf Spikesedge	*Kyllinga brevifolia*
Carolina Redroot	*Lachnanthes caroliniana*
Bogbuttons	*Lachnocaulon spp.*
Southern Cutgrass	*Leersia hexandra*
Duckweed	*Lemna valdiviana*
Bearded Spangletop	*Leptochloa fascicularis*
Frog's-bit; American Spongeplant	*Limnobium spongia*
Italian Ryegrass	*Lolium perenne*
Southern Watergrass	*Luziola fluitans*
Big moss	*Mayaca fluviatilis*
Gulf Hairawn Muhly	*Muhlenbergia capillaris var. filipes*
Marine naiad	*Najas marina*
Southern naiad	*Najas quadalupenis*
Woodsgrass	*Oplismenus hirtellus*
Bitter Panicgrass	*Panicum amarum*
Beaked Panicum	*Panicum anceps*
Fall Panicgrass	*Panicum dichotomiflorum*
Maidencane	*Panicum hemitomon*
Guineagrass	*Panicum maximum*

Common Name	**Scientific Name**
Torpedograss	*Panicum repens*
Redtop Panicum	*Panicum rigidulum*
Bluejoint Panicum	*Panicum tenerum*
Warty Panicgrass	*Panicum verrucosum*
Switchgrass	*Panicum virgatum*
Bull paspalum	*Paspalum boscianum*
Bahiagrass	*Paspalum notatum var. saurae*
Thin Paspalum	*Paspalum setaceum*
Vaseygrass	*Paspalum urvillei*
Pearl millet	*Pennisetum americanum*
Blackseed Needlegrass	*Piptochaetium avenaceum*
Annual Bluegrass	*Poa annua*
Rabbitsfootgrass	*Polypogon monspeliensis*
Pickerelweed	*Pontederia cordata*
Sago pondweed	*Potamogeton pectinatus*
Giant Orchid	*Pteroglossapsis ecristata*
Rose Natalgrass	*Rhynchelytrum repens*
Anglestem Beaksedge	*Rhynchospora caduca*
Starrush Whitetop	*Rhynchospora colorata*
Shortbristle Horned Beaksedge	*Rhynchospora corniculata*
Fascicled Beaksedge	*Rhynchospora fascicularis*
Threadleaf Beaksedge	*Rhynchospora filifolia*
Sandyfield Beaksedge	*Rhynchospora megalocarpa*
Southern Beaksedge	*Rhynchospora microcarpa*
Bunched Beaksedge	*Rhynchospora microcephala*
Bald rush	*Rhynchospora nitens*
Widgeon grass	*Ruppia maritima*
Cabbage Palm; Sabal Palm	*Sabal palmetto*
Sugarcane Plumegrass	*Saccharum giganteum*
American Cupscale	*Sacciolepis striata*
Floating leaf sagittaria	*Sagittaria filiformis*
Grassy Arrowhead	*Sagittaria graminea var. graminea*
Little Bluestem	*Schizachyrium scoparium var. scoparium*
Saltmarsh bulrush	*Schoenoplectus robustus*
Soft stem bulrush	*Schoenoplectus tabernaemontani*
Woolgrass	*Scirpus cyperinus*
Netted Nutrush	*Scleria reticularis*
Tall Nutgrass	*Scleria triglomerata*
Saw Palmetto	*Serenoa repens*
Giant Foxtail; Giant Bristlegrass	*Setaria magna*
Knotroot Foxtail	*Setaria parviflora*
Pointed blue eyed grass	*Sisyrinchium angustifolium*
Annual Blue-eyed Grass	*Sisyrinchium rosulatum*

Common Name	Scientific Name
Earleaf Greenbrier	*Smilax auriculata*
Saw Greenbrier	*Smilax bona-nox*
Cat Greenbrier; Wild Sarsaparilla	*Smilax glauca*
Sarsaparilla Vine	*Smilax pumila*
Hog Brier; Bristly Greenbrier	*Smilax tamnoides*
Lopsided Indiangrass	*Sorghastrum secundum*
Smooth cordgrass	*Spartina alterniflora*
Smooth Cordgrass; Saltmarsh Cordgrass	*Spartina alterniflora var. glabra*
Sand Cordgrass	*Spartina bakeri*
Marshhay Cordgrass; Saltmeadow Cordgrass	*Spartina patens*
Prairie Wedgescale	*Sphenopholis obtusata*
Ladies tresses	*Spiranthes praecox*
Woodland Ladies'-tresses	*Spiranthes sylvatica*
Spring Ladies'-tresses	*Spiranthes vernalis*
Duckmeat; Dotted Duckweed	*Spirodela punctata*
Smutgrass	*Sporobolus indicus var. indicus*
Seashore Dropseed	*Sporobolus virginicus*
St. Augustine grass	*Stenotaphrum secundatum*
Yellow Hatpins	*Syngonanthus flavidulus*
Bartram's Airplant	*Tillandsia bartramii*
Ballmoss	*Tillandsia recurvata*
Southern Needleleaf	*Tillandsia setacea*
Spanish Moss	*Tillandsia usneoides*
Bluejacket; Ohio Spiderwort	*Tradescantia ohiensis*
Purpletop; Tall Redtop	*Tridens flavus var. flavus*
Arrowgrass	*Triglochin striata*
Purple Sandgrass	*Triplasis purpurea*
Narrow leaved cattail	*Typha angustifolia*
Tropical cattail	*Typha domingensis*
Broadleaf Cattail	*Typha latifolia*
Sea Oats	*Uniola paniculata*
Sixweeks Fescue	*Vulpia octoflora*
Bog mat	*Wolffiella gladiata*
Shortleaf Yelloweyed Grass	*Xyris brevifolia*
Richard's Yelloweyed Grass	*Xyris jupicai*
Spanish Bayonet	*Yucca aloifolia*
Lawn Orchid	*Zeuxine strateumatica*
Slender Threeseed Mercury	*Acalypha gracilens*
Red Maple	*Acer rubrum*
Shyleaf; Joint-vetch	*Aeschynomene americana*
	Agalinis fasciculata
Hammock Snakeroot	*Ageratina jucunda*
Alligatorweed	*Alternanthera philoxeroides*

Common Name	Scientific Name
Southern Amaranth	*Amaranthus australis*
Pigweed	*Amaranthus spp.*
Common Ragweed	*Ambrosia artemisiifolia*
Fly poison	*Amianthium muscaetoxicum*
Toothcup	*Ammannia latifolia*
False indigo	*Amorpha fruticosa*
Peppervine	*Ampelopsis arborea*
Devil's Walkingstick	*Aralia spinosa*
Mexican Pricklypoppy	*Argemone mexicana*
Savannah Milkweed	*Asclepias pedicellata*
Velvetleaf Milkweed	*Asclepias tomentosa*
Smallflower Pawpaw	*Asimina parviflora*
Climbing Aster	*Aster carolinianus*
Rice Button Aster	*Aster dumosus*
Swamp Aster; Elliott's Aster	*Aster elliottii*
Annual Saltmarsh Aster	*Aster subulatus*
Perennial Saltmarsh Aster	*Aster tenuifolius*
Whitetop Aster; Dixie Aster	*Aster tortifolius*
Walter's Aster	*Aster walteri*
Sea beach atriplex	*Atriplex arenaria*
Crested Saltbush; Seabeach Orach	*Atriplex pentandra*
Black Mangrove	*Avicennia germinans*
Saltwater Falsewillow	*Baccharis angustifolia*
Silverling	*Baccharis glomeruliflora*
Salt Bush; Groundsel Tree; Sea Myrtle	*Baccharis halimifolia*
Blue Waterhyssop	*Bacopa caroliniana*
Smooth Waterhyssop; Herb-of Grace	*Bacopa monnieri*
Saltwort; Turtleweed	*Batis maritima*
Tarflower	*Bejaria racemosa*
Rattan Vine	*Berchemia scandens*
Beggarticks	*Bidens alba*
Spanish Needles	*Bidens bipinnata*
Burrmarigold	*Bidens laevis*
Crossvine	*Bignonia capreolata*
False Nettle; Bog Hemp	*Boehmeria cylindrica*
Red Spiderling; Wineflower	*Boerhavia diffusa*
Bushy Seaside Oxeye	*Borrichia frutescens*
American Bluehearts	*Buchnera americana*
Tough bumelia	*Bumelia tenax*
American Searocket	*Cakile edentula subsp. harperi*
American Beautyberry; French Mulberry	*Callicarpa americana*
Matted Waterstarwort	*Callitriche peploides*
Trumpetcreeper	*Campsis radicans*

Common Name	Scientific Name
Bitter cress	*Cardamine hirsuta*
Pennsylvania Bittercress	*Cardamine pensylvanica*
Thistle	*Carduus spp.*
Vanillaleaf	*Carphephorus odoratissimus*
Pignut Hickory	*Carya glabra*
Wild sensitive plant	*Cassia nictitans*
Sicklepod	*Cassia obtusifolia*
Sugarberry; Hackberry	*Celtis laevigata*
Spadeleaf; Coinwort	*Centella asiatica*
Spurred Butterfly Pea	*Centrosema virginianum*
Buttonbush	*Cephalanthus occidentalis*
Florida Rosemary; Sand Heath	*Ceratiola ericoides*
Coontail	*Ceratophyllum spp.*
Partridge Pea	*Chamaecrista fasciculata*
Sensitive Pea	*Chamaecrista nictitans var. aspera*
Dixie Sandmat	*Chamaesyce bombensis*
Eye-bane; Hyssopleaf Sandmat	*Chamaesyce hyssopifolia*
Spotted Sandmat	*Chamaesyce maculata*
Lamb's-quarters	*Chenopodium album*
Mexican Tea;Pigweed	*Chenopodium ambrosioides*
Bull Thistle; Yellow Thistle	*Cirsium horridulum*
Nuttall's Thistle	*Cirsium nuttallii*
Sour Orange	*Citrus aurantium*
Butterfly Pea; Atlantic Pigeonwings	*Clitoria mariana*
Stinging Nettle; Tread-softly; Finger-rot	*Cnidoscolus stimulosus*
Dwarf Canadian Horseweed	*Conyza canadensis var. pusilla*
Golden Tickseed	*Coreopsis tinctoria*
Swamp dogwood	*Cornus stricta*
Pursh's Rattlebox	*Crotalaria purshii*
Rabbitbells	*Crotalaria rotundifolia*
Showy Rattlebox	*Crotalaria spectabilis*
Hogwort; Woolly Croton	*Croton capitatus*
Vente Conmigo	*Croton glandulosus*
Beach Tea; Gulf Croton	*Croton punctatus*
Colombian Waxweed	*Cuphea carthagenensis*
Compact Dodder	*Cuscuta compacta*
Bigseed Alfalfa Dodder	*Cuscuta indecora*
Gulfcoast Swallowwort	*Cynanchum angustifolium*
Western Tansymustard	*Descurainia pinnata*
Hoary Ticktrefoil; Beggarweed	*Desmodium incanum*
Panicledleaf Ticktrefoil	*Desmodium paniculatum*
Dixie Ticktrefoil	*Desmodium tortuosum*
Threeflower Ticktrefoil	*Desmodium triflorum*

Common Name	**Scientific Name**
Carolina Ponysfoot	*Dichondra caroliniensis*
Poor Joe	*Diodia teres*
Virginia Buttonweed	*Diodia virginiana*
Common Persimmon	*Diospyros virginiana*
Wedgeleaf Whitlowgrass	*Draba cuneifolia*
Dwarf Sundew	*Drosera brevifolia*
Pink Sundew	*Drosera capillaris*
Oblong Twinflower	*Dyschriste oblongifolia*
False Daisy	*Eclipta prostrata*
Tall Elephantsfoot	*Elephantopus elatus*
Fireweed	*Erechtites hieracifolia*
Oakleaf Fleabane	*Erigeron quercifolius*
Baldwin's Eryngo	*Eryngium baldwinii*
Coralbean; Cherokee Bean	*Erythrina herbacea*
Coastal white snakeroot	*Eupatorium aromaticum*
Dog Fennel	*Eupatorium capillifolium*
Yankeeweed	*Eupatorium compositifolium*
Falsefennel	*Eupatorium leptophyllum*
Mohr's Thoroughwort	*Eupatorium mohrii*
Roundleaf Thoroughwort	*Eupatorium rotundifolium*
Lateflorwering Thoroughwort	*Eupatorium serotinum*
Slender Goldenrod	*Euthamia caroliniana*
Flat topped goldenrod	*Euthamia minor*
Florida Swampprivet	*Forestiera segregata*
Firewheel; Blanketflower	*Gaillardia pulchella*
Elliott's Milkpea	*Galactia elliottii*
Eastern Milkpea	*Galactia regularis*
Downy Milkpea	*Galactia volubilis*
Coastal Bedstraw	*Galium hispidulum*
Stiff Marsh Bedstraw	*Galium tinctorium*
Southern Beeblossom	*Gaura angustifolia*
Dwarf Huckleberry	*Gaylussacia dumosa*
Blue Huckleberry	*Gaylussacia frondosa var. tomentosa*
Dangleberry	*Gaylussacia nana*
Yellow Jessamine	*Gelsemium sempervirens*
Carolina Cranesbill	*Geranium carolinianum*
Narrowleaf Purple Everlasting	*Gnaphalium falcatum*
Rabbit Tobacco; Sweeteverlasting	*Gnaphalium obtusifolium*
Pennsylvania Everlasting	*Gnaphalium pensylvanicum*
Loblolly bay	*Gordonia lasianthus*
Rough Hedgehyssop	*Gratiola hispida*
Hedge hyssop	*Gratiola ramoa*
Innocence; Fairy Footprints	*Hedyotis procumbens*

Common Name	Scientific Name
Clustered Mille Graine	*Hedyotis uniflora*
Pinebarren Frostweed; Rock-rose	*Helianthemum corymbosum*
East Coast Dune Sunflower	*Helianthus debilis subsp. Debilis*
Camphorweed	*Heterotheca subaxillaris*
Swamp Rosemallow	*Hibiscus grandiflorus*
Queendevil	*Hieracium gronovii*
Largeleaf Marshpennywort	*Hydrocotyle bonariensis*
Manyflower Marshpennywort	*Hydrocotyle umbellata*
Whorled Marshpennywort	*Hydrocotyle verticillata var. verticillata*
Bedstraw St. John's-wort	*Hypericum galioides*
Roundpod St. John's-wort	*Hypericum cistifolium*
Pineweeds; Orangegrass	*Hypericum gentianoides*
St. Andrew's-cross	*Hypericum hypericoides*
Dwarf St. John's-wort	*Hypericum mutilum*
Myrtleleaf St. John's-wort	*Hypericum myrtifolium*
Naked St. John's wort	*Hypericum nudiflorum*
Atlantic St. John's-wort	*Hypericum reductum*
St. Peter's wort	*Hypericum stans*
Fourpetal St. John's-wort	*Hypericum tetrapetalum*
Carolina Holly; Sand Holly	*Ilex ambigua var. ambigua*
Dahoon	*Ilex cassine var. cassine*
Large gallberry	*Ilex coriacea*
Inkberry; Gallberry	*Ilex glabra*
American Holly	*Ilex opaca var. opaca*
Yaupon	*Ilex vomitoria*
Hairy Indigo	*Indigofera hirsuta*
Trailing Indigo	*Indigofera spicata*
Woody Indigo	*Indigofera suffruticosa*
Tievine	*Ipomoea cordatotriloba*
Beach Morningglory	*Ipomoea imperati*
Man-of-the-Earth; Wild Potato Vine	*Ipomoea pandurata*
Railroad Vine; Bayhops	*Ipomoea pes-caprae var. brasiliensis*
Saltmarsh Morningglory	*Ipomoea sagittata*
Beach morning glory	*Ipomoea stolonifera*
Littlebell	*Ipomoea triloba*
Standing Cypress; Spanish Larkspur	*Ipomopsis rubra*
Juba's Bush; Bloodleaf	*Iresine diffusa*
Marsh Elder	*Iva frutescens*
Seacoast Marshelder	*Iva imbricata*
Piedmont Marshelder	*Iva microcephala*
Virginia Saltmarsh Mallow	*Kosteletzkya virginica*
Virginia Dwarfdandelion	*Krigia virginica*
Woodland Lettuce	*Lactuca floridana*

Common Name	Scientific Name
Grassleaf Lettuce	*Lactuca graminifolia*
Lantana; Shrub Verbena	*Lantana camara*
Hairy Pinweed	*Lechea mucronata*
Pin weed	*Lechea racemulosa*
Virginia Pepperweed	*Lepidium virginicum*
Hairy Bush Clover	*Lespedeza hirta*
Slender Gayfeather	*Liatris gracilis*
Gopher Apple	*Licania michauxii*
Japanese Privet	*Ligustrum japonicum*
Carolina Sea Lavender	*Limonium carolinianum*
Canada Toadflax	*Linaria canadensis*
Florida Toadflax	*Linaria floridana*
Yellowseed False Pimpernel	*Lindernia dubia var. anagallidea*
Moistbank False Pimpernel	*Lindernia dubia var. dubia*
Carpetweed	*Lippia nodiflora*
Sweetgum	*Liquidambar styraciflua*
Lobelia	*Lobelia nuttalii*
Curtiss' Primrosewillow	*Ludwigia curtissii*
Seaside Primrosewillow	*Ludwigia maritima*
Mexican Primrosewillow	*Ludwigia octovalvis*
Creeping Primrosewillow	*Ludwigia repens*
Shrubby Primrosewillow	*Ludwigia suffruticosa*
Christmasberry	*Lycium carolinianum*
Rusty Lyonia; Rusty Staggerbush	*Lyonia ferruginea*
Coastalplain Staggerbush	*Lyonia fruticosa*
Fetterbush; Shiny Lyonia	*Lyonia lucida*
Wild Bushbean	*Macroptilium lathyroides*
Southern Magnolia	*Magnolia grandiflora*
Sweetbay	*Magnolia virginiana*
Angularfruit Milkvine	*Matelea gonocarpa*
Black Medick	*Medicago lupulina*
Burclover	*Medicago polymorpha*
Chinaberry	*Melia azedarach*
White Sweetclover	*Melilotus albus*
Indian Sweetclover	*Melilotus indicus*
Creeping Cucumber	*Melothria pendula*
Alamo Vine; Noyau Vine	*Merremia dissecta*
Shade Mudflower; Globifera	*Micranthemum umbrosum*
Florida Keys Hempvine	*Mikania cordifolia*
Climbing Hempvine	*Mikania scandens*
Sensitive Brier	*Mimosa quadrivalvis*
Spotted Beebalm; Spotted Horsemint	*Monarda punctata*
Indianpipe	*Monotropa uniflora*

Common Name	**Scientific Name**
Pigmypipes	*Monotropsis reynoldsiae*
Red Mulberry	*Morus rubra*
Wax Myrtle; Southern Bayberry	*Myrica cerifera*
Cutleaf Watermilfoil; Green Parrot's-feather	*Myriophyllum pinnatum*
American White Waterlily	*Nymphaea odorata*
Swamp Tupelo	*Nyssa sylvatica var. biflora*
Seabeach Evening Primrose	*Oenothera humifusa*
Cutleaf Evening Primrose	*Oenothera laciniata*
Devil Joint; Cockspur Pricklypear	*Opuntia pusilla*
Erect Pricklypear	*Opuntia stricta*
Wild Olive; Devilwood	*Osmanthus americanus*
Yellow Woodsorrel	*Oxalis corniculata*
Violet wood sorrel	*Oxalis corymbosa*
Wood sorrell	*Oxalis florida*
Yellow wood sorrel	*Oxalis stricta*
Florida Pellitory	*Parietaria floridana*
Baldwin's Nailwort	*Paronychia baldwinii*
Virginia Creeper; Woodbine	*Parthenocissus quinquefolia*
Purple Passionflower	*Passiflora incarnata*
Corkystem Passionflower	*Passiflora suberosa*
Red Bay	*Persea borbonia var. borbonia*
Swamp Bay	*Persea palustris*
Oak Mistletoe	*Phoradendron leucarpum*
Mistletoe	*Phoradendron serotinum*
Capeweed; Turkeytangle Fogfruit	*Phyla nodiflora*
Drummond's Leafflower	*Phyllanthus abnormis*
Chamber Bitter	*Phyllanthus urinaria*
Walter's Groundcherry	*Physalis walteri*
American Pokeweed	*Phytolacca americana*
Pokeweed	*Phytolacca rigida*
Violet butterwort	*Pinguicula vulgaris*
Grassleaf Goldenaster	*Pityopsis graminifolia*
English Plantain	*Plantago lanceolata*
Virginia Plantain	*Plantago virginica*
Camphorweed	*Pluchea camphorata*
Stinking Camphorweed	*Pluchea foetida*
Saltmarsh fleabane	*Pluchea purpuracens*
Rosy Camphorweed	*Pluchea rosea*
Painted-leaf; Fire-on-the-Mountain	*Poinsettia cyathophora*
Polygala	*Polygala cymosa*
Procession Flower	*Polygala incarnata*
Yellow milkwort	*Polygala lutea*
Orange milkwort	*Polygala nana*

Common Name	Scientific Name
Racemed Milkwort	*Polygala polygama*
Hairy Smartweed	*Polygonum hirsutum*
Mild Waterpepper	*Polygonum hydropiperoides*
Dotted Smartweed	*Polygonum punctatum*
Hairy Leafcup	*Polymnia uvedalia*
Rustweed; Juniperleaf	*Polypremum procumbens*
Little Hogweed	*Portulaca oleracea*
Pink purslane	*Portulaca pilosa*
Pink Purslane; Kiss-Me-Quick	*Portulaca pilosa*
Combleaf Mermaidweed	*Proserpinaca pectinata*
Carolina Laurelcherry	*Prunus caroliniana*
Black Cherry	*Prunus serotina var. serotina*
Flatwoods Plum	*Prunus umbellata*
Common Hoptree; Wafer Ash	*Ptelea trifoliata*
Blackroot	*Pterocaulon pycnostachyum*
Mock Bishopsweed	*Ptilimnium capillaceum*
Carolina Desertchicory; False Dandelion	*Pyrrhopappus carolinianus*
Chapman's Oak	*Quercus chapmanii*
Sand Live Oak	*Quercus geminata*
Laurel Oak; Diamond Oak	*Quercus laurifolia*
Myrtle Oak	*Quercus myrtifolia*
Water Oak	*Quercus nigra*
Live Oak	*Quercus virginiana*
Low Spearwort	*Ranunculus pusillus*
Wild Radish	*Raphanus raphanistrum*
Maryland Meadowbeauty	*Rhexia mariana*
Winged Sumac	*Rhus copallinum*
Climbing Dollar-weed; Least Snoutbean	*Rhynchosia minima*
Tropical Mexican Clover	*Richardia brasiliensis*
Rough Mexican Clover	*Richardia scabra*
Sawtooth Blackberry	*Rubus argutus*
Sand Blackberry	*Rubus cuneifolius*
Southern Dewberry	*Rubus trivialis*
Carolina Wild Petunia	*Ruellia caroliniensis*
Hastateleaf Dock	*Rumex hastatulus*
Swamp Dock	*Rumex verticillatus*
Marsh pink	*Sabatia bartramii*
Shortleaf Rosegentian	*Sabatia brevifolia*
Smallflower Mock Buckthorn	*Sageretia minutiflora*
Annual Glasswort	*Salicornia bigelovii*
Perennial Glasswort; Virginia Glasswort	*Salicornia perennis*
Perennial glasswort	*Salicornia virginica*
Carolina Willow	*Salix caroliniana*

Common Name	**Scientific Name**
Prickly Russian Thistle	*Salsola kali subsp. pontica*
Tropical Sage	*Salvia coccinea*
Lyreleaf Sage	*Salvia lyrata*
American Elder; Elderberry	*Sambucus canadensis*
Pineland Pimpernel	*Samolus valerandi subsp. parviflorus*
Blacksnakeroot	*Sanicula canadensis*
Southern soapberry	*Sapindus saponaria*
Soapberry	*Sapindus saponaria*
Lizard's tail	*Saururus cernuus*
Sweetbroom	*Scoparia dulcis*
Sicklepod; Coffeeweed	*Senna obtusifolia*
Bequilla	*Sesbania emerus*
Danglepod	*Sesbania herbacea*
Bladderpod; Bagpod	*Sesbania vesicaria*
Seapurslane	*Sesuvium portulacastrum*
Common Wireweed; Common Fanpetals	*Sida acuta*
Cuban Jute; Indian Hemp; Teaweed	*Sida rhombifolia*
Tough Buckthorn	*Sideroxylon tenax*
Sleepy Catchfly	*Silene antirrhina*
Horsenettle	*Solanum carolinense var. carolinense*
Black Nightshade	*Solanum chenopodioides*
Tropical Soda Apple	*Solanum viarum*
Canada Goldenrod	*Solidago canadensis var. scabra*
Pinebarren Goldenrod	*Solidago fistulosa*
Chapman's Goldenrod	*Solidago odora var. chapmanii*
Seaside Goldenrod	*Solidago sempervirens*
Spiny Sowthistle	*Sonchus asper*
Common Sowthistle	*Sonchus oleraceus*
Shrubby False Buttonweed	*Spermacoce verticillata*
Roughfruit Scaleseed	*Spermolepis divaricata*
Florida Betony; Florida Hedgenettle	*Stachys floridana*
Trailing Fuzzybean	*Strophostyles helvula*
Sea Blite; Annual Seepweed	*Suaeda linearis*
Wood Sage; Canadian Germander	*Teucrium canadense*
Eastern Poison Ivy	*Toxicodendron radicans*
Puncturevine	*Tribulus terrestris*
Forked Bluecurls	*Trichostema dichotomum*
Hop clover	*Trifolium dubium*
White Clover	*Trifolium repens*
Clasping Venus' Lookingglass	*Triodanis perfoliata*
Humped Bladderwort	*Utricularia gibba*
Floating bladderwort	*Utricularia inflata*
Eastern Purple Bladderwort	*Utricularia purpurea*

Common Name	**Scientific Name**
Little Floating Bladderwort	*Utricularia radiata*
Zigzag Bladderwort	*Utricularia subulata*
Sparkleberry; Farkleberry	*Vaccinium arboreum*
Highbush Blueberry	*Vaccinium corymbosum*
Shiny Blueberry	*Vaccinium myrsinites*
Deerberry	*Vaccinium stamineum*
Woolly Mullein	*Verbascum thapsus*
Wand Mullein	*Verbascum virgatum*
Purpletop Vervain	*Verbena bonariensis*
Brazilian Vervain	*Verbena brasiliensis*
Texas Vervain	*Verbena officinalis var. halei*
Harsh Vervain	*Verbena scabra*
Frostweed; White Crownbeard	*Verbesina virginica*
Giant Ironweed	*Vernonia gigantea*
Fourleaf Vetch	*Vicia acutifolia*
Hairypod Cowpea	*Vigna luteola*
White violet	*Viola affinis*
Bog White Violet	*Viola lanceolata*
Early Blue Violet	*Viola palmata*
Common Blue Violet	*Viola sororia*
Summer Grape	*Vitis aestivalis*
Muscadine	*Vitis rotundifolia*
Southern Rockbell	*Wahlenbergia marginata*
Hercules'-club	*Zanthoxylum clava-herculis*
Kingdom Animalia	
Phylum Porifera (sea sponges)	
Boring Sponge	*Cliona sp.*
Purple Sponge	*Haliclona permollis*
Sun Sponge	*Hymeniacidon heliophila*
Red Beard Sponge	*Microciona prolifera*
Phylum Cnidaria (jellyfishes and anemones)	
Class Anthozoa (anemones and corals)	
Brown Anemone	*Aiptasia pallida*
Anthopleura varioarmata	*GRM*
Astrangia danae	*GRM*
Tricolor Anemone	*Calliactis tricolor*
Sea Tube Anemone	*Ceriantheopsis americanus*
Sea Whip	*Leptogorgia virgulata*
Sea Pansy	*Renilla reniformis*
Class Hydrozoa (hydras)	
Pink-hearted hydroid	*Ectopleura crocea (Tubularia crocea)*
Portugese man-of-war	*Physalia physalia*

Common Name	Scientific Name
Class Scyphozoa (jellyfishes)	
Moon Jelly	*Aurelia aurita*
Sea Nettle	*Chrysaora quinquecirrha*
Lions' Mane Medusa	*Cyanea capillata*
Cannonball jellyfish	*Stomolophus meleagris*
Phylum Ctenophora (comb jellies)	
Beroe	*Beroe sp.*
Sea Walnut	*Mnemiopsis leidyi*
Sea gooseberry	*Pleurobrachia pileus*
Phylum Platyhelminthes (flatworms)	
Horseshoe Crab Worm	*Bdelloura candida*
Phylum Annelida (segmented worms)	
Parchment Worm	*Chaetopterus variopedatus*
Tube Worm	*Diopatra cuprea*
Blood Worm	*Glycera americana*
Phylum Arthropoda (spiders, insects, crustaceans)	
Class Arachnida (spiders, scorpions, mites)	
Grass spider	*Agelenopsis*
Lone star tick	*Amblyomma americanum*
Black-&-yellow argiope	*Argiope aurantia*
Black and yellow argiope	*Argiope aurantis*
Centruroides scorpion	*Centruroides spp.*
Florida Striped Bark Scorpion	*Centruroides Hentzi*
Wood tick	*Dermacentor spp.*
Chigger/Redbug	*Eutrombicula spp.*
Crablike spiny orb weaver	*Gasteracantha spp.*
Brown Widow Spider	*Latrodectus geometricus*
Southern Black widow spider	*Latrodectus mactans*
Giant vinegarone	*Mastigoproctus giganteus*
Golden silk spider	*Nephila clavipes*
Green lynx spider	*Peucetia viridans*
Brown daddy long legs	*Phalangium opilio*
Daring jumping spider	*Phidippus audax*
Sub-phylum Crustacea (shrimp, crabs, lobsters)	
Aviu Shrimp	*Acetes americanus carolinae*
Snapping Shrimp	*Alpheus heterochaelis*
Speckled Swimming Crab	*Arenaeus cribrarius*
Pillbug	*Armadillium spp.*
Square backed marsh crab	*Armases cinereum*
Acorn Barnacle	*Semibalanus balanoides*
Common Barnacle	*Balanus balanoides*

Common Name	**Scientific Name**
Ivory Barnacle	*Balanus eburneus*
Barnacles	*Balanus spp.*
Flame Box Crab	*Calappa flammea*
Carolina Ghost Shrimp	*Callichirus major*
Red Blue Crab	*Callinectes bocourti*
Ornate Blue Crab	*Callinectes ornatus*
Blue crab	*Callinectes sapidus*
Lesser blue crab	*Callinectes similis*
Indo-Pacific Swimming Crab	*Charybdis hellerii*
Gray Barnacle	*Chthamalus fragilis*
Striped Hermit Crab	*Clibanarius vittatus*
Say mud crab	*Dyspanopeus sayi*
Atlantic sand crab	*Emerita talpoida*
Flat Mud Crab	*Eurypanopeus depressus*
Broadback Mud Crab	*Eurytium limosum*
Brown shrimp	*Farfantepenaeus aztecus*
Pink shrimp	*Farfantepenaeus duorarum*
Scuds	*Gammarus spp.*
Calico Crab	*Hepatus epheliticus*
Smooth Mud Crab	*Hexapanopeus augustifrons*
Veined Shrimp	*Hippolysmata wurdemanni*
Duck Barnacle	*Lepas anatifera*
Portly Spider Crab	*Libinia emarginata*
Wharf Roach	*Ligia exotica*
White shrimp	*Penaeus setiferus*
	Lucifer faxoni
Cinnamon river shrimp	*Macrobrachium acanthurus*
Stone Crab	*Menippe spp.*
Florida Stone crab	*Menippe mercenaria*
Gulf Stone Crab	*Menippe adina*
	Neopanope texana sayi
Ghost crab	*Ocypode quadrata*
Mottled Shore Crab	*Pachygrapsus transversus*
Banded Hermit Crab	*Pagurus annulipes*
Long clawed hermit crab	*Pagurus longicarpus*
Flat-Clawed Hermit Crab	*Pagurus pollicaris*
Hermit crab	*Pagurus spp.*
Daggerblade Grass shrimp	*Palaemonetes pugio*
Panaeid shrimp	*Panaeus spp.*
Common Mud Crab	*Panopeus herbstii*
Furrowed Mud Crab	*Panopeus occidentalis*
Green Porchelain Crab	*Petrolisthes armatus*
Sea Spider	*Phoxichilidium femoratum*

Common Name	Scientific Name
Tube Pea Crab	*Pinnixa chaetopterana*
Pea crab	*Pinnixa retinens*
Mussel Crab	*Pinnotheres maculatus*
Oyster Crab	*Pinnotheres ostreum*
Tidal Spray Crab	*Plagusia depressa*
Eastern Tube Crab	*Polyonyx gibbesi*
Iridescent Swimming Crab	*Portunus gibbesii*
Sargassum Crab	*Portunus sayi*
Blotched Swimming Crab	*Portunus spinimanus*
Crayish	*Procambarus spp.*
Estuarine Mud Crab	*Rhithropanopeus harrisii*
Wharf Crab	*Sesarma cinereum*
Purple Marsh Crab	*Sesarma reticulatum*
Beach fleas	*Talorchestia spp.*
Arrow Shrimp	*Tozeuma carolinense*
Mussel Pea Crab	*Tumidotheres maculatus*
Red-Jointed Fiddler	*Uca minax*
Sand fiddler crab	*Uca pugilator*
Atlantic Marsh Fiddler	*Uca pugnax*
Coastal Mud Shrimp	*Upogebia affinis*
Oyster Pea Crab	*Zaops ostreum*
Class Insecta (insects)	
Green stink bug	*Acrosternum hilare*
Luna moth	*Actias luna*
Eastern salt marsh mosquito	*Aedes sollicitans*
Salt marsh mosquitos	*Aedes taeniorhynchus*
Virescent green metallic bee	*Agapostemon virescens*
Gulf fritillary	*Agraulis vanillae*
Pink spotted hawk moth	*Agrius cingulata*
Eastern eyed click beetle	*Alaus oculatus*
White Peacock	*Anartia jatrophae*
Common green darner	*Anax junius*
Comet darner	*Anax longipes*
Mosquito	*Anopheles*
Polyphemus moth	*Antheraea polyphemus*
Honeybee	*Apis mellifera*
Gray green clubtail	*Arigomphus pallidus*
Great southern white	*Ascia monuste*
Io moth	*Automeris io*
Pipevine swallowtail	*Battus philenor*
Love bug	*Bibio*
Bumblebee	*Bombus pensylvanicus*
Four spotted pennant	*Brachymesia gravida*

Common Name	**Scientific Name**
Fiery searcher	*Calosoma scrutator*
Black carpenter ant	*Camponotus pennsylvanicus*
Halloween pennant	*Celithemis eponina*
Double ringed pennant	*Celithemis verna*
Deerflies	*Chrysops*
Mosquito	*Coquillettidia*
Goldsmith beetle	*Cotalpa lanigera*
Sand flies	*Culicoides*
Monarch	*Danaus plexippus*
Virginia creeper sphinx	*Darapsa myron*
Cow killer	*Dasymutilla occidentalis*
Northern walking stick	*Diapheromera femorata*
Rosy maple moth	*Dryocampa rubicunda*
E. pond hawk	*Erythemis simplicicollis*
Blue dragonlet	*Erythrodiplax connata*
Little sulphur	*Eurema lisa*
Chigger	*Futrombicula spp.*
Field cricket	*Gryllus pennsylvanicus*
Small whirligig beetle	*Gyrinus spp.*
Ceraunus blue	*Hemiargus ceraunus*
Riparian earwig	*Labidura riparia*
Silverfish	*Lepisma saccharina*
Giant waterbug	*Lethocerus americanus*
Marl pennant	*Macrodiplax balteata*
Tent caterpillar moth	*Malacosoma americanum*
Freshwater mosquitos	*Mansonia spp.*
American carrion beetle	*Necrophila americana*
Northern mole cricket	*Neocurtilla hexadactyla*
Roseate skimmer	*Orthemis ferruginea*
Blue dasher	*Pachydiplax longipennis*
Wandering glider	*Pantala flavescens*
Giant swallowtail	*Papilio cresphontes*
E. Tiger swallowtail	*Papilio glaucus*
Palamedes swallowtail	*Papilio palamedes*
American cockroach	*Periplaneta americana*
Scarab beetle	*Phanaeus vindex*
Cloudless sulphur	*Phoebis sennae*
Phaon crescent	*Phyciodes phaon*
Paper wasp	*Polistes spp.*
Giant root borer	*Prionus spp.*
Flood-water Mosquito	*Psorophora spp.*
Black ground beetle	*Pterostichus spp.*
Brown water scorpion	*Ranatra fusca*

Common Name	Scientific Name
Termite	*Reticulitermes flavipes*
Termites	*Reticultermes flavipes*
SE. Lubber grasshopper	*Romalea microptera*
Black/yellow mud dauber	*Sceliphron caementarium*
Fire ant	*Solenopsis wagneri*
Oleander moth	*Syntomeida epilais*
Horseflies	*Tabanus spp.*
Violet masked glider	*Tramea carolina*
Common buckey	*Unonia coenia*
Long tailed skipper	*Urbanus proteus*
Bella moth	*Utetheisa ornatrix bella*
American lady	*Vanessa virginiensis*
Yellowjacket	*Vespula spp.*
Carpenter bee	*Xylocopa virginica*
Tersa moth	*Xylophanes tersa*
Class Merostomata	
Horseshoe crab	*Limulus polyphemus*
Mantis shrimp	*Squilla empusa*
Class Gastropoda (snails)	
Sea Hare	*Aplysia braziliana*
Striped Sea Slug	*Armina tigrina*
False Cerith	*Batillaria minima*
Variable Bittium	*Bittium varium*
West Indian Bubble	*Bulla occidentalis*
Ragged Sea Hare	*Bursatella leachi*
Knobbed Whelk	*Busycon carica*
Lightning Whelk	*Busycon sinistrum*
Sculptured Top-Shell	*Calliostoma euglyptum*
Tinted Cantharus	*Cantharus tinctus*
Ladder Horn Shell	*Cerithdea scalariformis*
Miniature Cerith	*Cerithiopsis greeni*
Florida Cerith	*Cerithium floridanum*
Spiny Slipper Shell	*Crepidula aculeata*
Atlantic Slipper Shell	*Crepidula fornicata*
Eastern White Slipper Shell	*Crepidula plana*
Giant Atlantic Cockle	*Dinocardium robustum*
Keyhold Limpet	*Diodora cayenensis*
Angulate Wentletrap	*Epitonium angulatum*
Banded Tulip	*Fasciolaria hunteria*
True Tulip	*Fasciolaria tulipa*
Mortons Egg Cockle	*Laevicardium mortoni*
Marsh periwinkle	*Littorina irrorata*
Zebra Periwinkle	*Littorina ziczac*

Common Name	Scientific Name
Common Marsh Snail	*Melampus bidentatus*
Saltmarsh snail	*Melampus coffeus*
Crown Conch	*Melongena corona*
Atlantic Modulus	*Modulus modulus*
Mud snail	*Nassarius obsoletus*
Eastern Nassa	*Nassarius vibex*
Olive Nerite	*Neritina reclivata*
Virgin Nerite	*Neritina virginea*
Impressed Odostome	*Odostomia impressa*
Olive Shell	*Oliva sayana*
Variable Dwarf Olive	*Olivella mutica*
Horse Conch	*Pleuroploca gigantea*
Shark Eye	*Polinices duplicatus*
Miniature Cerith	*Seila adamsi*
False Limpet	*Siphonaria pectinata*
Terrestrial gastrpod	*Succinea campestris*
Florida Rock Shell	*Thais haemastoma floridana*
Black-Lined Trifora	*Triphora nigrocincta*
Chestnut Turban	*Turbo castaneus*
Atlantic Oyster Drill	*Urosalpinx cinerea*
Class Polyplacophora (chitons)	
Eastern Chiton	*Chaetopleura apiculata*
Class Bivalvia (clams, mussels, oysters)	
Common Atlantic Abra	*Abra aequelis*
Paper Mussel	*Amygdalum papyria*
Greedy Dove-Shell	*Anachis avara*
Fat Dove-Shell	*Anachis obesa*
Transverse Ark	*Anadara transversa*
Jingle Shell	*Anomia simplex*
Zebra Turkey Wing	*Arca zebra*
Sawtooth Pen Clam	*Atrina serrata*
Angel Wing	*Barnea costata*
Scorched Mussel	*Brachidontes exustus*
Hooked Mussel	*Brachidontes recurvus*
Cross-Barred Venus	*Chione cancellata*
Conrad's False Mussel	*Congeria leucophaeata*
Contracted Corbula	*Corbula contracta*
Eastern Oyster	*Crassostrea virginica*
Angelwing Clam	*Cyrtopleura costata*
Coquina clam	*Donax variabilis*
Disk Dosinia	*Dosinia discus*
Jackknife Clam	*Ensis minor*
Razor clams	*Ensis spp.*

Common Name	Scientific Name
Comb Bittersweet	*Glycymeris pectinata*
Marsh Mussel	*Guekensia demissa*
Ribbed mussel	*Ischadium demissum*
Mahogany Date Mussel	*Lithophaga bisulcata*
Calico clam	*Macrocallista maculata*
Wedge-Shaped Martesia	*Martesia cuneiformis*
Southern Quahog	*Mercenaria campechiensis*
Quahog	*Mercenaria mercenaria*
Lunar Dove-Shell	*Mitrella lunata*
Dwarf Surf Clam	*Mulinia lateralis*
Pondersous Ark	*Noetia ponderosa*
Crested Oyster	*Ostrea equestris*
Carolina Marsh Clam	*Polymesoda caroliniana*
Florida Marsh Clam	*Pseudocyrena floridana*
Common Rangia	*Rangia cuneata*
Purplish Tagelus	*Tagelus divisus*
Stout Tagelus	*Tagelus plebius*
Rose Petal Tellin	*Tellina lineata*
Class Cephalopoda (squids and octopus)	
Squid	*Loligunculus brevis*
Atlantic Octopus	*Octopus vulgaris*
Phylum Bryozoa (Ectoprocta, moss animals)	
	Zoobotryon verticillatum
Rubber bryozoan	*Alcyonidium hauffi*
	Anguinella palmata
	Bugula neritina
Common sea mat	*Membranipora tenuis*
	Schizoporella errata
Phylum Echinodermata	
Common Starfish	*Asterias forbesi*
Margined Sea Star	*Astropecten articulatus*
Lines Sea Star	*Luidea clathrata*
Class Echnioidea (sea urchins)	
Purple Spined Sea Urchin	*Arbacea punctulata*
Variable Urchin	*Lytechinus variegatus*
Sand Dollar	*Mellita quinquesperforata*
Class Holothuroidea (sea cucumbers)	
Common Thyone	*Thyone briatus*
Class Ophiuroidea (brittle stars)	
Angular brittle star	*Ophiothrix angulata*
Phylum Hemichordata (acorn worms)	
Southern acorn worm	*Ptychodera bahamensis*
Phylum Chordata (vertebrates and	

Common Name	**Scientific Name**
relatives)	
Class Ascidiacea (sea squirts)	
	Didemnum candidum
Mangrove Tunicate	*Ecteinascidia turbinata*
Common sea grape	*Molgula manhattensis*
Pleated sea squirt	*Styela plicata*
Sea pork	*Amaroucium stellatum*
Class Cephalochordata (lancelets)	
Caribean Lacelet	*Branchiostoma caribaeum*
Sub-phylum Vertebrate (vertebrates)	
Class Agnatha (jawless fishes)	
Sea Lamprey	*Petromyzon marinus*
Class Chondrichthyes (cartilaginous fishes)	
Shortnose Sturgeon	*Acipenser brevirostrum*
Gulf Sturgeon	*Acipenser oxyrinchus desotoi*
Spinner shark	*Carcharhinus brevipinna*
Bull shark	*Carcharhinus leucas*
Blacktip shark	*Carcharhinus limbatus*
Sandbar shark	*Carcharhinus plumbeus*
Southern Sting Ray	*Dasyatis americana*
Atlantic stingray	*Dasyatis sabina*
Smooth butterfly ray	*Gymnura micrura*
Lemon Shark	*Negaprion brevirostris*
Sand Shark	*Odontaspis taurus*
Clearnose Skate	*Raja eglanteria*
Atlantic Guitarfish	*Rhinobatos lentiginosus*
Cownose ray	*Rhinoptera bonasus*
Hammerhead sharks	*Shyrna spp.*
Scalloped Hammerhead	*Sphyrna lewini*
Great Hammerhead	*Sphyrna mokarran*
Bonnethead	*Sphyrna tiburo*
Super-class Osteichthyes (bony fishes)	
Seargeant major	*Abudefduf saxatilis*
Cowfish	*Acanthostracion quadricornis*
Lined sole	*Achirus lineatus*
Bonefish	*Albula vulpes*
Hickory shad	*Alosa mediocris*
Filefish	*Aluterus spp.*
Yellow bullhead	*Ameiurus natalis*
Bowfin	*Amia calva*
Striped anchovy	*Anchoa hepsetus*
Bay anchovy	*Anchoa mitchilli*
Anchovy	*Anchoa spp.*

Common Name	**Scientific Name**
Oscillated flounder	*Ancylopsetta quadrocellata*
American Eel	*Anguilla rostrata*
Sheepshead	*Archosargus probatocephalus*
Sea catfish	*Ariopsis felis*
S. stargazer	*Astroscopus y-graecum*
Gafftopsail catfish	*Bagre marinus*
Silver perch	*Bairdiella chrysoura*
Triggerfish	*Balistes spp.*
Frillfin goby	*Bathygobius soporator*
Atlantic menhaden	*Brevoortia tyrannus*
Yellow jack	*Carangoides bartholomaei*
Crevalle jack	*Caranx hippos*
Horse-eye jack	*Caranx latus*
Snook	*Centropomus undecimalis*
Rock sea bass	*Centropristis philadelphica*
Black sea bass	*Centropristis striata*
Atlantic spadefish	*Chaetodipterus faber*
Striped blenny	*Chasmodes bosquianus*
Florida blenny	*Chasmodes saburrae*
Atlantic bumper	*Chloroscombrus chrysurus*
Striped Burrfish	*Cilomycterus schoepfi*
Spotted whiff	*Citharichthys macrops*
Bay whiff	*Citharichthys spilopterus*
Common Dolphin	*Coryphaena hippurus*
Spotted sea trout	*Cynoscion nebulosus*
Atlantic weakfish	*Cynoscion regalis*
Sheepshead minnow	*Cyprinodon variegatus*
Irish pompano	*Diapterus auratus*
Striped mojarra	*Diapterus plumieri*
Balloon fish	*Diodon holocanthus*
Dwarf sand perch	*Diplectrum bivittatum*
Sand perch	*Diplectrum formosum*
Silver porgy	*Diplodus argenteus*
Spottail pinfish	*Diplodus holbrooki*
Gizzard shad	*Dorosoma cepedianum*
Threadfin shad	*Dorosoma petenense*
Sharksucker	*Echeneis naucrates*
Ladyfish	*Elops saurus*
Nassau Grouper	*Ephinephelus striatus*
Goliath grouper	*Epinephelus itajara*
Groupers	*Epinephelus spp.*
Lake chubsucker	*Erimyzon sucetta*
Fringed flounder	*Etropus crossotus*

Common Name	**Scientific Name**
Silver jenny	*Eucinostomus gula*
Tidewater mojarra	*Eucinostomus harengulus*
Slender mojarra	*Eucinostomus jonesi*
Spotfin mojarra	*Eugerres plumieri*
Flying halfbeak	*Euleptorhamphus velox*
Little tunny	*Euthynnus alleteratus*
Golden topminnow	*Fundulus chrysotus*
Marsh killifish	*Fundulus confluentus*
Gulf killifish	*Fundulus grandis*
Mummichog	*Fundulus heteroclitus*
Striped/longnose killifish	*Fundulus majalis*
Tiger shark	*Galeocerdo cuviera*
Mosquitofish	*Gambusia affinis*
Eastern mosquitofish	*Gambusia holbrooki*
Yellowfin Mojarra	*Gerre cinereus*
Skilletfish	*Gobiesox strumosus*
Violet goby	*Gobioides broussonetii*
Darter goby	*Gobionellus boleosoma*
Highfin goby	*Gobionellus oceanicus*
Freshwater goby	*Gobionellus shufeldti*
Emerald goby	*Gobionellus smaragdus*
Marked goby	*Gobionellus stigmaticus*
Naked goby	*Gobiosoma bosc*
Twoscale goby	*Gobiosoma longipala*
Code goby	*Gobiosoma robustum*
Grunts	*Haemulon spp.*
Scaled sardine	*Harengula jaguana*
Least killifish	*Heterandria formosa*
Lined seahorse	*Hippocampus erectus*
Barred blenny	*Hypleurochilus bermudensis*
American halfbeak	*Hyporhamphus meeki*
Feather blenny	*Hypsoblennius hentz*
Brown bullhead	*Ictalurus nebulosus*
FL. Flagfish	*Jordanella floridae*
Hairy blenny	*Labrisomus nuchipinnis*
Trunkfish	*Lactophrys trigonus*
Pinfish	*Lagodon rhomboides*
Warmouth	*Lapomis gulosus*
Banded drum	*Larimus fasciatus*
Spot	*Leiostomus xanthurus*
Longnose gar	*Lepisosteus osseus*
Redbreasted sunfish	*Lepomis auritus*
Bluegill	*Lepomis macrochirus*

Common Name	**Scientific Name**
Redear sunfish	*Lepomis microlophus*
Stumpknocker	*Lepomis punctatus*
Tripletail	*Lobotes surinamensis*
Red Snapper	*Lutjanus campechanus*
Gray snapper	*Lutjanus griseus*
Lane snapper	*Lutjanus synagris*
Atlantic Manta	*Manta birostris*
Tarpon	*Megalops atlanticus*
Rough silvereside	*Membras martinica*
Tidewater Silverside	*Menidia beryllina*
Atlantic silverside	*Menidia menidia*
Silverside	*Menidia spp.*
Whiting	*Menticirrhus americanus*
Gulf kingfish	*Menticirrhus littoralis*
Northern kingfish	*Menticirrhus saxatilis*
Clown goby	*Microgobius gulosus*
Green goby	*Microgobius thalassinus*
Opposum pipefish	*Microphis brachyurus*
Atlantic croaker	*Micropogonias undulatus*
Largemouth bass	*Micropterus floridanus*
Filefish	*Monacanthus spp.*
Striped mullet	*Mugil cephalus*
White mullet	*Mugil curema*
Gag	*Myctoperca microlepis*
Speckled worm eel	*Myrophis punctatus*
Golden shiner	*Notemigonus crysoleucus*
Polka-dot batfish	*Ogcocephalus cubifrons*
Leatherjack	*Oligoplites saurus*
Shrimp eel	*Ophichthus gomesi*
Cusk-eel	*Ophidion spp.*
Atlantic thread herring	*Opisthonema oglinum*
Oyster toadfish	*Opsanus tau*
Pigfish	*Orthopristis chrysoptera*
Gulf flounder	*Paralichthys albigutta*
Summer flounder	*Paralichthys dentatus*
S. flounder	*Paralichthys lethostigma*
Broad flounder	*Paralichthys squamilentus*
Harvest fish	*Peprilus paru*
Sailfin molly	*Poecilia latipinna*
Mollies	*Poecilia spp.*
Blackdrum	*Pogonias cromis*
Bluefish	*Pomatomus saltatrix*
Northern searobin	*Prionotus carolinus*

Common Name	Scientific Name
Striped searobin	*Prionotus evolans*
Blackfin searobin	*Prionotus rubio*
Leopard searobin	*Prionotus scitulus*
Bighead searobin	*Prionotus tribulus*
Short bigeye	*Pristigenys alta*
Cobia	*Rachycentron canadum*
Remora	*Remora remora*
Bonito	*Sarda sarda*
Spanish sardine	*Sardinella aurita*
Red drum	*Sciaenops ocellatus*
King Mackeral	*Scomberomorus cavalla*
Spanish mackerel	*Scomberomorus maculatus*
Barbfish	*Scorpaena brasiliensis*
Spotted scorpionfish	*Scorpaena plumieri*
Bigeye scad	*Selar crumenophthalmus*
Atlantic moonfish	*Selene setapinnis*
Lookdown	*Selene vomer*
Amberjack	*Seriola dumerili*
Florida Puffer	*Sphoerodies nephelus*
Northernpuffer	*Sphoeroides maculatus*
Southern puffer	*Sphoeroides nephelus*
Checkered puffer	*Sphoeroides testudineus*
Great barracuda	*Sphyraena barracuda*
Guaguanche	*Sphyraena guachancho*
Star drum	*Stellifer lanceolatus*
Planehead filefish	*Stephanolepis hispida*
Atlantic needlefish	*Strongylura marina*
Redfin needlefish	*Strongylura notata*
Blackcheek tonguefish	*Symphurus plagiusa*
Dusky pipefish	*Syngnathus floridae*
N. pipefish	*Syngnathus fuscus*
Chain pipefish	*Syngnathus louisianae*
Gulf pipefish	*Syngnathus scovelli*
Inshore lizardfish	*Synodus foetens*
Pompano	*Trachinotus carolinus*
Permit	*Trachinotus falcatus*
Rough scad	*Trachurus lathami*
Atlantic cutlassfish	*Trichiurus lepturus*
Hogchoker	*Trinectes maculatus*
Southern hake	*Urophycis floridana*
Class Amphibia (frogs and salamanders)	
Florida Cricket frog	*Acris gryllus dorsalis*
Mole salamander	*Ambystoma talpoideum*

Common Name	**Scientific Name**
Oak toad	*Bufo quercicus*
Southern Toad	*Bufo terrestris*
Greenhouse frog	*Eleutherodactylus planirostris*
Dwarf salamander	*Eurycea quadradigitata*
Narrow-mouthed toad	*Gastrophryne carolinensis*
Green tree frog	*Hyla cinerea*
Pine woods tree frog	*Hyla femoralis*
Barking treefrog	*Hyla gratiosa*
Squirrel tree frog	*Hyla squirella*
Striped newt	*Notophthalmus perstriatus*
Cuban tree frog	*Osteopilus septentrionalis*
Spring peeper	*Pseudacris crucifer*
Florida Chorus frog	*Pseudacris nigrita verrucosa*
Little grass frog	*Pseudacris ocularis*
Gopher Frog	*Rana capito*
Bullfrog	*Rana catesbeiana*
Pig frog	*Rana grylio*
Florida leopard frog	*Rana sphenocephala*
Eastern spadefoot	*Scaphiopus holbrookii*
Class Reptilia (reptiles)	
Florida cottonmouth	*Agkistrodon piscivorus conanti*
American Alligator	*Alligator mississippiensis*
Green anole	*Anolis carolinensis*
Brown anole	*Anolis sagrei*
Florida Softshell Turtle	*Apalone ferox*
Six-lined racerunner	*Aspidoscelis sexlineatus*
Loggerhead sea turtle	*Caretta caretta*
Florida scarlet snake	*Cemophora coccinea*
Green sea turtle	*Chelonia mydas*
Florida Snapping turtle	*Chelydra serpentina osceola*
Florida cooter	*Chrysemys floridana*
Spotted Turtle	*Clemmys guttata*
Black racer	*Coluber constrictor priapus*
Eastern Diamondback rattlesnake	*Crotalus adamanteus*
Chicken turtle	*Deirochelys reticularia*
Leatherback sea turtle	*Dermochelys coriacea*
Southern Ringneck snake	*Diadophis punctatus punctatus*
Eastern Indigo snake	*Drymarchon corais couperi*
Red rat snake	*Elaphe guttata*
SE five-lined skink	*Eumeces inexpectatus*
Broad-headed skink	*Eumeces laticeps*
Eastern Mud snake	*Farancia abacura abacura*
Gopher tortoise	*Gopherus polyphemus*

Common Name	**Scientific Name**
Florida red bellied turtle	*Grysemys nelsoni*
Mediteranian gecko	*Hemidactylus garnotii*
Striped mud turtle	*Kinosternon bauri*
Florida Mud turtle	*Kinosternon subrubrum steindachneri*
Eastern Mud turtle	*Kinosternon subrubrum subrubrum*
Eastern King snake	*Lampropeltis getula getula*
Scarlet king snake	*Lampropeltis triangulum elapsoides*
Kemp's Ridley	*Lepidochelys kempii*
Diamondback terrapin	*Malaclemys terrapin centrata*
E. Coachwhip	*Masticophis flagellum flagellum*
Coral Snake	*Micrurus fulvius*
Fl. water snake	*Nerodia fasciata pictiventris*
Rough green snake	*Opheodrys aestivus*
E. Glass lizard	*Ophisaurus ventralis*
Corn snake	*Pantherophis guttata guttata*
Yellow rat snake	*Pantherophis obsoleta quadrivittata*
FL. Redbelly turtle	*Pseudemys nelsoni*
Peninsula cooter	*Pseudemys peninsularis*
Pine woods snake	*Rhadinaea flavilata*
Ground skink	*Scincella lateralis*
Greater siren	*Siren lacertina*
Dusky pigmy rattlesnake	*Sistrurus miliarius barbouri*
FL. Box turtle	*Terrapene carolina bauri*
Peninsula ribbon snake	*Thamnophis sauritus nitae*
E. Garter snake	*Thamnophis sirtalis*
Yellow-bellied slider	*Trachemys scripta*
Florida softshell	*Apalone ferox*
Class Aves (birds)	
Cooper's hawk	*Accipiter cooperii*
Sharp-shinned Hawk	*Accipiter striatus*
Spotted Sandpiper	*Actitis macularia*
Red-winged Blackbird	*Agelaius phoeniceus*
Wood Duck	*Aix sponsa*
Roseate Spoonbill	*Ajaia ajaja*
Saltmarsh Sharp-tailed Sparrow	*Ammodramus caudacutus*
Seaside Sparrow	*Ammodramus maritimus*
Nelson's Sharp-tailed Sparrow	*Ammodramus nelsoni*
Grasshopper Sparrow	*Ammodramus savannarum*
Northern Pintail	*Anas acuta*
American Widgeon	*Anas americana*
Northern Shoveler	*Anas clypeata*
Green-winged Teal	*Anas crecca*
Blue-winged Teal	*Anas discors*

Common Name	**Scientific Name**
Mottled Duck	*Anas fulvigula*
Mallard	*Anas platyrhynchos*
American black duck	*Anas ruprides*
American black duck	*Anas ruprides*
Gadwall	*Anas strepera*
Anhinga	*Anhinga anhinga*
American Pipit	*Anthus rubescens*
Water pipit	*Anthus spinoletta*
Florida Scrub Jay	*Aphelocoma coerulescens*
Fox sparrow	*Apsserella iliaca*
Limpkin	*Aramus guarauna*
Ruby-throated Hummingbird	*Archilochus colubris*
Great Egret	*Ardea alba*
Great Blue Heron	*Ardea herodias*
Ruddy Turnstone	*Arenaria interpres*
Lesser Scaup	*Aythya affinis*
Redhead	*Aythya americana*
Ring-necked Duck	*Aythya collaris*
Greater Scaup	*Aythya marila*
Canvasback	*Aythya valisineria*
Tufted Titmouse	*Baeolophus bicolor*
Cedar Waxwing	*Bombycilla cedrorum*
American Bittern	*Botaurus lentiginosus*
Brant	*Branta bernicla*
Great Horned Owl	*Bubo virginianus*
Cattle Egret	*Bubulcus ibis*
Bufflehead	*Bucephala albeola*
Common Goldeneye	*Bucephala clangula*
Red-tailed Hawk	*Buteo jamaicensis*
Red-shouldered Hawk	*Buteo lineatus*
Green Heron	*Butorides virescens*
Sanderling	*Calidris alba*
Dunlin	*Calidris alpina*
Red Knot	*Calidris canutus*
Western Sandpiper	*Calidris mauri*
Least Sandpiper	*Calidris minutilla*
Semipalmated Sandpiper	*Calidris pusilla*
Chuck-will's-widow	*Caprimulgus carolinensis*
Whip-poor-will	*Caprimulgus vociferus*
Northern Cardinal	*Cardinalis cardinalis*
American Goldfinch	*Carduelis tristis*
Purple finch	*Carpodacus purpureus*
Turkey Vulture	*Cathartes aura*

Common Name	**Scientific Name**
Veery	*Catharus fuscescens*
Hermit Thrush	*Catharus guttatus*
Gray-cheeked Thrush	*Catharus minimus*
Swainson's Thrush	*Catharus ustulatus*
Willet	*Catoptrophorus semipalmatus*
Belted Kingfisher	*Ceryle alcyon*
Chimney Swift	*Chaetura pelagica*
Piping Plover	*Charadrius melodus*
Semipalmated Plover	*Charadrius semipalmatus*
Killdeer	*Charadrius vociferus*
Wilson's Plover	*Charadrius wilsonia*
Snow Goose	*Chen caerulescens*
Black Tern	*Chlidonias niger*
Lark Sparrow	*Chondestes grammacus*
Common Nighthawk	*Chordeiles minor*
Northern Harrier	*Circus cyaneus*
Marsh Wren	*Cistothorus palustris*
Sedge Wren	*Cistothorus platensis*
Yellow-billed Cuckoo	*Coccyzus americanus*
Northern Flicker	*Colaptes auratus*
Northern Bobwhite	*Colinus virginianus*
Rock Pigeon	*Columbia livia*
Common Ground-Dove	*Columbina passerina*
Eastern Wood-Pewee	*Contopus virens*
Black Vulture	*Coragyps altratus*
American Crow	*Corvus brachyrhynchos*
Fish Crow	*Corvus ossifragus*
Blue Jay	*Cyanocitta cristata*
Tundra swan	*Cygnus columbianus*
Black-bellied Whistling Duck	*Dendrocygna autumnalis*
Fulvous Whistling-Duck	*Dendrocygna bicolor*
Black-throated Blue Warbler	*Dendroica caerulescens*
Bay-breasted Warbler	*Dendroica castanea*
Cerulean Warbler	*Dendroica cerulea*
Yellow-rumped Warbler	*Dendroica coronata*
Prairie Warbler	*Dendroica discolor*
Yellow-throated Warbler	*Dendroica dominica*
Blackburnian Warbler	*Dendroica fusca*
Kirtland's Warbler	*Dendroica kirtlandii*
Magnolia Warbler	*Dendroica magnolia*
Palm Warbler	*Dendroica palmarum*
Chestnut-sided Warbler	*Dendroica pensylvanica*
Yellow Warbler	*Dendroica petechia*

Common Name	Scientific Name
Pine Warbler	*Dendroica pinus*
Blackpoll Warbler	*Dendroica striata*
Cape May Warbler	*Dendroica tigrina*
Black-throated Green Warbler	*Dendroica virens*
Bobolink	*Dolichonyx oryzivorus*
Pileated Woodpecker	*Dryocopus pileatus*
Gray Catbird	*Dumetella carolinensis*
Little Blue Heron	*Egretta caerulea*
Reddish Egret	*Egretta rufescens*
Snowy Egret	*Egretta thula*
Tricolored Heron	*Egretta tricolor*
Swallow-tailed Kite	*Elanoides forficatus*
White Ibis	*Eudocimus albus*
Merlin	*Falco columbarius*
Peregrine Falcon	*Falco peregrinus*
American Kestrel	*Falco sparverius*
Magnificent Frigate bird	*Fregata magnificens*
American Coot	*Fulica americana*
Common Snipe	*Gallinago gallinago*
Common Moorhen	*Gallinula chloropus*
Common Loon	*Gavia immer*
Red-throated Loon	*Gavia stellata*
Common Yellowthroat	*Geothlypis trichas*
Florida Sandhill Crane	*Grus canadensis pratensis*
Blue Grosbeak	*Guiraca caerulea*
American Oystercatcher	*Haematopus palliatus*
Bald Eagle	*Haliaeetus leucocephalus*
Worm-eating Warbler	*Helmitheros vermivora*
Black-necked Stilt	*Himantopus mexicanus*
Barn Swallow	*Hirundo rustica*
Wood Thrush	*Hylocichla mustelina*
Baltimore Oriole	*Icterus galbula*
Orchard Oriole	*Icterus spurius*
Least Bittern	*Ixobrychus exilis*
Dark-eyed Junco	*Junco hyemalis*
Loggerhead Shrike	*Lanius ludovicianus*
Herring Gull	*Larus argentatus*
Laughing Gull	*Larus atricilla*
Ring-billed Gull	*Larus delawarensis*
Lesser black backed gull	*Larus fuscus*
Great Black-backed Gull	*Larus marinus*
Bonaparte's Gull	*Larus philadelphia*
Short-billed Dowitcher	*Limnodromus griseus*

Common Name	**Scientific Name**
Long-billed Dowitcher	*Limnodromus scolopaceus*
Marbled Godwit	*Limosa fedoa*
Hooded Merganser	*Lophodytes cucullatus*
Wild Turkey	*Melagris gallopavo*
Red-bellied Woodpecker	*Melanerpes carolinus*
Red-headed Woodpecker	*Melanerpes erythrocephalus*
White-winged Scoter	*Melanitta fusca*
Black Scoter	*Melanitta nigra*
Surf Scoter	*Melanitta perspicillata*
Swamp Sparrow	*Melospiza georgiana*
Song Sparrow	*Melospiza melodia*
Red-breasted Merganser	*Mergus serrator*
Northern Mockingbird	*Mimus polyglottos*
Black-and-white Warbler	*Mniotilta varia*
Brown-headed Cowbird	*Molothrus ater*
Northern Gannet	*Morus bassanus*
Wood Stork	*Mycteria americana*
Great Crested Flycatcher	*Myiarchus crinitus*
Whimbrel	*Numenius phaeopus*
Yellow-crowned Night-Heron	*Nyctanassa violacea*
Black-crowned Night-Heron	*Nycticorax nycticorax*
Yellow crowned night heron	*Nycticorax violaceous*
Wilson's Storm-Petrel	*Oceanites oceanicus*
Eastern Screech-Owl	*Otus asio*
Ruddy Duck	*Oxyura jamaicensis*
Osprey	*Pandion haliaetus*
Northern Parula	*Parula americana*
House Sparrow	*Passer domesticus*
Savannah Sparrow	*Passerculus sandwichensis*
Painted Bunting	*Passerina ciris*
Indigo Bunting	*Passerina cyanea*
American White Pelican	*Pelecanus erythrorhynchos*
Brown Pelican	*Pelecanus occidentalis*
Double-crested Cormorant	*Phalacrocorax auritus*
Rose-breasted Grosbeak	*Pheucticus ludovicianus*
Red-Cockaded Woodpecker	*Picoides borealis*
Downy Woodpecker	*Picoides pubescens*
Hairy Woodpecker	*Picoides villosus*
Eastern Towhee	*Pipilo erythrophthalmus*
Scarlet Tanager	*Piranga olivacea*
Summer Tanager	*Piranga rubra*
Snow Bunting	*Plectrophenax nivalis*
Glossy Ibis	*Plegadis falcinellus*

Common Name	Scientific Name
Black-bellied Plover	*Pluvialis squatarola*
Horned grebe	*Podiceps auritus*
Red-necked Grebe	*Podiceps grisegena*
Pied-billed Grebe	*Podilymbus podiceps*
Carolina Chickadee	*Poecile carolinensis*
Blue-gray Gnatcatcher	*Polioptila caerulea*
Vesper Sparrow	*Pooecetes gramineus*
Purple Gallinule	*Porphyrula martinica*
Sora	*Porzana carolina*
Purple Martin	*Progne subis*
Prothonotary Warbler	*Protonotaria citrea*
Boat-tailed Grackle	*Quiscalus major*
Common Grackle	*Quiscalus quiscula*
King rail	*Rallus elegans*
Virginia Rail	*Rallus limicola*
Clapper Rail	*Rallus longirostris*
American Avocet	*Recurvirostra americana*
Ruby-crowned Kinglet	*Regulus calendula*
Golden-crowned Kinglet	*Regulus satrapa*
Black Skimmer	*Rynchops niger*
Eastern Phoebe	*Sayornis phoebe*
American Woodcock	*Scolopax minor*
Ovenbird	*Seiurus aurocapillus*
Louisiana Waterthrush	*Seiurus motacilla*
Northern Waterthrush	*Seiurus noveboracensis*
American Redstart	*Setophaga ruticilla*
Eastern Bluebird	*Sialia sialis*
Red breasted nuthatch	*Sitta canadensis*
Brown-headed Nuthatch	*Sitta pusilla*
Yellow-bellied Sapsucker	*Sphyrapicus varius*
Chipping Sparrow	*Spizella passerina*
Field sparrow	*Spizella pusilla*
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*
Least Tern	*Sterna antillarum*
Caspian Tern	*Sterna caspia*
Roseate Tern	*Sterna dougallii*
Forster's Tern	*Sterna forsteri*
Common Tern	*Sterna hirundo*
Royal Tern	*Sterna maxima*
Gull-billed Tern	*Sterna nilotica*
Sandwich Tern	*Sterna sandvicensis*
Eurasian Collared-Dove	*Streptopelia decaocto*
Barred owl	*Strix varia*

Common Name	Scientific Name
Eastern Meadowlark	*Sturnella magna*
European Starling	*Sturnus vulgaris*
Northern rough winged swallow	*Telgidopteryx serripennis*
Carolina Wren	*Thryothorus ludovicianus*
Brown Thrasher	*Toxostoma rufum*
Tree Swallow	*Trachycineta bicolor*
Lesser Yellowlegs	*Tringa flavipes*
Greater Yellowlegs	*Tringa melanoleuca*
Solitary Sandpiper	*Tringa solitaria*
House Wren	*Troglodytes aedon*
American Robin	*Turdus migratorius*
Gray Kingbird	*Tyrannus dominicensis*
Eastern Kingbird	*Tyrannus tyrannus*
Western Kingbird	*Tyrannus verticalis*
Barn Owl	*Tyto alba*
Orange-crowned Warbler	*Vermivora celata*
Golden-winged Warbler	*Vermivora chrysoptera*
Tennessee Warbler	*Vermivora peregrina*
Blue-winged Warbler	*Vermivora pinus*
Nashville Warbler	*Vermivora ruficapilla*
Yellow-throated Vireo	*Vireo flavifrons*
White-eyed Vireo	*Vireo griseus*
Red-eyed Vireo	*Vireo olivaceus*
Blue-headed Vireo	*Vireo solitarius*
Hooded Warbler	*Wilsonia citrina*
Wilson's Warbler	*Wilsonia pusilla*
Mourning Dove	*Zenaida macroura*
White-throated Sparrow	*Zonotrichia albicollis*
White-crowned Sparrow	*Zonotrichia leucophrys*
Class Mammalia (mammals)	
Right whale	*Balaena glacialis*
Short tail shrew	*Blarina brevicauda*
Rafinesque's Big-Eared Bat	*Corynorhinus rafinesquii*
Nine-banded armadillo	*Dasypus novemcinctus*
Virginia opossum	*Didelphis virginiana*
Atlantic right whale	*Eubalaena glacialis*
Southeastern pocket gopher	*Geomys pinetis*
S. Flying squirrel	*Glaucomys volans*
Pygmy Sperm Whale	*Kogia breviceps*
E. Red Bat	*Lasiurus borealis*
River otter	*Lontra canadensis*
Bobcat	*Lynx rufus*
Humpback whale	*Megaptera novaeangliae*

Common Name	**Scientific Name**
Striped skunk	*Mephitis mephitis*
House mouse	*Mus musculus*
Florida mink	*Mustela vison lutensis*
Florida Mink	*Mustela vison mink*
S.E. Myotis	*Myotis austroriparius*
Round tailed muskrat	*Neofiber alleni*
Eastern woodrat	*Neotoma floridana*
Seminole bat	*Nycteris seminolis*
Golden mouse	*Ochrotomys nuttalli*
White-tailed deer	*Odocoileus virginianus*
Marsh rice rat	*Oryzomys palustris*
Cotton mouse	*Peromyscus gossypinus gossypinus*
Anastasia Island Beach Mouse	*Peromyscus polionotus phasma*
Old field mouse	*Peromyscus polionotus polionotus*
Florida mouse	*Podomys floridanus*
Raccoon	*Procyon lotor*
Norway rat	*Rattus norvegicus*
Black rat	*Rattus rattus*
Eastern harvest mouse	*Reithrodontomys humulis*
Eastern mole	*Scalopus aquaticus*
Gray squirrel	*Sciurus carolinensis*
Hispid cotton rat	*Sigmodon hispidus*
Southeastern shrew	*Sorex longirostris*
Eastern spotted skunk	*Spilogale putorius*
Feral pig	*Sus scrofa*
Eastern Cottontail	*Sylvilagus floridanus*
Marsh rabbit	*Sylvilagus palustris*
West Indian manatee	*Trichechus manatus*
Bottle-nosed dolphin	*Tursiops truncatus*
Gray fox	*Urocyon cinereoargenteus*
Florida Black Bear	*Ursus americanus floridanus*
Red fox	*Vulpes vulpes*

APPENDIX B. LIST OF WATER QUALITY SAMPLING STATIONS

Organization Name	ID	Latitude	Longitude	Station ID	Station Name	WBID
FDACS	21FLSEAS	30 1 19.7998	81 19 41.3998	92SEAS600	Tip of Guana River at dam	2320
FDACS	21FLSEAS	30 0 2.3998	81 19 34.1998	92SEAS617	Smith's lease mid-way up Guana River	2320
FDACS	21FLSEAS	30 0 2.3998	81 19 34.1998	92SEAS617	Smith's lease mid-way up Guana River	2320
FDACS	21FLSEAS	29 58 41.3998	81 19 20.3999	92SEAS205	Up Sombrero Creek as far as possible	2470
FDACS	21FLSEAS	29 57 57.6	81 19 28.7998	92SEAS021	Northernmost marker Lease 1088 in XimaniesC.	2477
FDACS	21FLSEAS	29 57 31.1998	81 20 8.9999	92SEAS010	W end of basin adjacent to St. Aug. Airport	2363I
FDACS	21FLSEAS	29 57 43.7998	81 19 43.7999	92SEAS015	ICWW CM 48	2363I
FDACS	21FLSEAS	29 56 6	81 18 25.7998	92SEAS065	Creek mouth E shore north of ICWW CM 55	2363I
FDACS	21FLSEAS	29 56 11.9998	81 18 45.5998	92SEAS081	Mouth of Robinson Creek	2363I
FDACS	21FLSEAS	29 56 25.8	81 18 49.7999	92SEAS091	Mouth of Pancho Creek	2363I
FDACS	21FLSEAS	29 56 56.9998	81 18 38.3998	92SEAS111	Fishing pier E of ICWW CM 52	2363I
FDACS	21FLSEAS	29 57 28.8	81 18 54	92SEAS141	Creek on E shore north of ICWW CM 51	2363I
FDACS	21FLSEAS	29 57 20.9999	81 18 50.4	92SEAS145	ICWW CM 51	2363I
FDACS	21FLSEAS	29 57 31.7999	81 19 32.3998	92SEAS161	Mouth of airport canal	2363I
FDACS	21FLSEAS	29 58 34.7999	81 19 54.5999	92SEAS190	Mouth of Casa Cola Creek	2363I
FDACS	21FLSEAS	29 58 44.9998	81 19 40.1999	92SEAS200	Mouth of Sombrero Creek	2363I
FDACS	21FLSEAS	29 58 50.9999	81 19 43.1998	92SEAS201	Midway between #200 and Guana R.	2363I
FDACS	21FLSEAS	29 58 25.7999	81 19 43.7999	92SEAS210	ICWW CM 47	2363I
FDACS	21FLSEAS	30 3 40.2	81 21 22.2	92SEAS602		2363I
FDACS	21FLSEAS	29 59 25.1999	81 19 46.7998	92SEAS606	ICWW CM 45	2363I
FDACS	21FLSEAS	29 59 55.1998	81 19 55.2	92SEAS609	Mouth of creek on E shore N of ICWW CM 44	2363I
FDACS	21FLSEAS	29 59 45.6	81 19 57.5998	92SEAS610	ICWW CM 44	2363I
FDACS	21FLSEAS	30 0 5.9998	81 20 37.1998	92SEAS612	ICWW CM 38	2363I
FDACS	21FLSEAS	30 0 46.1999	81 20 56.4	92SEAS613	Mouth of Stokes Creek	2363I
FDACS	21FLSEAS	30 1 21	81 20 55.7999	92SEAS614	Creek E of ICWW CM 35	2363I
FDACS	21FLSEAS	30 1 47.3999	81 21 40.7999	92SEAS615	Spartina flats NE of ICWW CM 33	2363I
FDACS	21FLSEAS	29 59 4.7998	81 19 37.7998	92SEAS618	Mouth of Guana River	2363I
FDACS	21FLSEAS	30 2 13.2	81 21 54	92SEAS620	Midway between ICWW CMs 28 & 29	2363I

Organization Name	ID	Latitude	Longitude	Station ID	Station Name	WBID
FDACS	21FLSEAS	30 3 43.7998	81 22 13.1999	92SEAS621	W shore across from ICWW CM 24	2363I
FDACS	21FLSEAS	30 1 50.3998	81 21 42.5999	92SEAS625	Up Capo Creek as far as possible	2363I
FDACS	21FLSEAS	29 43 .5999	81 14 22.2	88SEAS011	Across from Fort Matanzas at creek mouth	2363F
FDACS	21FLSEAS	29 43 7.1998	81 14 15	88SEAS012	Up creek from station 11	2363F
FDACS	21FLSEAS	29 43 8.9998	81 14 46.7999	88SEAS100	CM 80A	2363F
FDACS	21FLSEAS	29 46 1.7998	81 15 22.1998	88SEAS150	Marina south of SR 206 bridge	2363F
FDACS	21FLSEAS	29 45 55.8	81 15 22.1998	88SEAS155	CM 60	2363F
FDACS	21FLSEAS	29 45 27	81 15 23.9998	88SEAS183	West of CM 64 lease 55-AQ-015	2363F
FDACS	21FLSEAS	29 44 16.8	81 14 57.5999	88SEAS187	Creek mouth west of CM 75	2363F
FDACS	21FLSEAS	29 44 22.7998	81 15 10.1999	88SEAS185	Up creek west of CM 75	2363F
FDACS	21FLSEAS	29 43 35.9998	81 14 49.2	88SEAS010	Mouth of creek southeast of CM 79	2363F
FDACS	21FLSEAS	29 43 50.9999	81 14 38.9998	88SEAS015	Up creek from station 10	2363F
FDACS	21FLSEAS	29 42 40.1998	81 14 38.4	88SEAS189	Mouth of 2nd creek southwest of CM 81C	2363F
FDACS	21FLSEAS	29 45 10.1999	81 15 2.3998	88SEAS191	CM 70	2363F
FDACS	21FLSEAS	29 42 32.9998	81 14 45.6	88SEAS174	Up creek from station 189	2363F
FDACS	21FLSEAS	29 41 48.5999	81 13 49.8	88SEAS171	Mouth of creek southwest of CM 83A	2363F
FDACS	21FLSEAS	29 45 7.7998	81 14 58.7998	88SEAS050	South of Devils Elbow Fish Camp east shore	2363F
FDACS	21FLSEAS	29 44 36.6	81 14 40.2	88SEAS030	Culvert south of boat ramp east of CM 72	2363F
FDACS	21FLSEAS	29 44 34.8	81 14 43.8	88SEAS130	CM 72	2363F
FDACS	21FLSEAS	29 44 13.7998	81 14 43.1999	88SEAS031	Mouth of creek east of CM 75	2363F
FDACS	21FLSEAS	29 44 7.8	81 14 40.2	88SEAS032	Up creek from station 31	2363F
FDACS	21FLSEAS	29 52 50.9999	81 16 53.9998	92SEAS777	Southernmost dock in Salt Run mainland	2502A
FDACS	21FLSEAS	29 52 32.3998	81 16 31.1999	92SEAS778	Salt Run between Jet Ski signs	2502A
FDACS	21FLSEAS	29 52 12.5998	81 16 27.5999	92SEAS774	Drainage ditch at S end of Salt Run	2502A
FDACS	21FLSEAS	29 52 57	81 16 46.7998	92SEAS773	Creek mouth E shore of Salt Run	2502A
FDACS	21FLSEAS	29 40 6.7199	81 13 .0599	88SEAS151	ICWW CM #87	2363E
FDACS	21FLSEAS	29 41 48.5999	81 13 27.5999	88SEAS061	East of Summer Haven at northwest turn	2363E

Organization Name	ID	Latitude	Longitude	Station ID	Station Name	WBID
FDACS	21FLSEAS	29 42 .5998	81 13 44.9998	88SEAS055	Mouth of residential canal south of inlet	2363E
FDACS	21FLSEAS	29 40 40.8	81 13 22.8	88SEAS101	Mouth of creek northwest of CM 86	2363E
FDACS	21FLSEAS	29 40 32.3998	81 13 43.7999	88SEAS102	Upstream from station 101	2363E
FDACS	21FLSEAS	29 40 58.1999	81 13 9.5999	88SEAS091	Tip of small island east of Rattlesnake Is	2363E
FDACS	21FLSEAS	29 40 33.6	81 13 14.3998	88SEAS105	ICWW @CM 86 near Flagler Co. line	2363E
FDACS	21FLSEAS	29 41 42.5998	81 13 41.9999	88SEAS176	Culvert on west shore of Summer Is	2363E
FDACS	21FLSEAS	29 41 10.1998	81 13 25.7999	88SEAS081	Mouth of creek southwest of CM 85	2363E
FDEP	21FLA	29 59 4.8	81 19 15	27010148	ICW AT GUANA RIVER	2320
FDEP	21FLA	30 1 18.2	81 19 37.7	27010169	GUANA LAKE APPROX 50 YARDS S OF DAM	2320
FDEP	21FLA	29 58 45.5	81 19 3.9	27010010	SOMBRERO CR AT N BEND AB ICW	2470
FDEP	21FLA	29 58 41.7	81 19 22	27010054	SOMBRERO CR 50 M BELOW FORK	2470
FDEP	21FLA	29 57 59	81 19 24.4	27010053	XMANIES CR @ 1st SE BEND	2477
FDEP	21FLA	29 49 18.87	81 19 20.81	27010055	MOULTRIE CR @ US 1	2493
FDEP	21FLA	29 50 50.7	81 21 39	27010188	MOULTRIE CREEK AT CR 207	2493
FDEP	21FLA	30 10 30	81 24 .5	20030445	ICW @ EAST TO WEST DITCH WEST OF ROSCOE RD	2363I
FDEP	21FLA	30 9 39.6	81 23 54.8	20030446	ICW JUST SOUTH PLANTATION CANAL PALM VALLEY	2363I
FDEP	21FLA	30 8 34.233	81 23 29.65	20030447	ICW WEST OF PALM LANE ~ 0.8MI N SR210	2363I
FDEP	21FLA	30 10 24.9	81 24 5.8	27010124	ICW AT WARDS LANDING	2363I
FDEP	21FLA	30 9 45.1	81 23 55.6	27010125	ICW JUST NORTH PLANTATION CANAL PALM VALLEY	2363I
FDEP	21FLA	30 9 1.8	81 23 44.2	27010126	ICWW DK PAINTED DPC #6	2363I
FDEP	21FLA	30 8 3.4	81 23 12.9	27010127	ICWW RED CHANNEL MARKER #2	2363I

Organization Name	ID	Latitude	Longitude	Station ID	Station Name	WBID
FDEP	21FLA	30 7 39.9	81 22 57.1	27010128	CREEK 1/2 MILE FROM BRIDGE ICWW	2363I
FDEP	21FLA	30 6 1	81 22 2	27010145	ICWW St Johns #9	2363I
FDEP	21FLA	30 3 57	81 22 11.7	27010146	ICWW 10 MARKER 21 TOLOMATO RIVER	2363I
FDEP	21FLA	30 1 58	81 21 55	27010147	ICWW St Johns #11 MARKER 30	2363I
FDEP	21FLA	30 9 39.8	81 22 37.6	27010167	PONTE VEDRA LAKE AT MICKLERS CUTOFF	2363I
FDEP	21FLA	30 0 46	81 20 56.7	27010172	STOKES CR AT MOUTH	2363I
FDEP	21FLA	29 57 43.6	81 19 14.6	27010175	ICW @ UNNAMED CR SE OF XIMANIES CR	2363I
FDEP	21FLA	29 57 34.9	81 20 8.7	27010176	ST AUG AIRPORT BASIN @ W CULVERT	2363I
FDEP	21FLA	29 57 29	81 19 36	27010177	ICW @ DITCH SE OF AIRPORT	2363I
FDEP	21FLA	30 1 41.9	81 21 45.8	27010202	ICW AT CM 32	2363I
FDEP	21FLA	29 42 15.1	81 14 1.5	27010098	ICWW AT CHANNEL CUT TO MATANZAS	2363F
FDEP	21FLA	29 49 50	81 18 4	27010155	INTRACOASTAL WATERWAY AT EAST CREEK	2363G1
FDEP	21FLA	29 51 58	81 18 18	27010154	INTRACOASTAL WATERWAY AT STP II OUTFALL	2363G1
FDEP	21FLA	29 52 27	81 18 15	27010153	INTRACOASTAL WATERWAY AT OUTFALL OF STP 1	2363G1
FDEP	21FLA	29 53 8.4	81 18 18.6	27010139	MATANZAS R 1/2 MI S OF BRIDGE	2363G1
FDEP	21FLA	29 51 26.8	81 18 40	27010140	MATANZAS R BY CHANNEL MARKER NO	2363G1
FDEP	21FLA	29 51 58.8	81 18 32.3	27010200	ICW 100 FT. SOUTH OF SR 312	2363G1
FDEP	21FLA	29 51 10.1	81 18 12.1	27010158	ICW AT ASD WWTP POD	2363G1
FDEP	21FLA	29 50 48.8	81 17 59.6	27010157	ICW AT CM 21	2363G1
FDEP	21FLA	29 52 33.3	81 18 30	27010162	ST AUGUSTINE WWTP #1 EFF.	2363G1
FDEP	21FLA	29 51 25.9	81 18 44.2	27010201	ICW AT CM 17	2363G1
FDEP	21FLA	29 52 46.4	81 18 11.6	27010161	ICW AT CM 12	2363G1
FDEP	21FLA	29 52 4.2	81 18 23.5	27010160	ICW 50 FEET NORTH OF SR 312	2363G1

Organization Name	ID	Latitude	Longitude	Station ID	Station Name	WBID
FDEP	21FLA	29 51 11.2	81 18 24.3	27010159	ICW AT CM 18	2363G1
FDEP	21FLA	29 51 21.7	81 17 29.6	27010164	ANASTASIA SANITARY DISTRICT WWTP EFF	2363G1
FDEP	21FLA	29 52 49.8	81 16 48.6	27010137	SALT RUN OFFSHORE FROM ANASTASIA	2502A
FDEP	21FLA	30 4 4.4	81 23 18.1	27010190	DEEP CREEK AT TRAIL (WOODEN) BRIDGE	2406
FDEP	21FLA	30 3 26.7	81 22 47.9	27010166	DEEP CR AT SWEETWATER CR	2406
FDEP	21FLA	29 39 36.4	81 13 .2	27011115	MARINELAND R/O WATER PLANT EFF	2363E
FDEP	21FLA	29 39 32.2	81 13 2.6	27010143	ICW S OF MARINELAND	2363E
FDEP	21FLA	29 39 40.6	81 13 2.9	27010142	ICW N OF MARINELAND	2363E
FDEP	21FLA	29 39 12	81 13 5	27010100	ICWW MARKER 94 AT PELLICER CR CO	2363E
FDEP	21FLA	29 40 7	81 13 2	27010099	ICWW MARKER 87 AT MARINELAND	2363E
FDEP	21FLGW	29 53 18.474	81 22 14.886	14799	SJB-SL-1003 WILSONS PIT	2493
FDEP	21FLGW	29 50 49.937	81 21 38.914	21201	MTC	2493
FDEP	21FLKWAT	29 58 25.02	81 19 44.28	ST.-STJ1-417	St. Johns-STJ1-417	2363I
FDEP	21FLKWAT	29 58 25.68	81 19 43.32	ST.-STJ1-428	St. Johns-STJ1-428	2363I
FDEP	21FLKWAT	29 58 26.7	81 19 46.02	ST.-STJ1-445	St. Johns-STJ1-445	2363I
FDEP	21FLKWAT	29 56 54.54	81 18 45.9	ST.-STJ2-909	St. Johns-STJ2-909	2363I
FDEP	21FLKWAT	29 56 54.6	81 18 45.24	ST.-STJ2-910	St. Johns-STJ2-910	2363I
FDEP	21FLKWAT	29 56 55.02	81 18 46.74	ST.-STJ2-917	St. Johns-STJ2-917	2363I
FDEP	21FLKWAT	29 55 16.5	81 18 9.42	ST.-STJ3-275	St. Johns-STJ3-275	2363I
FDEP	21FLKWAT	29 55 17.7	81 18 8.88	ST.-STJ3-295	St. Johns-STJ3-295	2363I
FDEP	21FLKWAT	29 55 18.42	81 18 8.94	ST.-STJ3-307	St. Johns-STJ3-307	2363I
FDEP	21FLKWAT	29 42 37.62	81 14 32.28	ST.-STJ14-627	St. Johns-STJ14-627	2363F
FDEP	21FLKWAT	29 42 37.32	81 14 32.34	ST.-STJ14-622	St. Johns-STJ14-622	2363F
FDEP	21FLKWAT	29 44 5.34	81 14 49.5	ST.-STJ13-089	St. Johns-STJ13-089	2363F

Organization Name	ID	Latitude	Longitude	Station ID	Station Name	WBID
FDEP	21FLKWAT	29 42 39.3	81 14 33.6	ST.-STJ14-655	St. Johns-STJ14-655	2363F
FDEP	21FLKWAT	29 44 5.28	81 14 48.6	ST.-STJ13-088	St. Johns-STJ13-088	2363F
FDEP	21FLKWAT	29 44 4.56	81 14 49.5	ST.-STJ13-076	St. Johns-STJ13-076	2363F
FDEP	21FLKWAT	29 50 20.64	81 18 3.12	ST.-STJ6-344	St. Johns-STJ6-344	2363G1
FDEP	21FLKWAT	29 50 19.14	81 18 5.46	ST.-STJ6-319	St. Johns-STJ6-319	2363G1
FDEP	21FLKWAT	29 50 18.9	81 18 5.04	ST.-STJ6-315	St. Johns-STJ6-315	2363G1
FDEP	21FLKWAT	29 51 59.1	81 18 24.48	ST.-STJ5-985	St. Johns-STJ5-985	2363G1
FDEP	21FLKWAT	29 51 57.9	81 18 24.3	ST.-STJ5-965	St. Johns-STJ5-965	2363G1
FDEP	21FLKWAT	29 51 56.52	81 18 24.72	ST.-STJ5-942	St. Johns-STJ5-942	2363G1
FDEP	21FLKWAT	29 41 4.08	81 13 22.98	ST.-STJ15-068	St. Johns-STJ15-068	2363E
FDEP	21FLKWAT	29 41 43.62	81 13 27.3	ST.-STJ15-727	St. Johns-STJ15-727	2363E
FDEP	21FLKWAT	29 37 24.7	81 12 12.7	FLA-AVALON-3	Flagler-Avalon-3	2363E
FDEP	21FLKWAT	29 37 24.7	81 12 12.7	FLA-AVALON-2	Flagler-Avalon-2	2363E
FDEP	21FLKWAT	29 37 28.9	81 11 45.2	FLA-SEAVISTA-1	Flagler-Sea Vista-1	2363E
FDEP	21FLKWAT	29 37 26	81 11 47.88	FLA-MEDFORD-2	Flagler-Medford-2	2363E
FDEP	21FLKWAT	29 37 26	81 11 47.88	FLA-MEDFORD-1	Flagler-Medford-1	2363E
FDEP	21FLKWAT	29 37 24.7	81 12 12.7	FLA-AVALON-1	Flagler-Avalon-1	2363E
FDEP	21FLKWAT	29 38 54.4	81 12 19.6	FLA-LAKESIDE-3	Flagler-Lakeside-3	2363E
FDEP	21FLKWAT	29 39 2.7	81 12 30.6	FLA-LAKESIDE-2	Flagler-Lakeside-2	2363E
FDEP	21FLKWAT	29 39 8.4	81 12 29.1	FLA-LAKESIDE-1	Flagler-Lakeside-1	2363E
FDEP	21FLKWAT	29 37 49.68	81 12 39	FLA-FLG2-828	Flagler-FLG2-828	2363E
FDEP	21FLKWAT	29 39 16.62	81 13 9	FLA-FLG1-277	Flagler-FLG1-277	2363E
FDEP	21FLKWAT	29 39 16.56	81 13 5.22	FLA-FLG1-276	Flagler-FLG1-276	2363E
FDEP	21FLKWAT	29 39 15.48	81 13 6	FLA-FLG1-258	Flagler-FLG1-258	2363E
FDEP	21FLKWAT	29 37 28.9	81 11 45.2	FLA-SEAVISTA-2	Flagler-Sea Vista-2	2363E

Organization Name	ID	Latitude	Longitude	Station ID	Station Name	WBID
FDEP	21FLKWAT	29 37 31.44	81 11 42.9	FLA-NANTUCKET-3	Flagler-Nantucket-3	2363E
FDEP	21FLKWAT	29 37 31.44	81 11 42.9	FLA-NANTUCKET-2	Flagler-Nantucket-2	2363E
FDEP	21FLKWAT	29 37 31.44	81 11 42.9	FLA-NANTUCKET-1	Flagler-Nantucket-1	2363E
FDEP	21FLKWAT	29 37 50.58	81 12 41.16	FLA-FLG2-843	Flagler-FLG2-843	2363E
FDEP	21FLKWAT	29 37 50.4	81 12 40.44	FLA-FLG2-840	Flagler-FLG2-840	2363E
FDEP	21FLKWAT	29 38 17.04	81 12 58.86	FLA-FLG5-284	Flagler-FLG5-284	2363E
FDEP	21FLKWAT	29 41 6.06	81 13 22.68	ST.-STJ15-101	St. Johns-STJ15-101	2363E
FDOH	21FLDOH	29 51 56.8742	81 16 10.4786	St Johns244	FL300583	2502A
FMRI	21FLFMRI	30 5 24	81 21 36	HAL200101	Halifax - Tolomato River	2363I
FMRI	21FLFMRI	29 59 24	81 19 48	HAL200102	Halifax - Tolomato River	2363I
FMRI	21FLFMRI	29 57 0	81 18 36	HAL200103	Halifax - Tolomato River	2363I
FMRI	21FLFMRI	30 7 12	81 22 12	HAL200128	Halifax - SE Side CR 210	2363I
FMRI	21FLFMRI	29 43 48	81 14 24	HAL200106	Halifax - Intracoastal Waterway	2363F
FMRI	21FLFMRI	29 52 48	81 16 48	HAL200104	Halifax - Salt Run	2502A
GTMNERR	21FLGTM	30 3 3	81 22 3	GTMPINUT	Pine Island Channel Marker 25	2363I
GTMNERR	21FLGTM	29 44 13.2	81 14 45.6	GTMFMNUT	Matanzas River Channel Marker 75	2363F
GTMNERR	21FLGTM	29 52 6	81 18 16.8	GTMSSNUT	San Sebastian & Matanzas River confluence Channel Marker 1	2363G1
GTMNERR	21FLGTM	29 40 9	81 15 22.2	GTMPCNUT	Pellicer Creek	2580A
SJRWMD	21FLSJWM	30 1 15.17	81 19 38.19	GAR	GUANA RIVER 100 meters south of the Dam	2320
*SJRWMD	21FLSJWM	29 49 40	81 18 46	MCICW	MOULTRIE CREEK OFF ICWW	2493
*SJRWMD	21FLSJWM	29 50 49.94	81 21 38.91	MTC	Moultrie Creek @ SR 207	2493
SJRWMD	21FLSJWM	29 53 18.474	81 22 14.886	SJB-SL-1003	WILSONS PIT	2493
SJRWMD	21FLSJWM	29 59 5	81 19 42	JXTR17	Confluence of Tolomato and Guana Rivers - ICWW	2363I
SJRWMD	21FLSJWM	30 5 25	81 22 15	SMITHSCR	Smith's Creek	2363I
*SJRWMD	21FLSJWM	30 3 43.86	81 22 9.03	TOL	TOLOMATO R 1 MI N DEEP CR @ SPANISH LNDG	2363I

Organization Name	ID	Latitude	Longitude	Station ID	Station Name	WBID
*SJRWMD	21FLSJWM	29 51 58.28	81 18 21.27	MR312	MATANZAS RIVER AT CR 312	2363G1
*SJRWMD	21FLSJWM	29 39 53	81 13 5	MRT	Confluence of Pellicer Creek and ICWW	2363E

*Primary SJRWMD Stations

APPENDIX C. BIOLOGICAL AND WATER QUALITY DATA AND SAMPLES AVAILABLE FOR THE GTMNERR, FROM THE UNIVERSITY OF FLORIDA (Revised April 17, 2008)

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1) Monthly grab sampling

Monthly grab samples were collected at four stations within the Reserve. These samples were taken at the four principal datasonde stations (Pine Island, San Sebastian, Fort Matanzas and Pellicer Creek). Samples were analyzed for nutrient and chlorophyll *a* concentrations as well as water clarity characteristics. In addition, aliquots of the monthly grab samples were separately preserved for plankton analyses. See Reserve nutrient metadata report for details.

2) Diel sampling

Diel sampling was carried out at the Pellicer Creek site generally during the same time periods as the monthly grab samples. All water samples were collected automatically at 2.5 hour intervals for a 25 hour (lunar day) period using an ISCO sampler. Samples were processed for nutrients, chlorophyll, and water clarity in the same manner as described for the grab samples.

In addition to monthly diel sampling at Pellicer Creek, ISCO samplers were set up on docks at other locations throughout theReserve.

Dates	Station Locations
8/23-8/24/2005	St. Augustine Inlet - private dock
8/23-8/24/2005	Matanzas Inlet - fort dock
9/13-9/14/2005	San Sebastian River - St. Augustine Marine dock
10/4-10/5/2005	Matanzas River - private dock
12/7-12/8/2005	Matanzas Inlet - fort dock
2/13-2/14/2006	St. Augustine Inlet - private dock
2/13-2/14/2006	San Sebastian River - St. Augustine Marine dock
4/23-4/24/2007	Matanzas River - private dock
4/23-4/24/2007	San Sebastian River - St. Augustine Marine dock
10/4-10/5/2007	Matanzas River - private dock
10/4-10/5/2007	San Sebastian River - St. Augustine Marine dock

3) Spatial nutrient sampling

Grab samples were collected at 41 stations within the GTM near the San Sebastian and Fort Matanzas water quality stations. Samples were analyzed for total nitrogen, total phosphorus, and turbidity. In the field, temperature, salinity, and dissolved oxygen were measured at the bottom, middle, and surface of the water column. Spatial nutrient surveys will be continued approximately every four months through 2008.

Dates	Station Locations
2/22/2007, 6/28/2007, 10/4/2007	Matanzas region, south of 206 bridge to Summerhaven (20 stations)
2/23/2007, 6/29/2007, 10/5/2007	San Sebastian region, south of Bridge of Lions, up San Sebastian River, and south to Moultrie and East Creeks (21 stations)

4) Periphyton sampling

Periphyton collection trays were tied to docks and channel markers throughout the GTM and left to float just under the surface of the water for various time periods corresponding to diel water quality sampling events. Samples were processed for chlorophyll *a* and biomass (i.e., dry weight and ash-free dry weight).

Dates	Station Locations
8/22-9/1/2005	Matanzas Inlet - fort dock
10/3-10/10/2005	Matanzas River - private dock
10/3-10/10/2005	Pellicer Creek - Faver Dykes dock
11/14-11/28/2005	Pellicer Creek - Faver Dykes dock
11/22-12/20/2005	Matanzas Inlet - fort dock
2/13-3/14/2006	San Sebastian River - St. Augustine Marine dock
4/23-5/15/2007	San Sebastian River - St. Augustine Marine dock
4/23-5/4/2007	Matanzas River - private dock
3/10-3/24/2008	Matanzas River – channel marker #74

5) Infauna sampling

Infaunal organisms were collected with petite ponar grabs at various locations near the GTM San Sebastian and Fort Matanzas water quality stations. Samples were sieved and sorted at the lab and preserved for identification. Presently, organisms in all samples from three of the five stations have been identified to the lowest possible taxonomic level.

Dates	Station Locations
2/23/2007	29°49’49.9”N 81°18’0.2”W – mouth of East Creek
6/7/2007	29°44’16.2”N 81°14’52.9”W – west side of ICW near marker #75
6/7/2007	29°42’39.9”N 81°13’53.2”W – mud flat between Fort Matanzas and Matanzas Inlet
6/8/2007	29°52’40.0”N 81°18’55.7”W – San Sebastian River across from St. Augustine Marine
6/8/2007	29°52’07.7”N 81°18’29.2”W – south side of San Sebastian River near the mouth

6) Sediment grain size analysis

Sediment was collected with three replicate petite ponar grabs at the infauna sampling stations. In the lab, sediment was sieved to determine grain size composition.

7) Oyster community sampling

Oysters were collected from 0.25-m^2 quadrats by hand at 8 reefs near the GTM San Sebastian and Fort Matanzas water quality stations during February 2008. Living oysters were classified by size to be used in density measurements. Condition indices will be measured for a subset of oysters from each collection quadrat. Percent cover of living oysters was also determined in the field at six 1.0-m^2 quadrats per transect (one transect at the highest elevation and one at the lowest elevation of each reef). Additional reefs will be sampled in the summer of 2008.

APPENDIX D. ADDITIONAL SCIENTIFIC STUDIES AND REFERENCES RELEVANT TO THE GTMNERR

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