



Protocol for Monitoring Coastal Salt Marsh Elevation and Vegetation Communities in Southeast Coast Network Parks

Natural Resource Report NPS/SECN/NRR—2015/985



ON THE COVER
Salt Marsh at Canaveral National Seashore
Photograph by Jennifer Asper (NPS)

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Executive Summary

The National Park Service (NPS) Inventory & Monitoring Program has initiated coastal salt marsh wetland elevation and vegetation community monitoring in the vicinity of Cape Hatteras National Seashore (CAHA), Cape Lookout National Seashore (CALO), Canaveral National Seashore (CANA), Cumberland Island National Seashore (CUIS), Fort Matanzas National Monument (FOMA), Fort Pulaski National Monument (FOPU), Timucuan Ecological and Historic Preserve (TIMU), and Fort Frederica National Monument (FOFR). This monitoring was initiated programmatically by the Natural Resource Challenge and implemented in the beginning of 2010 to focus specifically on supporting science-based management of natural resources and improving the agency's ability to respond to effects of climate change. This protocol relies on widely-used data collection methods and Standard Operating Procedures (SOPs) used by the U.S. Geological Survey (USGS), U.S. Fish and Wildlife Service (USFWS), NPS and several states with the intent of ensuring NPS data are comparable with existing, contemporary, and future data sets collected under these and other monitoring programs.

The Southeast Coast Network's (SECN) salt marsh elevation and vegetation monitoring effort collects sediment elevation, accretion, soil salinity, and vegetation community data at permanent monitoring stations deployed in park salt marsh wetlands to provide data to park resource managers on the status of, and trends in, salt marsh conditions within and near parks. Salt marsh elevation and vegetation monitoring is currently conducted at eight SECN parks in partnership with U.S. Fish and Wildlife Service's Inventory and Monitoring Initiative, and the Guana Tolomato Matanzas (GTM) National Estuarine Research Reserve (NERR) System-Wide Monitoring Program. Monitoring at SECN parks is conducted annually (at a minimum), but efforts conducted by the NERR program are intended to investigate intra-annual variability.

The overarching purposes of this protocol are to provide a monitoring framework for collecting scientifically sound data and to supply information to help evaluate the current status and trends in salt marsh conditions that may affect the composition, structure, and function of park ecosystems and visitor experiences. These data can then be evaluated to help determine if current management practices are sustaining those functions and uses. Data collected under this protocol are also intended to support and be analyzed in the context of broader scale investigations, including syntheses of data collected under other SECN Vital Signs, climate change response planning, and landscape-scale conservation planning and design.

Data collected under this protocol are stored locally in SECN managed databases and are uploaded annually to bureau databases (the NPS Integrated Resource Management Applications portal; <http://irma.nps.gov>) as well as the DOI Southeast Climate Science Center. In addition to utilizing customized data handling and reporting procedures, this protocol and its accompanying SOPs set guidelines for data to be made available internally to park resources managers and employees as well as for publication to larger audiences via annual data reports and briefing statements.

Acknowledgments

Several individuals from Southeast Coast Network and parks have assisted with various aspects of protocol development and implementation. Shauna Allen and Michael Rikard assisted with the acquisition of necessary permits for the installation of monitoring stations. Sara Strickland, Laura Pickens, Damien Hardgrove, Darren Bouldin, Michael Rikard, Paula Messing, Kurt Foote, John Stiner, Cameron Welch, Kate Hargrove, Phil Amoroso, Rachel McManamay, and Marylou Moore participated in site condition assessments during the site-selection phase of protocol development. Aaron Rinehart, Sara Strickland, Richard Bryant, Julie Dingle, Erin Voigt, Mickey Campbell, Andrew Flanagan, Brian Gregory, Pete Mockus, and Jason Gardner assisted with the installation of monitoring platforms and monitoring stations.

The authors would like to thank Matt Kimball, formerly of Guana Tolomato Matanzas National Estuarine Research Reserve (GTMNERR) for being a sounding board and directly supporting the effort, as well as Katie Petrinec, Wendy Eash-Louke, Jamie Pawelek, and Matt Welsh who assisted with site selection and installation at the GTMNERR study area.

Additionally, the authors would like to thank Laurel Barnhill and Steve Holzman USFWS for assistance with integration of methodology among agencies as well as several staff from refuges who have assisted in refining the SOPs included with this protocol.

Additional Notes on Attributions

Because this protocol is largely based on monitoring efforts that have been in use and development for more than two decades, we have borrowed heavily (sometimes verbatim) from several published and forthcoming reports. Although we have tried to indicate clearly in the document where we have pulled such information, the following is a brief overview of some of the major efforts that we have relied on in the development of this protocol:

- Much of the discussion on sampling design and data analysis has been borrowed (heavily) from years of work by Don Cahoon, Phillipe Hensel, Jim Lynch, and several others that have developed and refined the Rod-Surface Elevation Table (RSET) methods used to measure elevation changes in salt marshes. This document is intended to serve as a set of standards to facilitate data compatibility among programs moving forward so we felt it important to base our sampling designs and methods on these standards to the greatest extent possible. Additionally, the authors' feedback and technical support while developing this protocol—as well as their guidance document—were also invaluable.
- The Standard Operating Procedures developed by Louisiana Department of Natural Resources were used heavily in development of the SOPs that accompany this protocol as they are designed for monitoring soft-bottomed marsh systems typical of those found in the Southeast Coast Network (Folse and West 2004, Folse et al. 2008).
- Several of the reports and documents by Charlie Roman and others were used to develop the vegetation monitoring component of the protocol, including the protocol developed by Roman et

al. (2001) for monitoring salt marsh vegetation at Cape Cod National Seashore. We have augmented this with Moore's (2009) protocol for monitoring emergent wetlands in coastal marshes being used by the National Estuarine Research Reserve System.

- Wiegert and Freeman's (1990) report on general ecology of tidal salt marshes along the southeast Atlantic coast was used as the primary source for discussion on the ecology of salt marsh ecosystems in SECN parks.
- Sections related to factors affecting coastal wetlands were taken from the SE Climate Science Center Operations plan (Jones and Dalton 2012).

List of Commonly Used Acronyms

Acronyms for National Park Service, U.S. Fish and Wildlife Service, and National Estuarine Research Reserve Management Units

Acronym	Management Unit
CAHA	Cape Hatteras National Seashore
CALO	Cape Lookout National Seashore
CANA	Canaveral National Seashore
CUIS	Cumberland Island National Seashore
GTMNERR	Guana Tolomato Matanzas National Estuarine Research Reserve
FOCA	Fort Caroline National Monument
FOFR	Fort Frederica National Monument
FOMA	Fort Matanzas National Monument
FOPU	Fort Pulaski National Monument
PLD	Pea Island National Wildlife Refuge
SAIM	South Atlantic Refuges Inventory & Monitoring Network
SECN	Southeast Coast Inventory & Monitoring Network
TIMU	Timucuan Ecological and Historic Preserve

Other commonly used acronyms used in this report

Acronym	Definition
CO-OPS	Center for Operational Oceanographic Products and Services
FGDC	Federal Geographic Data Committee
HUCs	Hydrologic Unit Codes
ICW	Intracoastal waterway
I&M	Inventory & Monitoring
IPCC	Intergovernmental panel on climate change
IRMA	Integrated Resource Management Applications portal (http://irma.nps.gov)
MSL	Mean Sea Level
NERR	National Estuarine Research Reserve
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
QA/QC	Quality Assurance / Quality Control
RSET	Rod-Surface Elevation Table
RSL	Relative Sea Level
SALCC	South Atlantic Landscape Conservation Cooperative
SBRS	Spatially-Balanced Random Sample
SET	Surface Elevation Table
SOP	Standard Operating Procedure
SWMP	System-Wide Monitoring Program

Acronym	Definition
USGS	U.S. Geological Survey
USFWS	U.S. Fish and Wildlife Service

1. Background and Objectives

Introduction

In 1999, the National Park Service's (NPS) Inventory and Monitoring Program initiated a long-term ecological monitoring program known as Vital Signs Monitoring. It was designed to provide the infrastructure to allow more than 270 national park system units to identify and monitor conditions of their highest priority resources (Fancy et al. 2009). Established programmatically under the Natural Resource Challenge, the Southeast Coast Network (SECN) is one of 32 networks formed to implement this integrated monitoring program which is tailored to the specific needs of parks located in similar environmental settings. The overarching purpose of natural resource monitoring conducted under this program is to collect data and produce scientifically sound information on the current status of—and long-term trends in—the composition, structure, and function of park ecosystems as well as determine how current management practices are sustaining those systems. Efforts implemented under the Vital Signs Monitoring Program seek to address the following five major goals for all parks with significant natural resources:

- Determine the status and trends in selected indicators of the condition of park ecosystems to allow managers to make better-informed decisions and work more effectively with other agencies and individuals for the benefit of park resources.
- Provide early warning of abnormal conditions of selected resources to help develop effective mitigation measures and reduce costs of management.
- Provide data to better understand the dynamic nature and condition of park ecosystems and to provide reference points for comparisons with other, altered environments.
- Provide data to meet certain legal and Congressional mandates related to natural resource protection and visitor enjoyment.
- Provide a means of measuring progress toward performance goals.

The main objectives of this document are three-fold; first, it provides a scientifically rigorous strategy to monitor coastal wetland elevation, vegetation, and condition in eight SECN parks with significant coastal wetland resources. Second, it provides a specific set of instructions in the form of Standard Operating Procedures (SOPs) that are sufficiently detailed to ensure consistent and comparable data collection into the future. Third, it provides a blueprint for consistent implementation of these methods by partners managing lands in other coastal areas along the South Atlantic coast in order to address regional resource management and conservation challenges related to climate change.

This report also broadly summarizes important characteristics of coastal marsh resources along the southeastern U.S., highlighting similarities and differences as they relate to monitoring objectives, and makes a strong case for the relevancy of this effort by highlighting many known issues in certain

parks that may help provide early warnings of changing conditions or help elucidate problematic conditions that may be an issue of concern in the future.

Beginning in 2009, the federal government engaged in a renewed effort to consider the interwoven effects of energy production and consumption and the effects of global climate change in the stewardship of its resources. As a part of EO 13514 (2009), the President directed all federal agencies to participate in the Climate Change Adaptation Task Force and develop strategies in support of the national adaptation strategy.

The subsequent Secretarial Order 3289 charged the DOI Bureaus to take the lead in protecting our country's water, land, fish and wildlife, and cultural heritage resources from the dramatic effects of climate change by establishing a "...Department-wide approach for applying scientific tools to increase understanding of climate change and to coordinate an effective response to its impacts on tribes and on the land, water, ocean, fish and wildlife, and cultural heritage resources that the Department manages."

This included a directive to each bureau to "consider and analyze potential climate change impacts when undertaking long-range planning exercises, setting priorities for scientific research and investigations, developing multi-year management plans, and making major decisions regarding potential use of resources under the Department's purview," with a further expectation that data collected under this directive "will support the integration of our nation's scientific database, improving availability and dissemination of climate change impact and vulnerability information, and access and decision-support to scientists, resource managers, decision makers, and the general public through www.data.gov and other appropriate mechanisms."

As a portion of the NPS's effort to implement these new programs, the SECN received planning funds in FY2010 to identify ways to augment its existing Vital Signs Monitoring Program to (a) improve parks' ability to incorporate climate science into planning, while (b) collaborating with and contributing to other DOI climate science programs within the South Atlantic LCC (SALCC) and Southeastern Climate Science Center (SECSC) to meet the other Departmental goals.

An additional purpose of this protocol, therefore, is to serve as an operational guide to collect Vital Signs Monitoring data that can be used by NPS and other strategic partners to better plan for—and respond to—impacts caused by global climate change (DeVivo et al. 2011).

South Atlantic Salt Marsh Systems

Tidal salt marshes along the southeastern Atlantic coast are located from the Chesapeake in Virginia, south to north-central Florida. Tidal conditions are relatively low in the north, increasing southward, peaking in Georgia, and then decreasing until the salt marshes transition to mangroves in central-south Florida. Although the marshes within this range are in some respects quite distinctive, within a given salinity range and community type, they share similar flora and combined comprise 82% of the existing marshes on the east coast of the U.S. (Reimold 1977). Georgia, with the least shoreline of the other states, has 33% of the total area of east coast salt marsh, followed by South Carolina with 30%, North Carolina with 11% and Florida, with less than 8%.

The successional development of salt marshes is a process of interaction among vegetation, sediment and water. This development requires protection from the full blunt of the high-energy coast. As a result, salt marshes of the southeastern U.S. are almost without exception found in the shallow sedimentary lagoons behind barrier islands, or in protected estuaries. Perhaps the need for protection comes primarily in the seedling stage. After establishment, mature *Spartina*-dominated marshes modify the physical regime to a considerable degree and resist erosion. Apparently, after the marsh has developed in a protected environment, subsequent shifts in barrier sandbars and exposure to the open sea need not result in the immediate destruction of the marsh. It may persist for decades if not centuries, becoming an example of a relic community that was not formed through a change in climate (Wiegert et al. 1981).

Because coastal salt marshes develop in such low-lying sedimented depressions, a primary influence on their development and function is tidal regime. Along the southeastern U.S. coast, coastal marshes are subjected to frequent (twice daily or diurnal) tidal flooding with water of moderate to high salinity. This predictable inundation is both characteristic of—and one of the most important influences on—successional development, species composition, stability and productivity of marine and brackish water ecosystems (Wiegert and Freeman 1990).

In the transitional zone in northern Florida, driven primarily by relatively low tides, the vegetation mosaic can be very complex compared to the marshes to the north. The transition between salt marsh and mangrove associations occurs at about 30°N in north-central Florida (Odum et al. 1982). From this point north, the most common vegetation association on low-energy coasts and sheltered intertidal areas is the salt marsh, dominated primary by cordgrasses (*Spartina* spp.).

Numerous fish, invertebrate, bird, and reptile species routinely use these diverse estuarine habitats for a multitude of critical functions such as refuge from predators, foraging, and reproduction (Odum et al. 1982, Kneib 1997, Sheaves 2005). Among these habitats, emergent intertidal habitats are of particular importance to estuarine organisms as they link marsh surface and subtidal habitats during periods of tidal inundation (McIvor and Odum 1988, Rozas 1988). Because emergent intertidal habitats form such an extensive and direct land-water interface, they may be impacted the greatest by the effects of climate change and sea level rise in estuarine ecosystems (Najjar et al. 2000, Scavia et al. 2002, Craft et al. 2009).

Ecosystem functions of salt marshes include the following:

- High primary productivity,
- High detrital production that is important for fish nurseries and linked estuarine systems,

Additionally, detrital decomposition is the major pathway for energy flow within salt marshes, and salt marshes can be either a source or a sink for nutrients.

Wetlands within SECN parks vary widely from intermittent interdunal pools to riparian floodplains to vast salt marshes. These systems are particularly sensitive to changes in water quantity. Within Network parks, these areas are affected by visitor uses, commercial and recreational fishing and ecosystem drivers from inland and upstream areas. The long-term stability of salt marsh ecosystems

will likely be increasingly affected by inland and upstream processes such as water use, changes in landscape dynamics, and their cumulative effects on incoming water quality and quantity (DeVivo et al. 2008).

Study Area: Marsh Wetlands in Southeast Coast Network Parks

The coastal portion of SECN is located along the southeastern U.S. coast, stretching from Cape Hatteras National Seashore in North Carolina to Canaveral National Seashore in central Florida (Figure 1). Although the National I&M Network design sought to group parks with similar environmental settings and ecologies, the background conditions that influence coastal park waters are varied among these parks primarily due to differences in their geomorphic origins, proximity to large rivers and urban areas, and tidal ranges. The common linkage among the larger parks along the southeastern coast is the suite of global climate and geophysical processes that resulted in their formation and their dynamic coexistence at the interface between flowing freshwater systems and tidally-influenced marine system.

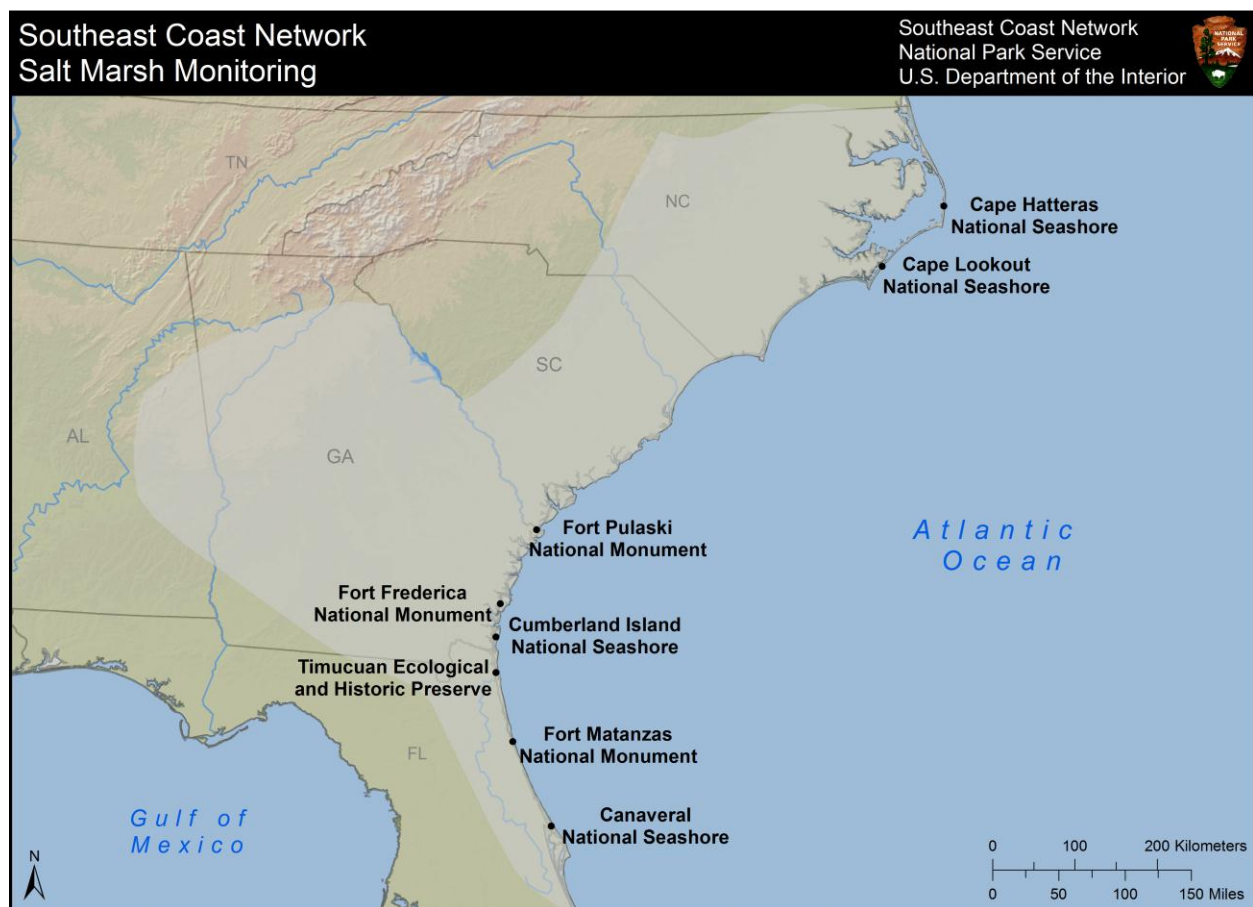


Figure 1. Overview map showing locations of National Park Service units within the Southeast Coast Network with significant salt marsh systems.

Estuarine systems in the SECN were formed due to the creation of a semi-protected aquatic zone where freshwater from rivers slowly mixes with salt water from the ocean. Estuarine and barrier island systems are not unique to the southeastern coast of the U.S., but form anywhere along a coastline where a gentle sloping coastal plain intersects a wave-energy dominated coastline that has an adequate sediment supply and a tidal range less than three meters (Bascom 1980). The system of barrier islands, estuaries and lagoons that we see today formed recently—in some cases less than 5,000 years ago. These landforms began to form about 15,000 years ago after the cooler global temperatures that had caused sea levels to drop by as much as 300 feet began to warm. As the temperatures warmed, the rising Atlantic Ocean pushed landward, flooding the relatively young coastal river and inlet systems that had developed along the late Pleistocene coastline. The slowly rising water, along with prevailing winds, slowly pushed ridges of sand inland until the ridges either pushed against the existing coastline or stopped moving due to stabilization of the sea levels. The complex land and water forms observed in different areas of the coast resulted as migrating ridges of sand met existing or remnant coastal landforms including older relic dunes or protruding ridges of sedimentary rock. For example, in North Carolina, Cape Lookout and Cape Hatteras (as well as the surrounding sound areas) formed as the inland-migrating primary barrier/dune system intercepted the still standing secondary dune system; inundation of a large area of low-lying land between the barrier islands and the mainland formed the Pamlico Sound and Back Sound areas.

The barrier island-marsh systems located along the South Carolina, Georgia, and northern Florida coasts were formed when the migrating primary barrier systems met the relic Pleistocene sand dune and ridges and were pushed against them. The extensive marshes around Fort Pulaski, Fort Frederica, Cumberland Island and Timucuan Ecological and Historic Preserve are due to a combination of the barrier island system along the South Atlantic coastline, and tidal fluctuations associated with the Georgia Embayment. The odd shape of Cumberland Island and Sound are due to the interaction of both the large tidal amplitude and the strong tidal current moving through rather large river inlets. The low areas behind these barrier islands were well protected from wave energy of the open ocean which allowed fine silt and clay sediment to accumulate in large muddy flat areas that were later colonized by salt-tolerant cord grasses, particularly those that could also tolerate the high tidal ranges of this section of the coastline.

Similarly, the barrier islands of north-central Florida formed as the inland-migrating sand ridges were pushed against an exposed ridge of coquina. As barrier islands developed in these areas they were fed by sand transported to the ocean by the larger rivers of Georgia and South Carolina that were moved southward by the long-shore current. The semi-enclosed Cape Canaveral-Mosquito Lagoon area is unique in that it is believed to have formed as the long-shore current forced a southward migrating cape to progressively form parallel dune ridges along the coast. The outermost ridge in this system was later joined to the landward migrating sand ridge that was being pushed inland by rising sea levels. Mosquito Lagoon, managed as part of Cape Canaveral National Seashore, formed when the low-lying areas behind the barrier islands flooded between 5,000 and 6,000 years ago, forming an almost entirely enclosed body of water. The Lagoon currently has no direct connection with the Atlantic Ocean although at least five major inlets have been documented over this period with the most recent closing more than 1,500 years ago (Mehta and Brooks 1973).

The first European forts built along the coast were originally sited in the coastal landscape due to strategic positions on islands overlooking important inlets, harbors, or rivers as early as 1565. Today, this 800-mile stretch of coastline has had some of its natural areas protected although much has been extensively developed, especially along the I-95 corridor. Cities of moderate size are located in the vicinity of, or in some cases adjacent to, many of the National Park protected areas. Cities such as Titusville, Nags Head, and Beaufort are home to important centers of recreational and commercial fishing, and tourism, whereas Jacksonville and Savannah are larger urban areas where shipping and other human activities have caused documented degradation in water resources. Dredging activity to support shipping, recreational boating, and military installations is ongoing adjacent to several parks including TIMU, CUIS, FOPU, CALO and CAHA. This degradation could cause unacceptable impacts in the future by further changing park lands through increased wave action, erosion, and degradation of water quality conditions as well as other scenic values that the National Park Service has been charged to manage and protect.

Salt marsh communities within Southeast Coast Network coastal parks include a significant portion of the entire park landscape (Table 1). The percentage of salt marsh to total acreage ranges from a low of 21.44% in Cape Hatteras National Seashore to over 77% in Fort Pulaski National Monument. Of the estimated total 248,058 acres of SECN parks, more than 64,836 acres are salt marsh communities and more than 31,358 acres include open estuary waters. Timucuan Ecological and Historic Preserve and the combined Fort Matanzas National Monument / Guana Tolomato Matanzas National Estuarine Research Reserve (GTMNERR) include the largest blocks of salt marsh.

Table 1. Acreage of regularly and irregularly flooded marsh and open water at coastal parks in the Southeast Coast Network. Data from NPS Vegetation Inventory Project (unpublished) and Saint Johns River Water Management District GIS data.

PARK	Total Marsh Area	Open Water Area	Percent Marsh Area
Cape Hatteras National Seashore (and Pea Island NWR)	6,662.147	3,282.833	21.44%
Cape Lookout National Seashore	3,541.448	1,039.565	28.74%
Fort Pulaski National Monument	4,187.721	584.770	77.37%
Fort Frederica National Monument	163.903	0.000	58.08%
Cumberland Island National Seashore	9,485.331	9,452.967	26.06%
Timucuan Ecological and Historic Preserve	23,173.598	10,084.003	50.75%
Fort Matanzas National Monument (and GTMNERR)	11,121.985	6,914.075	28.90%
Canaveral National Seashore (mangroves included)	6,500.486	31,332.476 ¹	11.22%

¹Includes non-estuarine open-waters.

Cape Hatteras National Seashore and Pea Island National Wildlife Refuge

Cape Hatteras National Seashore is the northern most park unit in the Network (Figure 2). Located along the northern section of the Outer Banks, Cape Hatteras contains 35,400 acres of land and 74 miles (119 km) of beaches. Pea Island National Wildlife Refuge (PLD; administered by USFWS) is embedded within Cape Hatteras and contains an additional 5,834 acres of land, 25,700 acres of Proclamation Boundary Waters, and 13 miles of beaches within the Seashore boundary.

The Seashore and Refuge barrier islands are separated from the mainland by a series of marshes and sounds which range from very narrow to 25 miles in width. Seashore and Refuge marshes contribute heavily to primary estuarine productivity and provide habitat for numerous wildlife and aquatic species. The unique and varied habitats, such as mature broad-leafed evergreen forest and shrub, freshwater and brackish marsh and ponds, ocean beach, barrier dunes, tidal creeks, and bog support an unusual assemblage of aquatic, terrestrial, and avian species. The Seashore and Refuge have been designated as Globally Important Bird Areas by the American Bird Conservancy because of the importance of the habitats to avian breeding, migration, and wintering.

The ecological zonation of Cape Hatteras National Seashore is due in part to artificial alterations dating from the turn of the twentieth century. The most important perturbations were due to early efforts at mosquito control and waterfowl management which involved excavation of drainage ditches, construction of water control structures, and vegetative stabilization of primary dunes along the length of the Seashore. Later changes were wrought when road construction included excavation of borrow ponds for road bed material. For the most part, these actions ended by the 1970s, except for localized projects designed to protect specific and discrete portions of infrastructure.

Nags Head, as well as nine other smaller towns, borders the Seashore, causing some developmental pressure from outside the park. Visitor and recreational uses represent the major categories of threat to the integrity of natural resources in Cape Hatteras and Peas Island. Because of the need to protect route NC12 along the barrier island, sand moved westward by high-energy weather events such as northeasters and hurricanes is seldom allowed to migrate over to the sound side of the barrier island to build or sustain saltmarshes. Thus, the lack of natural sediment redistribution hinders the island's natural migration, and salt marsh systems are at increased risk of being lost.

Cape Hatteras National Seashore Salt Marsh Sampling Locations

Southeast Coast Network
National Park Service
U.S. Department of the Interior

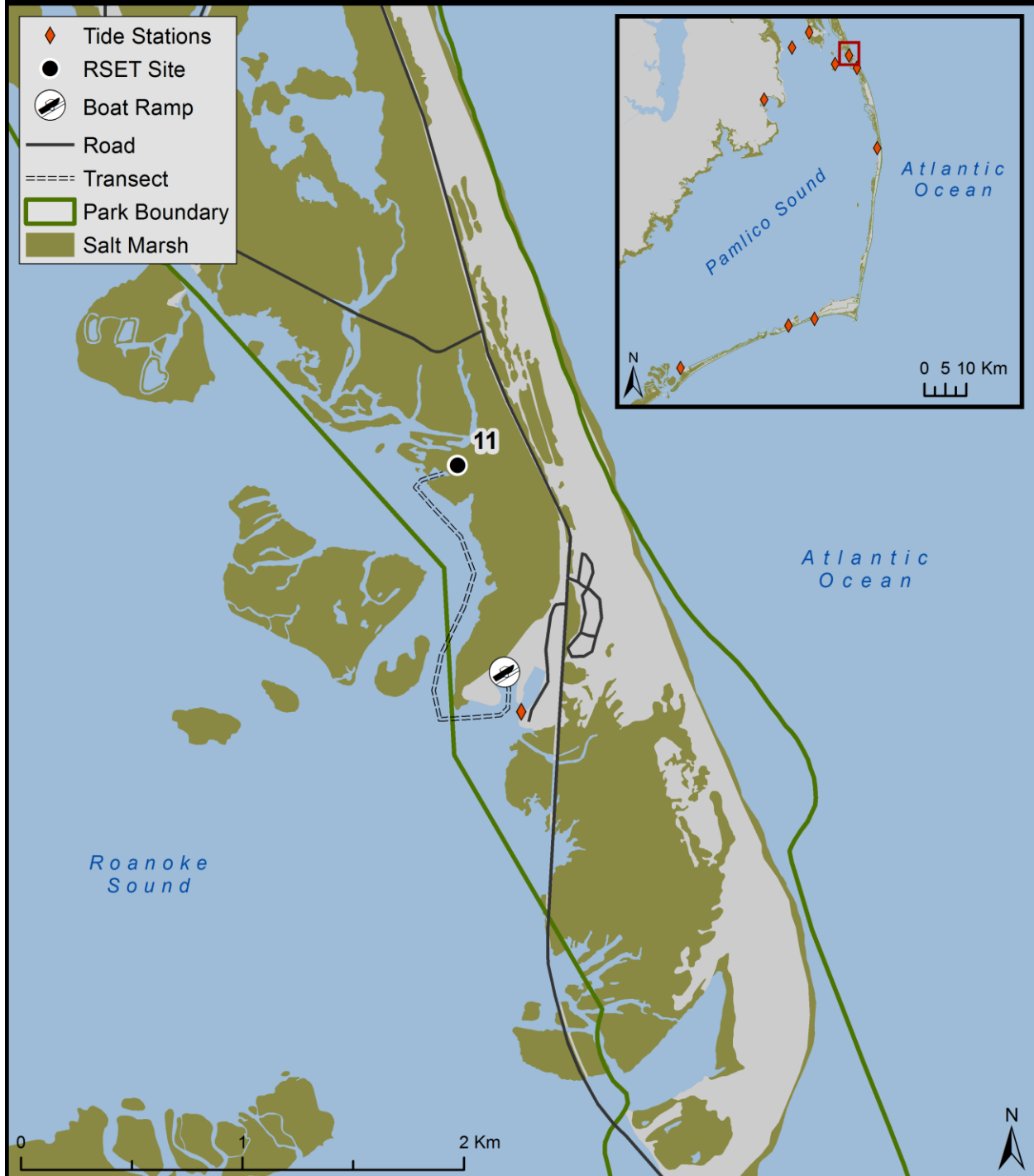


Figure 2. Coastal salt marsh elevation and vegetation community monitoring stations at Cape Hatteras National Seashore in North Carolina. Indicated are areas of salt marsh (USFWS 2013) and CO-OPS tidal monitoring stations (NOAA 2013).

Cape Lookout National Seashore

Cape Lookout National Seashore, located along the southern end of the Outer Banks, is largely undeveloped and accessible only by boat. Cape Lookout National Seashore is made up of three barrier islands covering 56 miles (90 km) of the central coast of North Carolina (Figure 3). Most of the Seashore consists of North and South Core Banks, a 44-mile (71 km) long barrier system oriented in a southwest to northeast direction and separated by Ophelia Inlet. The National Seashore extends into the Atlantic Ocean from its southern end. The other barrier system within the Seashore, Shackleford Banks, extends westward from Cape Lookout. The salt marsh community in Cape Lookout includes over 3,541 acres, 28.74% of total managed area (Table 1).

Core Banks is a long, narrow expanse of low dunes, maritime grasslands, and extensive salt marshes. Shrub thickets border the grassland in many places, and a low maritime forest occupies small areas of higher ground. The islands are generally about 3 to 6 feet (0.9 to 1.8 m) above sea level and 0.6 to 1.2 miles (1 to 2 km) wide. For the most part, these areas are open and treeless.

Instead of exhibiting the typical zonation of a wide berm, low dunes, grasslands and shrub thickets, and salt marsh, the northern end of Portsmouth Island is characterized by vast tidal sand flats (averaging 0.6 miles or 1 km in width) located between the berm and the dunes of a series of marsh-fringed islands. At the triangular shaped Cape Lookout, continuous dunes characterize its southwest side, with several small freshwater marshes present in depressions between the dunes. A long spit extends from the western tip of Cape Lookout, where a jetty built in the early 1900s has encouraged accretion in this direction.

Areas of frequent washover are dominated by annuals, plants that withstand frequent burial such as dune grasses, or salt-tolerant species (Hosier 1973). Fresh sediment input to the marsh was the dominant factor in determining the height and yield of saltmarsh cordgrass, and the marsh acts as a buffer for the entire estuarine system, providing a sink for excess nutrients which resulted from municipal wastes and land runoff (Broome 1975).

Cape Lookout National Seashore Salt Marsh Sampling Locations

Southeast Coast Network
National Park Service
U.S. Department of the Interior

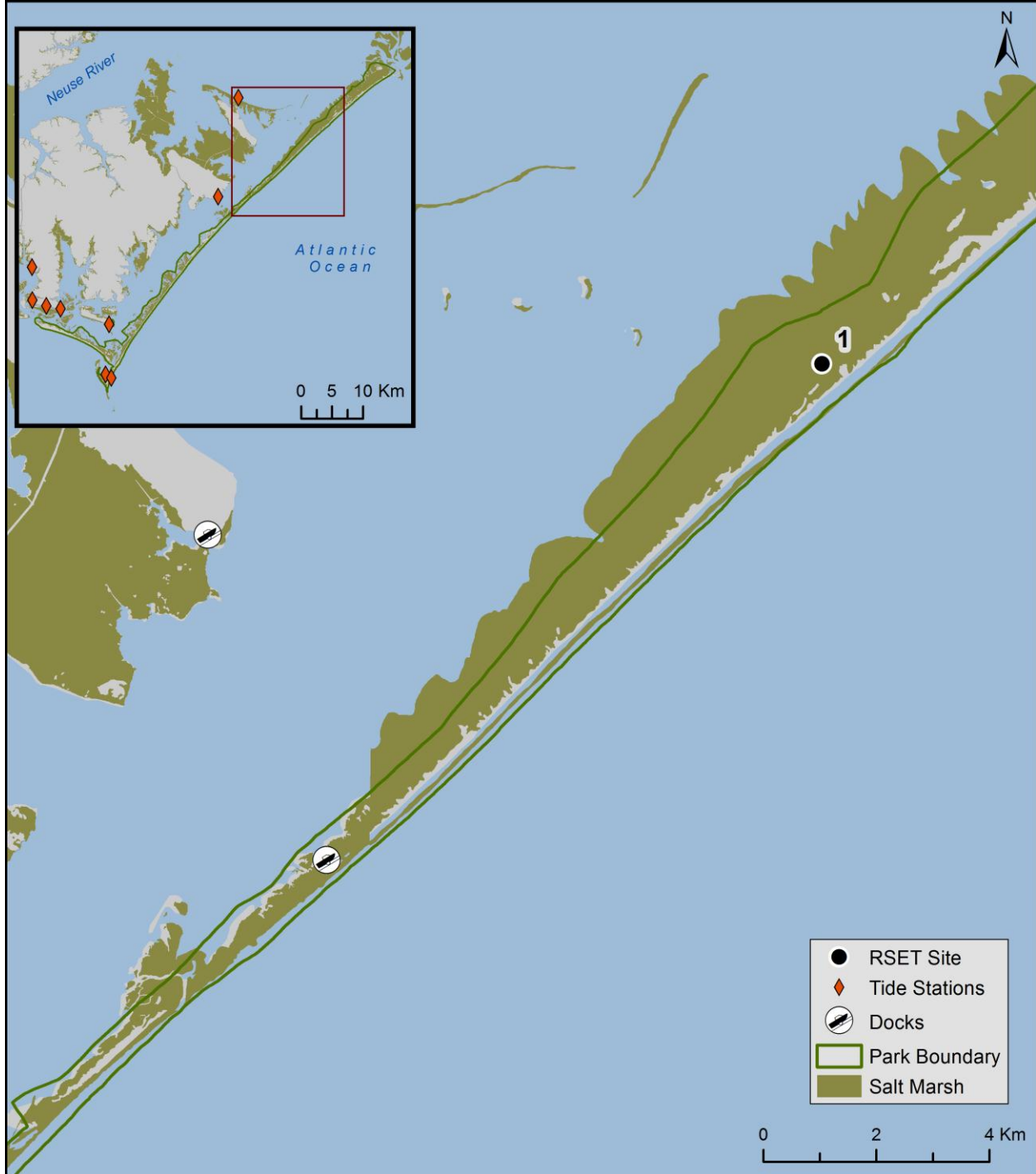


Figure 3. Coastal wetland and tidal monitoring stations near Cape Lookout National Seashore in North Carolina. Indicated are areas of salt marsh (National Wetlands Inventory 2011), CO-OPS tidal monitoring stations (NOAA 2013).

Fort Pulaski National Monument

Fort Pulaski National Monument (Figure 4) is located in Chatham County, Georgia along the Savannah River only a few miles from its junction with the Atlantic Ocean. The site consists of two islands that were, before human intervention, primarily salt marsh. Judging from the composition of existing vegetation, Cockspur Island probably supported some coastal hammock forest or woodland. It was selected for fortification as early as the 1700s. In the 1800s, as part of the development of the site for defense, the island was modified by the installation of drainage canals and a dike system. In later years, the site was also impacted by the deposition of spoil material. The addition of dredge material from the Savannah River to Cockspur Island has continued until recently. During the civil war period, the vegetation was removed to enhance visibility and kept in early successional stages. Since the abandonment of the fort in the late 1800s, a large portion of central Cockspur Island has reverted to maritime forest. Currently, the upland portions of Cockspur (approximately 260 acres) support a mosaic of maritime forest, maritime shrub communities, maintained grasslands and successional spoil deposit areas. It also includes more than 340 acres of tidal shrubland and tidal herbaceous marsh.

McQueens Island makes up the largest portion of land holdings for the National Monument (about 4,900 acres) and the majority of this consists of salt marsh. A railroad was constructed along the northern edge of the island in 1887 to connect the city of Savannah with Tybee Island and operated until 1933. In 1923, US Highway 80 was constructed, occupying a location across the central portion of the island and adjacent the old railroad grade along the eastern section. In 1994 Chatham County converted the abandoned railroad right-of-way to a multipurpose hiking trail. Both the highway and the converted rails-to-trails areas support ruderal habitat for a number of coastal plain herbaceous species. Other upland habitat on McQueens Island occurs in association with a public fishing and boat ramp on the eastern end of the island and an abandoned section of US 80 leading to the Bull River.

Today, the majority of vegetation within the Fort Pulaski boundary (4,188 of 5,412 acres) is salt marsh (Table 1). Specifically, 4,188 of the 5,412 acres consist of marsh.



Figure 4. Coastal wetland and tidal monitoring stations near Fort Pulaski National Monument in Georgia. Indicated are areas of salt marsh (National Wetlands Inventory 2011), CO-OPS tidal monitoring stations (NOAA 2013).

Fort Frederica National Monument

Established on St. Simons Island in 1736 to protect South Carolina and Georgia from the Spanish, the town of Frederica was the southernmost post of the British colonies in North America. Today, old-growth oaks, exceptionally large grapevines (*Vitis* spp.), and Spanish moss (*Tillandsia usneoides*) lend an air of antiquity unequaled on the coast. Salt marsh areas at Fort Frederica (Figure 5) are bisected by the Frederica River, one of the primary tidal rivers in the Brunswick area. Marsh lands along the Frederica River total 158 acres, comprising approximately 58% of the total park area. The Bloody Marsh site consists of an additional 8 acres of tidal marsh habitat.

External stressors from recreational boating and fisheries activities are presumed to have a minimal impact on park conditions. However, wave action from watercraft presents a possible threat to the wetlands and cultural landscape of the park through increased rates of erosion. Also, the Bloody Marsh unit is used by the local community for acquiring bait (i.e., fiddler crabs [*Uca* spp.]); the detrimental effects of bait harvesting (if any) are unknown.

Fort Frederica National Monument Salt Marsh Sampling Locations

Southeast Coast Network
National Park Service
U.S. Department of the Interior



Figure 5. Coastal wetland and tidal monitoring stations near Fort Frederica National Monument in Georgia. Indicated are areas of salt marsh (National Wetlands Inventory 2011), CO-OPS tidal monitoring stations (NOAA 2013).

Cumberland Island National Seashore

Cumberland Island National Seashore (CUIS) is off the coast of Georgia between St. Andrews Sound and the mouth of the St. Marys River. At 17.5 miles (28.2 km) long, Cumberland is one of the largest and most diverse islands on the Atlantic coast (Figure 6). Slightly more than a quarter of its 36,415 total acres are *Spartina*-dominated salt marsh habitat (Table 1). These areas include oyster mud flats, and six tidal creeks which provide the habitat for a diverse marine-based fauna. The island is known for nesting loggerhead sea turtles, abundant shore birds, undeveloped dune fields, maritime forest ecosystems, and historic structures. Cumberland Island provides habitat for 18 federally listed threatened or endangered species (Alber et al. 2005) although most are terrestrial or bird species, four species of sea turtles are commonly observed along the beaches and West Indian Manatees are known to be in the estuarine areas.

Cumberland Island National Seashore was established in 1972 to preserve the scenic, scientific, and historical values of the island as well as to provide public outdoor recreational uses to its visitors. Specified areas of Cumberland Island are also part of the South Atlantic-Carolinian Biosphere Reserve and will be permanently protected in a primitive state. The northern half of the island has also been designated a wilderness area. This unspoiled environment, once prevalent on all the barrier islands, provides a unique opportunity to experience the flora and fauna of a natural coastal ecosystem.

Cumberland Sound and the Cumberland River are influenced by freshwater inflows mainly from the St. Marys River to the south and the Satilla River on its northern boundary. Marsh areas at Cumberland are adjacent to the Intracoastal Waterway, which are a routine passageway for Naval vessels associated with the King's Bay Naval Base and Atlantic Trident submarine fleet (in addition to commercial vessels and the seasonal transit of recreational watercraft). Wave action from the wakes of these vessels has potentially high erosive energy on the sound side of the island.

Additionally, the Georgia coast has been going through an era of fast growth in new, residential communities, many of which have sought to incorporate marinas. The nearby town of St. Marys, Georgia—although a relatively small coastal community—was poised to dramatically increase residential development in its adjacent marshlands just prior to 2008 until economic slowdown at least temporarily eased some of this development pressure. Recreational pressure could increase on the island, and the threat to resources and critical habitats may also intensify. Erosion on the western side of the island is currently being investigated by Cumberland Island National Seashore staff (John Fry, personal communication).

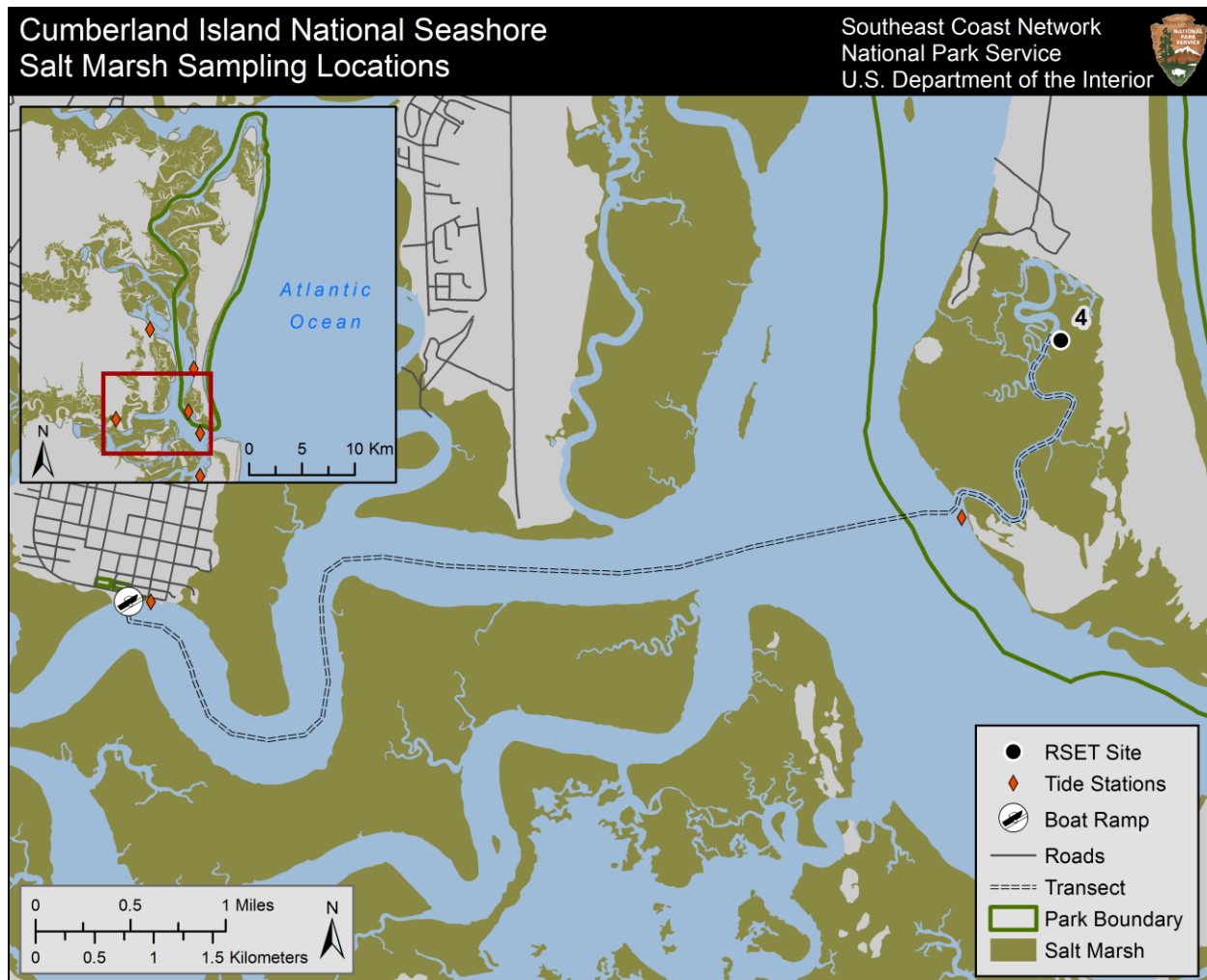


Figure 6. Coastal wetland and tidal monitoring stations near Cumberland Island National Seashore in Georgia. Indicated are areas of salt marsh (National Wetlands Inventory 2011), CO-OPS tidal monitoring stations (NOAA 2013).

Timucuan Ecological and Historic Preserve

Timucuan Ecological and Historic Preserve (TIMU) is situated entirely within Duval County and the city limits of Jacksonville, Florida (Figure 7). Timucuan is operated as a partnership park and encompasses approximately 46,000 acres of mostly salt marshes, open water, and river (including a reach of the Intracoastal Waterway) between the St. Johns and Nassau Rivers (Table 1). The southern one-third of the preserve lies at the mouth of the extensive St. Johns River watershed, which drains parts of the urbanized portions of the City of Jacksonville. The northern two-thirds of the preserve lie within the Nassau River drainage basin, a smaller watershed that drains parts of Duval and Nassau counties. The area surrounding the preserve to the west and north is predominantly marsh and low uplands utilized for timbering, residential and agricultural uses.

Timucuan Ecological & Historic Preserve Salt Marsh Sampling Locations

Southeast Coast Network
National Park Service
U.S. Department of the Interior

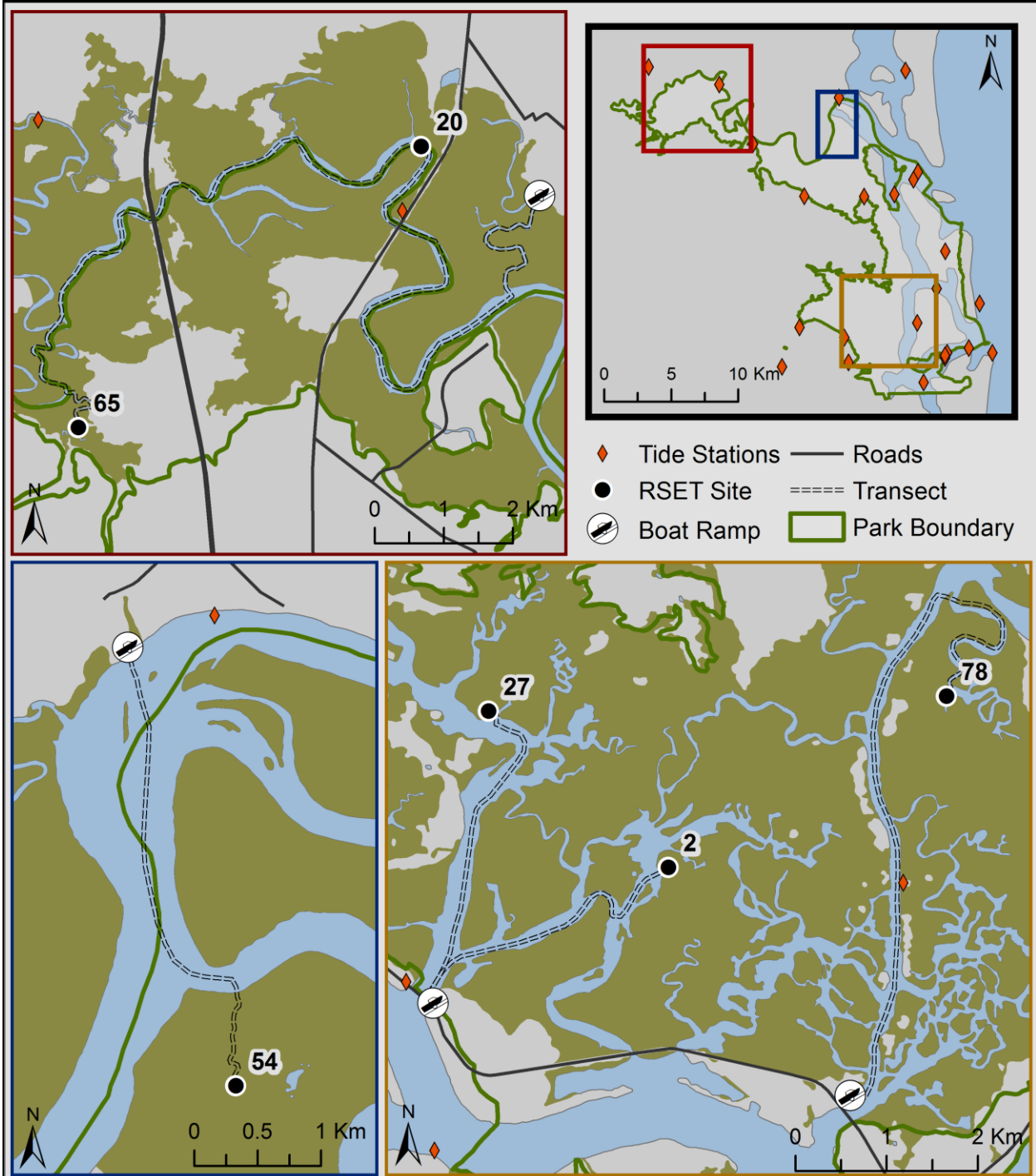


Figure 7. Coastal wetland and tidal monitoring stations near Timucuan Ecological and Historic Preserve in Florida. Indicated are areas of salt marsh (National Wetlands Inventory 2011), CO-OPS tidal monitoring stations (NOAA 2013).

Fort Matanzas National Monument and Guana Tolomato Matanzas National Estuarine Research Reserve

Fort Matanzas National Monument is located 22 km (14 mi) south of St. Augustine on the northeast Atlantic coast of Florida, embedded within the boundaries of the Guana Tolomato Matanzas National Estuarine Reserve (GTMNERR; Figure 8). It encompasses a total of 298 acres divided between the southern tip of Anastasia Island (108 acres) and the northern end of Rattlesnake Island (190 acres). Both are barrier islands separated from the Florida mainland by the Matanzas River and the Intracoastal Waterway.

The Anastasia Island portion of Fort Matanzas consists of stabilized beach dunes rising as much as 7.6 m (25 ft) above sea level. Predominant habitats in this portion of the park include beaches along both the Matanzas River and the Atlantic shore, stabilized sand dunes supporting maritime forest, secondary dunes further inland, and salt marsh.

Most of Rattlesnake Island is less than 1.5 m (5 ft) above sea level, though it rises to 4.52 m (15 ft) at one point on its northern end. Much of northern portion of Rattlesnake Island consists of sandy fill pumped in from dredging operations that maintain the boat channels in the Intracoastal Waterway. In addition to the habitats found on Anastasia Island, Rattlesnake Island supports slash pine and red bay woodlands, oyster shell beaches, and developing hardwood forests typified by wax myrtle (*Myrica cerifera*), cedar (*Juniperus silicicola*), and cabbage palm (*Sabal palmetto*).

The GTMNERR is comprised of approximately 30,000 ha (74,000 acres) of relatively undeveloped coastal and estuarine habitat along the northeast coast of Florida. The reserve, which is split into two main components north and south of the city of St. Augustine, forms a narrow (east-west) bar-bounded estuarine ecosystem that spans approximately 56 km (35 mi) north to south (Figure 8). Similar to other southeastern US Atlantic coast estuaries, the GTMNERR consists of a mosaic of multiple interconnected estuarine habitats that includes the vegetated marsh edge and surface, marsh pools, tidal creeks, and open water habitats (Minello et al. 2003, Rountree and Able 2007).

Salt marsh vegetation comprises more than 11,122 of the total 36,402 acres in the study area (Table 1). The study area is biogeographically positioned at the ecotone of two different emergent vegetation habitats, salt marsh (dominated by smooth cordgrass, *Spartina alterniflora*) and mangroves (dominated by black mangroves, *Avicennia germinans*; Zomlefer et al. 2006, Frazel 2009). In addition, the northernmost record of red mangrove (*Rhizophora mangle*) was recorded within the GTMNERR (Zomlefer et al. 2006). The primary factor limiting the northern distribution of mangroves is temperature (Odum et al. 1982) and historical mangrove distribution within the reserve has fluctuated in recent decades due to episodes of severe winter freezing. In south Florida, mangrove forests thrive and replace salt marsh vegetation primarily as a result of shading (Lugo and Snedaker 1974). Within the southern extent of the GTMNERR, black mangroves dominate large portions of the emergent intertidal vegetation, while emergent intertidal habitats in the northern portion of the reserve are dominated by smooth cordgrass (Leitholf 2008). The overlapping distribution of these two species within the GTMNERR provides a unique opportunity to examine the potential effects of climate change and sea level rise on the distribution and diversity of emergent intertidal vegetation in this transitional zone. Further, since one of the most important factors

determining the ecological function of marsh habitats is the dominant vegetation (Weinstein et al. 1997), changes in the habitat ranges for these emergent intertidal marsh vegetation species may potentially impact numerous organisms throughout the estuary.

Fort Matanzas National Monument Salt Marsh Sampling Locations

Southeast Coast Network
National Park Service
U.S. Department of the Interior

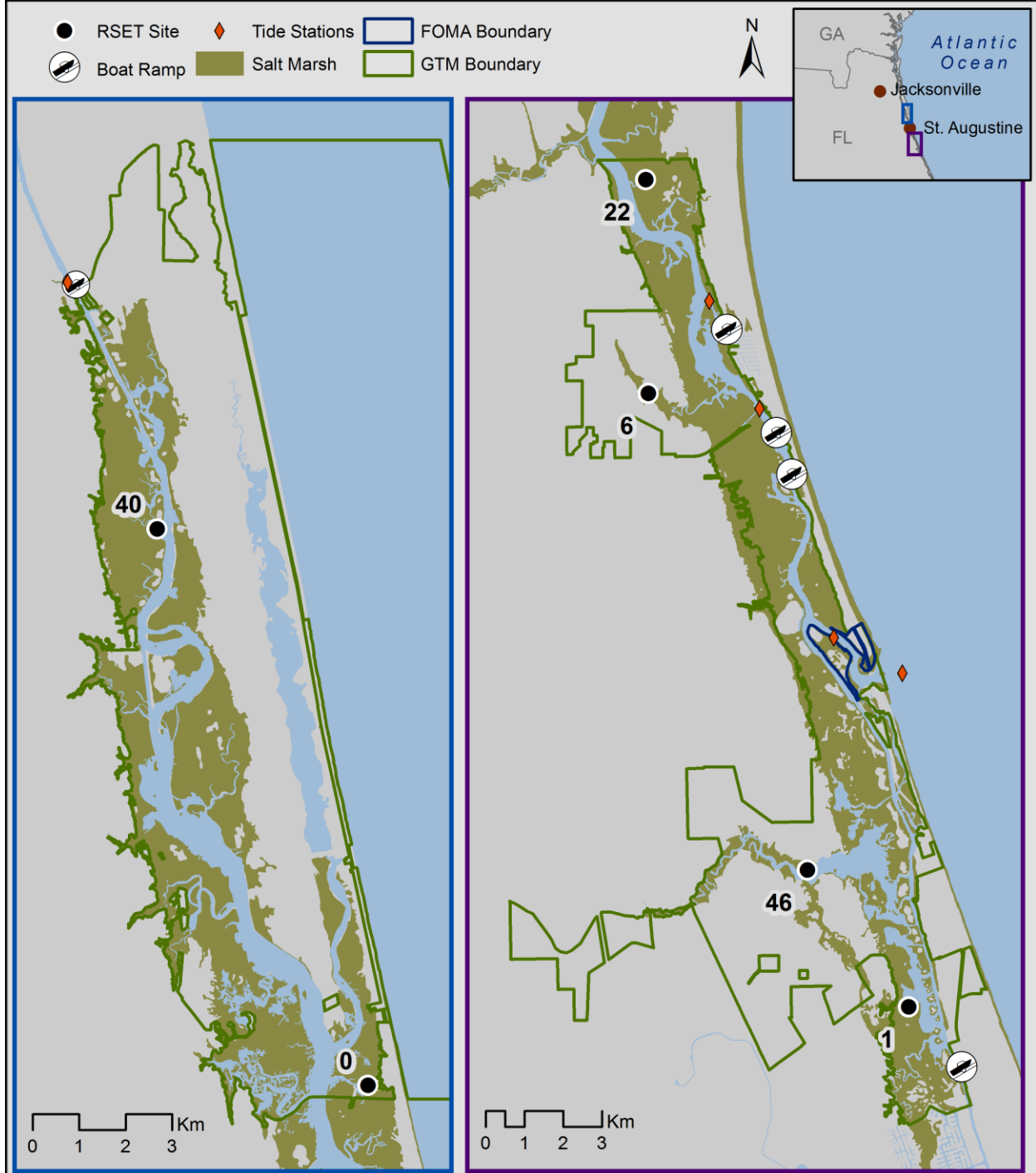


Figure 8. Coastal wetland and tidal monitoring stations near Fort Matanzas National Monument and Guana Tolomato Matanzas National Estuarine Research Reserve in Florida. Indicated are areas of salt marsh (National Wetlands Inventory 2011), CO-OPS tidal monitoring stations (NOAA 2013).

Canaveral National Seashore

Canaveral National Seashore's (CANA) natural resources include a diverse assemblage of wildlife, plant communities, geophysical features and natural processes reflecting the complexity of the land/lagoon/sea interface of east central Florida (Figure 9). Unlike many barrier islands, Canaveral has only a single dune ridge, averaging approximately 12 ft (3.7 m) in height. For the vast majority of its length the dune is quite stable, backed by a dense growth of saw palmetto (*Serenoa repens*) and several other species of hardy shrubs and grasses.

Mosquito Lagoon, extending along the backside of Canaveral's barrier island, is the northernmost part of the Indian River System, an area which contains one of the most diverse assemblages of aquatic species on the entire Eastern Seaboard. This 155-mile (250 km) long lagoon has been designated as an Estuary of National Significance by the Environmental Protection Agency and an Outstanding Florida Water by the State of Florida. It contains one of the last significant oyster harvesting areas on the Atlantic coast that has not been depleted by over harvesting or pollution. Commercial shell fishing is important to the local economy and recreational fishing and shrimping in the lagoon support a multimillion-dollar tourist industry. The estuary also serves as an important nursery area for a number of commercially important ocean-going species such as flounder, mullet, black drum and shrimp.

The park is located along the "frost line", resulting in a unique combination of temperate and subtropical plants. Several temperate species extend no farther south than Canaveral, while a number of subtropical species occur no farther north. Signs of this unusual mixture include Canaveral's hammocks, which contain an overstory dominated by temperate species and an understory comprised of subtropical plants. Another sign is the significant shift in vegetation along the edge of the lagoon from salt marsh cordgrass, which predominates in areas north of Canaveral, to mangrove species that predominate to the south. Roughly 4,191 acres at the Seashore are salt marsh, with an additional 2,309 acres of mangroves (Table 1). Canaveral has the largest percentage of open water of all parks, much of which includes large seagrass beds.

Canaveral National Seashore Salt Marsh Sampling Locations

Southeast Coast Network
National Park Service
U.S. Department of the Interior

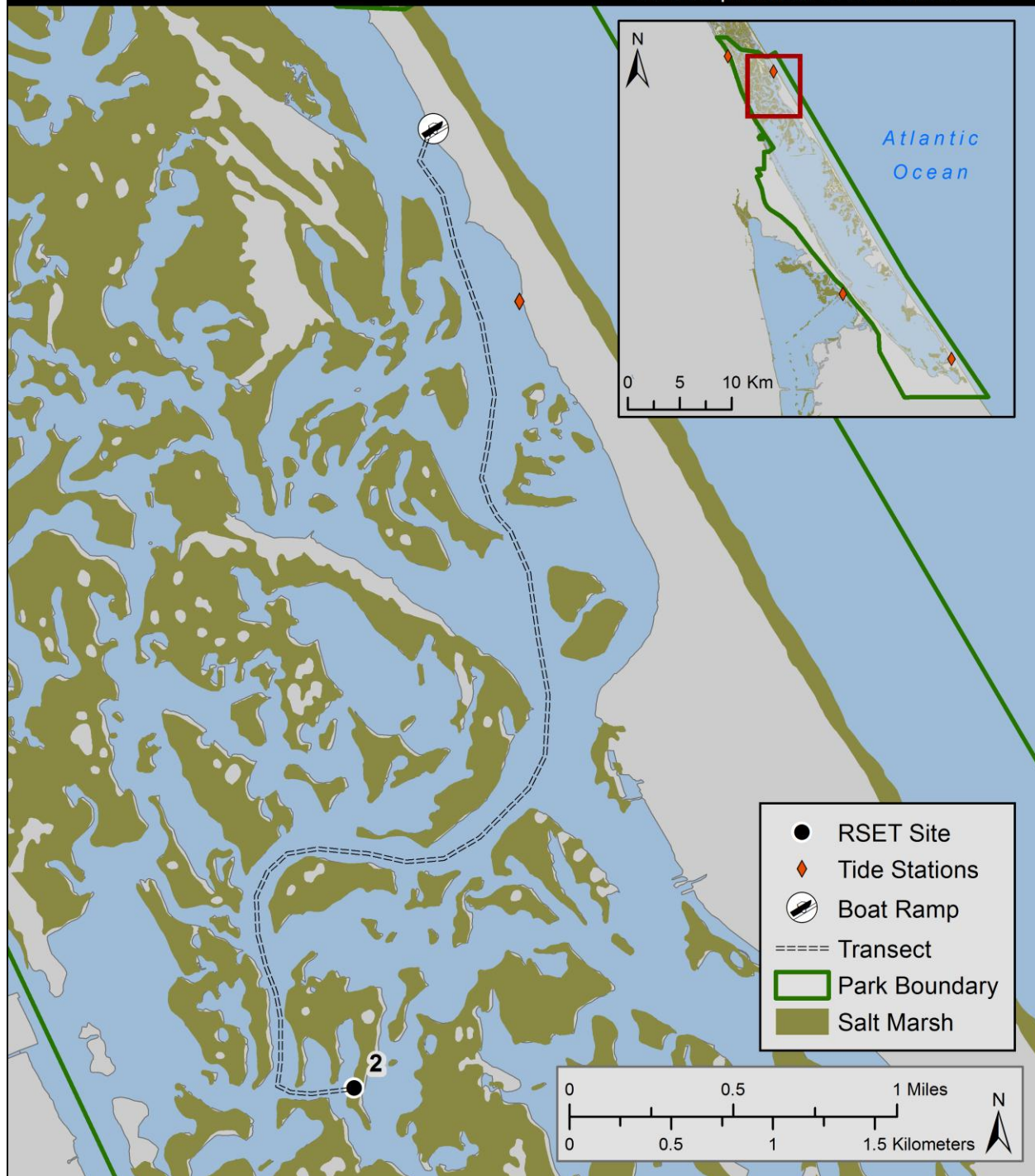


Figure 9. Coastal wetland and tidal monitoring stations near Canaveral National Seashore in Florida. Indicated are areas of salt marsh (National Wetlands Inventory 2011), urbanization (US Census Bureau 2001), and CO-OPS tidal monitoring stations (NOAA 2013).

Factors Affecting Coastal Wetlands in Southeast Coast Network Parks

SECN park ecosystems are influenced by a variety of factors at the local and landscape scales. Changes in salt marsh extent, diversity, and quality are presumed to be related to a combination of sea level rise (relative to changes in salt marsh elevation), tidal variability, and other local/regional issues such as changes in surrounding land and water use that can affect subsidence rates (Table 2). Additionally within several parks, recreational use by visitors or impacts from non-native or naturalized animal populations can further affect various components of marsh wetland ecosystems through trampling, grazing or nutrient enrichment (Turner 1988). Understanding the effects of multiple concurrent stressors affecting parks, and mitigating the impacts of those stressors at multiple spatial and temporal scales is an ongoing challenge for SECN park managers.

Table 2. Factors affecting coastal marsh wetlands in Southeast Coast Network Parks and potential measures for Vital Signs Monitoring. Measures in **bold** have been selected for inclusion in Southeast Coast Network monitoring efforts; measures in **bold and italic** are collected through other monitoring initiatives by NPS or partners.

Category	Issue	Potential Measures
Landscape Change	Changes in the distribution and types of land uses relative to parks influence sediment and nutrient loads and consequently productivity of estuarine and salt marsh ecosystems.	% Change in spatial extent of salt marsh land cover, Rate of conversion of marsh cover classes to/from open water.
Relative Sea Level Rise	During the 21st century, the IPCC projects that sea level rise will likely accelerate 2- to 5-fold compared to the global rate during the 1900s, very likely affecting natural ecosystems in the low-lying South Atlantic coastal zone (Burkett et al. 2001).	Ground surface elevation, Subsidence rate, Mean sea level, Sediment accretion
Tidal Variability	Frequency, magnitude, and duration of storm events as well as local variations tidal ranges influence vulnerability to wetland loss.	Mean sea level, tidal range
Extreme Weather events	Climate change is projected to increase the frequency and magnitude of landfalling storm events, which in turn is projected to increase vulnerability to coastal wetland inundation or loss.	Storm frequency & intensity, flood frequency & duration
Altered Hydrology	Freshwater input and availability and consequent effects on marsh ecosystems can be altered through alterations in drainage, tidal flushing patterns, groundwater dynamics or subsidence.	Soil porewater salinity, Depth to shallow groundwater, Sediment accretion, flow pattern analysis
Vegetation Change	Changes in hydrology, elevation, tidal patterns, and disturbance regime may alter the structure, function, and composition of plant communities.	% Cover of plant species, Diversity, Range expansion
Human / Non-natural disturbance	Trampling, grazing, and litter pressure resulting from uncontrolled/ unsupervised visitor use or non-native or naturalized animal populations such as feral hogs and horses.	% Cover of bare ground, Presence/absence/intensity of disturbance sign

Landscape Change

The southeastern United States is among the fastest growing regions in the country, and planning for and responding to climate impacts must be done in the context of land use change (Jones and Dalton 2012). The pattern and extent of land cover change has important implications for conservation of species and ecosystems; changes in land use can affect terrestrial and aquatic habitat, may lead to habitat fragmentation, and affect water quality.

The Southeast has undergone tremendous changes in land cover since European settlement. Prior to settlement, longleaf pine woodlands were the dominant vegetation type in the coastal uplands (Christensen 1999, Frost 1993). Extensive river corridors bisected the upland matrix and concentrations of non-riverine wetlands covered vast acreages (Richardson 2000). In their conservation assessment of the U.S. and Canada, the World Wildlife Fund identified every ecoregion in the Southeast as vulnerable, endangered, or critical (Ricketts et al. 1999).

The direct and indirect impacts of rapid urbanization and climate change on vegetation, ecosystems, and habitats are major challenges to park management. The scale and extent of the potential impacts of these new threats require that managers consider strategies across ownership boundaries, multiple species, cultural resources, and at multiple temporal and spatial scales.

The low-lying southeastern coastal zone was characterized as a hot spot of ecological vulnerability in the first two National Assessments (Karl et al. 2009) and numerous other assessment reports and independent investigations (Boesch et al. 2000, Scavia et al. 2002, Burkett et al. 2005, Savonis et al. 2008). The South Atlantic coast is characterized by low topographic relief and is subject to both hurricanes and strong frontal passages, during which coastal shorelines may retreat by several meters and wetlands may be permanently lost to open water. Like most U.S. coasts, the direct impacts of human activities on the coastal zone were more significant over the past century than impacts that can be directly attributed to observed climate change (Scavia et al. 2002). Between 1980 and 2003, coastal counties of the South Atlantic region showed the largest rate of population increase (58%) of any coastal region in the conterminous United States (Laporte et al. 2011). The major direct impacts of human development in the South Atlantic coastal zone include drainage of coastal wetlands, changes in hydrology that alter sediment and fresh water delivery to the coast, land clearing and deforestation, the discharge of sewage and contaminants into coastal waters, and the construction of seawalls and other structures that “harden” the coast.

The Southeast has historically experienced the highest rates of coastal wetland losses in the United States (Dahl 2005, Stedman and Dahl 2008). As barrier islands recede and passes enlarge, the dominance of marine forces (tides, salinity, waves) will tend to increase and accelerate change in coastal marshes and estuaries. Wetlands that cannot accrete sediments at rates that keep pace with sea level rise will either drown in place or, possibly, migrate inland if their landward transgression is not prevented by human developments such as roads, levees, and other impediments.

Relative Sea Level Rise and Tidal Variability

Mean and diurnal tidal ranges at parks within the SECN span from roughly 0.2 to 2.3 m, with annual mean sea level increasing at rates of 2–3 mm per year (Table 3). Given that ecosystem drivers at both of these scales are expected to continue for the indefinite future, it is important for park managers to

be able to understand and predict the effects of these agents of change on sensitive and declining resources. In transgressive coastal areas sea level rise is the driving force responsible for the transformation of upland soils into tidal wetlands (Gardner et al. 1992).

Table 3. Tidal characteristics and mean sea level trends at stations near Southeast Coast Network parks. Data from NOAA (2013). [–; Data Not Available]

Park	Station	ID	Mean Tide Range (m)	Diurnal Tide Range (m)	Mean Sea Level Trend (mm/yr)
CAHA	Oregon Inlet Marina, NC	8652587	0.28	0.36	2.82 ± 1.76
CAHA / CALO	USCG Station, Hatteras, NC	8654467	0.13	0.18	–
CALO	Beaufort, NC	8656483	0.95	1.07	2.57 ± 0.44
FOPU	Fort Pulaski, GA	8670870	2.11	2.29	2.98 ± 0.33
FOFR	St. Simons, GA	8677344	2.02	1.83	–
FOFR / CUIS	Fernandina Beach, FL	8720030	1.84	2.00	2.02 ± 0.20
TIMU	Mayport (Bar Pilots Dock), FL		1.38	1.40	2.40 ± 0.31
FOMA	State Road A1a Bridge, FL	8720692	1.11	1.26	–
	Crescent Beach, Matanzas River, FL	8720651	1.24	1.39	–
	I-295 Bridge, St. Johns River, FL	8720357	0.28	0.36	–
CANA	Trident Pier, FL	8721604	1.03	1.19	–

Many coastal regions are experiencing an apparent increase in sea level rise due to local land subsidence. Subsidence is a natural product of coastal sedimentation, as terrigenous sediments are deposited in deltas and along shorelines (NOAA 2009). Over time, these recent deposits compact, eventually forming sedimentary rock. It is this compaction that leads to a loss in elevation. As sedimentation continues, the elevation lost through compaction may be replaced by new deposition. However, if sediments are deposited inland (such as behind dams), coastal sedimentation is curtailed. Subsidence can also be exacerbated by anthropogenic fluid withdrawal, such as occurs with oil drilling and tapping aquifers for human water supply (NOAA 2009). Regardless of the cause of local subsidence it has the net result of increasing the rate of relative sea level rise. Examples of regions experiencing high rates of subsidence are southern Louisiana and Houston/Galveston Bay.

Some coastal regions are experiencing increases in elevation due to anthropogenic pressures from the watershed such as urban and agricultural development practices in areas characterized by steep slopes, highly erosive soils, and episodic high-energy rain events. When wetlands receive the impact from rapid impulses of sediment, the impacts are exacerbated by changes in the tidal prism and the decreased inability of the tides to flush the system of sediments. This makes the balancing act between sea level rise and elevation change more precarious and requires that resource managers have good information on both trends in local sea level and elevation to address resource management issues.

Marsh surface change is influenced by both subsurface processes occurring in the soil profile and above-surface processes that drive sediment accretion (Figure 10). When changes in both surface

elevation and accretion are measured, they can provide information on below-ground processes that influence surface change. Differences between the rates of vertical accretion and surface change can be attributed to processes occurring in the shallow soil layer. The RSETs will be surveyed, allowing the elevation data to not only be compared and analyzed within the site, but between sites. Additionally, the elevations will be able to be tied into the regional or local tidal datums, which can be used to provide measures of relative sea level change.

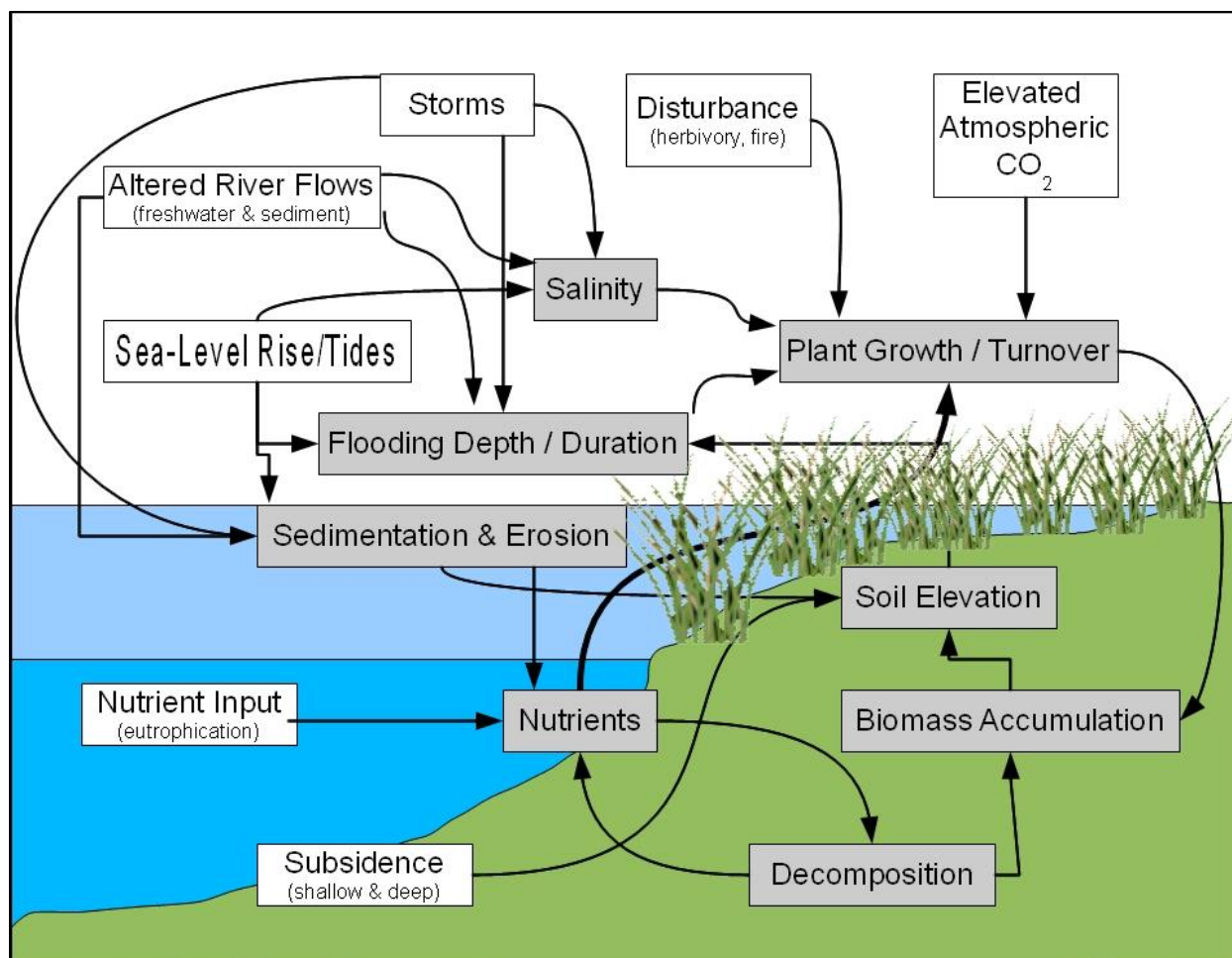


Figure 10. A conceptual diagram illustrating how environmental drivers influence vertical wetland development. White boxes indicate drivers and grey boxes show accretionary processes. From (Cahoon et al. 2009).

Extreme Weather Events

Natural forces can also have significant influences on these vegetation systems (Moore 2009). Storms can be powerful forcing functions modifying these areas over both the short and long term (Davis and Andronaco 1987, Short and Wyllie-Echeverria 1996, Roman 1997). Sea level rise or other changes in water level, as well as global climate change can have a wide range of effects on both submersed and emergent coastal plant communities including submergence and drowning, changes in salinity, temperature, runoff and water quality, as well as increasing UV radiation (Warren and Niering 1993, Watson et al. 1996, Short and Neckles 1999). Additionally, non-

indigenous or invasive plant species can have significant impacts on the structure and function of these habitats (Sandlund et al. 1999). Further, the process of natural recovery of systems impacted by extreme events such as hurricanes can be of significant interest. Evaluating the success of restoration efforts, as well as assessing the recovery of impacted communities requires detailed, statistically rigorous protocols that can be equally applied to both reference areas and impacted sites. Periodic, consistent, long-term monitoring of reference sites can also provide measures of natural variability that are very useful in evaluating restoration efforts or recovery from perturbation.

Altered Hydrology

Alteration to the hydrological regime is a common disturbance in a variety of southeastern ecosystems including coastal wetlands. Hydrological change has altered flood depth, duration, frequency, and seasonal timing in many of these systems, leading to a raising and lowering of the water table in specific cases. These changes are further affected by alterations in freshwater water inputs from storms, withdrawal from consumptive uses, or changes in sedimentation patterns, flow barriers, or channelization (Adams and Hackney 1992).

Vegetation Change

Emergent wetland vegetation is an important component of estuarine ecosystems (Roman et al. 2001, Moore 2009). They form a buffer between upland systems and the sea, and provide complex habitats with irreplaceable value to both coastal systems and their adjacent watersheds. Despite their value, the distribution, abundance and diversity of these communities have been lost as a direct result of human impact. For example, nearly 50% of the coastal wetlands have been lost in the United States through dredging and filling activities (Dahl 1990). Changes in hydrological regimes through alterations in drainage (Niering and Warren 1980) or tidal flushing patterns (Roman et al. 1984) as well as local subsidence (Davis and Andronaco 1987) have severely impacted many others. In the Chesapeake Bay region, beds of submersed aquatic vegetation are currently at their lowest levels of abundance in recorded history (Orth and Moore 1983); these declines can be directly related to watershed inputs of sediments and nutrients accelerated by human activities (Kemp et al. 1983, Brush 2001).

Human or Non-Natural Disturbances

Visitor uses of natural resources, though appropriate within the Natural Park System, can cause a number of direct and indirect changes within the ecosystem. Use of natural areas has increased steadily since 1965, with total recreational visitation in SECN coastal parks averaging between 6 and 7 million visitors per year in 2012 (Figure 11; Cole 1996, NPS 2013) and will likely continue as protected lands become increasingly rare in the rapidly developing landscape within the Southeast. Most visitor use impacts are assumed to increase as visitation rates increase. Additional visitor use impacts include litter, trampling, poaching, species introductions, and social trail creation (by foot or by watercraft).

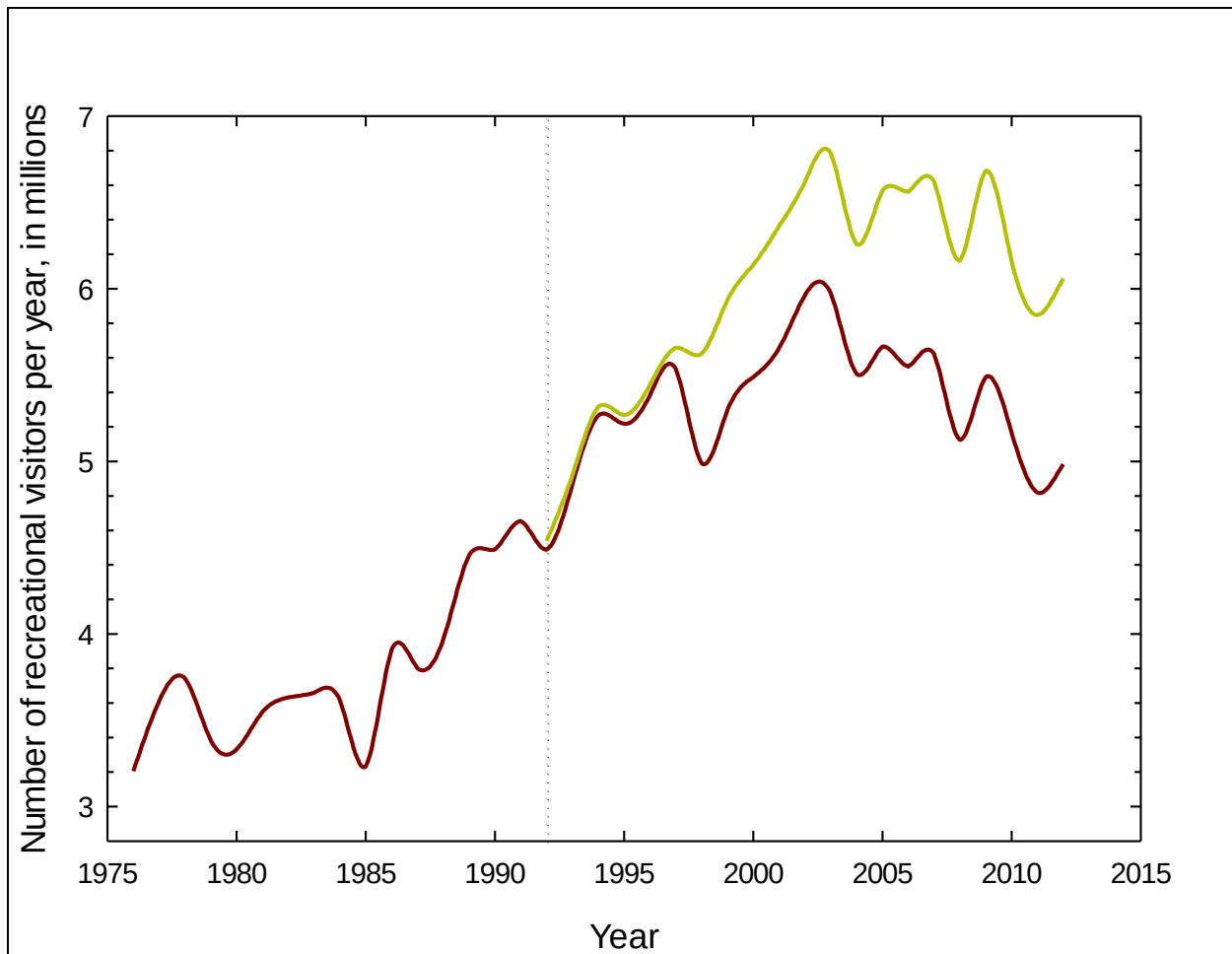


Figure 11. Total number of recreational visitors per year at Southeast Coast Network parks where coastal salt marsh elevation and vegetation communities are to be monitored, 1976–2012.

The dotted line represents when Timucuan Ecological and Historic Preserve was created in 1992. Red line does not include Timucuan Ecological and Historic Preserve and the yellow line includes the visitor data from Timucuan Ecological and Historic Preserve. Data from NPS (2013).

Overgrazing by exotic animals is also a problem on barrier island systems because of the large numbers of feral animals introduced to the islands, including horses, cattle, goats, pigs, and sheep (Stalter and Odum 1993). Two parks within the Network (CUIS and CALO) manage feral horse populations that are significant drivers of physical, biological, and chemical components of barrier island and marsh wetland processes (Turner 1988).

Development and Purpose of the Protocol

In 2001, the SECN began planning and implementing its long-term Vital Signs Monitoring Program which included salt marsh elevation and vegetation communities in the vicinity of forts, national seashores, and preserves along the Southeast coast. In 2004, SECN staff provided parks with resource prioritization questionnaires which asked natural resource staff to rank the importance of water resources to their parks as well as potential concerns that a monitoring program might address.

Findings from this survey indicated that salt marsh and estuary communities were a high priority for the Vital Signs Program to address (DeVivo et al. 2008).

In 2010, the SECN hosted a scoping meeting with representatives from the NPS, NOAA, USFWS, and USGS, whose interest in salt marsh and estuarine resources helped focus and shape the fundamental aspects of a salt marsh community monitoring program that could serve the needs of SECN coastal parks and its partners. This meeting further acknowledged the importance of this type of data and information in helping to better understand characteristics of the effects of relative sea level rise on intertidal marsh communities in parks, refuges, reserves and preserves as well as contributing to a better understanding park ecological processes and physical systems. The result of this meeting was the development of a set of minimum data collection standards to be utilized along the Atlantic coast (DeVivo et al. 2011).

This protocol is largely based on methods and procedures widely in use by other programs and agencies (Roman et al. 2001, Cahoon et al 2002a,b, Folse and West 2004, Folse et al. 2008, Moore 2009, Lynch et al. 2012). The use of existing protocols and published methods to the greatest extent possible is intended to provide information that can be evaluated in a regional and national context and can be easily combined with other data sets to gain additional insight on salt marsh trends in the vicinity of parks.

Two extra-park regions were identified in which sampling designs, protocol development, and implementation would be coordinated among partners to improve cross-agency utility of data and operational efficiency:

- In northeast Florida, the area encompassing Fort Matanzas National Monument and the GTMNERR were treated as a single study area and monitoring efforts are being coordinated jointly between NPS and NERR staff. In 1999, the GTMNERR was designated in St. Johns and Flagler counties, Florida as a part of the National Oceanic and Atmospheric Administration (NOAA) National Estuarine Research Reserve (NERR) 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.
- Pea Island National Wildlife Refuge was included in the sampling designs for Cape Hatteras National Seashore to ensure that findings applied to all DOI holdings within the CAHA legislative boundary. Executive Order 7864 established Pea Island NWR on April 8, 1938, as a refuge and breeding ground for migratory birds and other wildlife. Presidential Proclamation 2284 closed a 25,700-acre area encompassing the refuge and a portion of the Pamlico Sound west of and adjacent to the refuge to migratory bird hunting (USFWS 2006). Three impoundments covering 790 acres are managed for food production, to provide forage for waterfowl and shorebirds on the refuge.

2. Measurable Objectives

Monitoring Objectives

To characterize the effects of relative sea level rise on salt marsh communities, required data include accurately monitoring water level, site elevation, soil salinity and the vegetative community. Each component is integral to the group as a whole to provide a complete picture of surface elevation dynamics and vegetation response. The following six objectives will be monitored at sampling locations in all study areas (CAHA, CALO, TIMU, CANA, CUIS, FOMA-GTMNERR, FOFR, and FOPU):

1. Determine the magnitude, rate, and within-site variability of change in ground surface elevation in SECN salt marshes.
2. Determine the status, trends, and within-site variability in surface sediment accretion or erosion.
3. Determine the status and trends in the surveyed elevation of station benchmarks relative to the national elevation network.
4. Determine the status and trends in soil salinity.
5. Determine the status and trends in salt marsh vegetation species composition, cover, and height.
6. Determine the status and trends in percent area coverage of non-vegetative salt marsh surface characteristics such as oyster colonization, crab sign, wrack, and soil desiccation.

Enhanced Climate Change Monitoring Objectives

Two study areas (TIMU and FOMA-GTMNERR) have been selected for implementation of enhanced climate change monitoring, where more intensive efforts will be undertaken to assist parks with climate change response planning (NPS 2010, 2012).

7. Determine the within-park spatial variability in the ground surface elevation in SECN marshes.
8. Determine the within-park spatial variability in surface sediment accretion or erosion.

The DOI Southeast Climate Science Center (as well as several other programs in the Southeast) is developing models of direct relevance to SECN coastal ecosystems relating to coastal wetland loss (Plant et al. 2010, Jones and Dalton 2012). To estimate effects of climate change on shoreline erosion vulnerability and coastal wetland loss models, the USGS is factoring in parameters to represent local processes that affect land-surface elevation and other types of ecosystem changes (Pendleton et al. 2010, Plant et al. 2010). The team is using Bayesian network modeling approaches to design new tools for decision makers to visualize and assess change in coastal regions where a combination of inundation, land loss, and habitat change is occurring and expected to continue. Local variability in

relative sea level rise and accretion are key measures in these developing models (Thieler et al. 2010, Gutierrez et al. 2011).

Research Objectives

Within the FOMA-GTMNERR study area, an additional suite of research objectives will be addressed related to assessing seasonal variability and emergent intertidal vegetation (Kimball and Eastman 2012). Methods described herein are designed to be consistent with the NERRs Biological Monitoring protocols (Moore 2009) to ensure data compatibility in salt marsh communities throughout the coastal southeast Atlantic. Primary research questions addressed by data collection at FOMA-GTMNERR include:

- What are the characteristics of these plant communities including community structure (height), species abundance, species recruitment (including invasive species), or species loss?
- What are the patterns of inter-annual variability and spatial distribution of emergent intertidal vegetation and what are the patterns of both short- and long-term habitat change?
- How does this variability differ between cordgrass and mangrove-dominated marshes?
- How are any changes in habitat distribution, abundance, and composition related to abiotic and biotic factors and at what scale?
- What is the ecological response of the emergent intertidal vegetation community to local (e.g., watershed) and global (e.g., ocean) environmental impacts?

Objectives Addressed in Other Monitoring Protocols

Changes in the spatial extent and condition of salt marshes are also of importance to SECN park managers; both of which will be addressed through other monitoring efforts at the network, regional, or national scale. It is anticipated that changes in marsh extent will be addressed at the landscape scale either by the South Atlantic Landscape Conservation Cooperative or the Southeast Climate Science center (Jones and Dalton 2012, SALCC 2012), or at the national scale through the NPScape program (Monahan et al. 2012). Changes in sea level and tidal patterns as well as overall marsh condition will be addressed through SECN coastal shoreline and vegetation community monitoring efforts, the protocols for which is still in development (planned for publication in FY 2014).

3. Sampling Design

There are several issues to consider when designing a field program for monitoring salt marsh elevation and accretion dynamics, including the specific monitoring objectives being addressed, and the resultant implications for site selection, sampling frequency, the variables being measured, the sampling unit, and sample sizes. This section provides justification and supporting documentation for various aspects of the protocol related to sampling design. The overall design strategy upon which this protocol is based has three components:

- A clearly defined sampling frame based on imagery analysis. For each park the sample frame is the salt marsh system. Although the site locations are based on the initial extent of the sample frame based on landcover data in 2007, changes in the spatial extent of the vegetation class will be studied over time as a part of this protocol.
- A suite of sampling locations selected within each study area's sampling frame, the number of which varies by park depending on the monitoring objectives to be addressed. To preserve the marsh communities from human impact and maintaining the public's viewshed within the park, permanent monitoring stations have been established at locations limited to areas outside of public view, and to those that are regularly flooded or inundated at the surface twice daily by semidiurnal tides.
- Evaluation of surface elevation and vegetation dynamics at selected locations within the sampling frame using several response designs based on established methods.

Sample Frame

The sample frame for each park is the salt marsh system. Prior to site selection, salt marsh boundaries were delineated by SECN staff with ArcGIS 9.x using available aerial and land use / land cover data (Table 4). Open water areas less than 20 m across were included in the sample frame.

Table 4. Coverages used for salt marsh boundary delineation for the salt marsh elevation and vegetation community monitoring in Southeast Coast Network parks. Digital Orthophoto Quarter Quads (DOQQ), National Agriculture Imagery Program (NAIP), and Saint Johns River Water Management District Land Use / Land Cover (SJLULC) are shown.

Park	DOQQ	NAIP	SJLULC
CAHA	1998		
CALO	1999		
FOPU	1999		
FOFR		2005	
CUIS	1999	2005	
TIMU	2004	2005	
FOMA-GTMNERR			2007
CANA	2004		2000

Sample Locations

The monitoring objectives and the environmental setting influence the selection of appropriate sample locations. Salt marshes consist of multiple variables including elevation, hydrologic and salinity gradients, inundation periodicity, soil composition and geomorphology, and current velocities—all of which affect the salt marsh in differing ways.

The number of sampling locations for each park was determined after consideration of park size and hydrologic characteristics, safety concerns, the logistical issues regarding travel time and conducting monitoring activities, and whether monitoring objectives related to climate change are of interest at each park.

At each of the eight parks where the protocol is to be implemented, a minimum of one and a maximum of six sampling locations have been selected to address the monitoring objectives. At all parks, at least one sampling location was selected with three replicate stations where sediment elevation, accretion, vegetation, porewater chemistry, and other characteristics are measured. To provide data relevant to park- and region-wide climate change impact forecasting, sampling designs at two parks (TIMU and FOMA) have been expanded to include multiple sampling locations with a minimum of one placed in each of the parks' 12-digit hydrologic code watershed.

Sample Location Selection

The sampling frame for each park was divided into a systematic 0.5-ha grid; the area of the grid cell served as the potential sampling location (Byrne 2012). The 0.5-ha grid-cell size was chosen to provide an adequate number of sampling locations given the size and shape of SECN parks and because 0.5-ha is the minimum mapping unit of the SECN vegetation mapping inventory. A spatially-balanced random sample was drawn from this grid using the Reversed Randomized Quadrant-Recursive Raster (RRQRR) algorithm (Theobald and Norman 2006, Byrne 2012). The RRQRR algorithm provides a discrete sample (Theobald et al. 2007), thus inferences will be expressed relative to the number of grid-cell center points within the sampling frame. The sample draw included primary sampling locations and an “over-sample” to provide alternate sampling locations. Refer to SOP 1.1.7 and 1.1.1 for data preparation and generating sampling locations using the RRQRR using ArcGIS 9.1 and 9.3.1. These two SOPs were used to generate sites prior to 2014. Due to changes in software, future sites will be chosen using SOP 1.2.1 (Asper 2013), which utilizes ArcGIS10 and the corresponding ArcGIS tool that uses a RRQRR algorithm to generate sampling locations.

To maintain the integrity of the spatially-balanced properties of the RRQRR draw, the initial draw consisted a minimum of $1.5n$, where n is the desired number of sampling locations. Alternate sampling locations were used when selection criteria (Characteristics Evaluated in GIS, see below) were not met; approximately eight to ten alternate sampling locations are provided for each park-specific sampling design.

Selection criteria are applied to all sampling locations in lieu of *a priori* categorization of some grid cells as “exclusion zones” (Theobald et al. 2007), or unsampled areas as previously referred. Creating GIS-based exclusion zones can bias the design because of imprecision, spatially or temporally, in the

geospatial data used as the foundation of the sample draw process or our lack of location-specific knowledge that could influence sampling location inclusion (Theobald et al. 2007). Therefore, two levels of selection criteria are applied to all sampling locations: (1) those applied using GIS where relevant data layers were available, accurate, and reliable, and (2) those applied in the field. As previously mentioned, field evaluation is necessary because the resolution in available GIS data is too coarse for a determination of whether a site should be included in the sample design. Sampling locations are evaluated in the sampling order in which they were generated following the procedures outlined in SOP 1.3.1 (Asper 2012).

Characteristics Evaluated in a GIS

Sampling locations are excluded from the sampling draw if:

- The site is greater than 20,000 yards (10 nautical miles) from a boat launching facility; however, this distance may be reduced or increased based on boat used, normal water conditions and accessibility.
- The site is not accessible by open water.
- The sampling location occurs on private in-holdings where access is not permitted.
- The characteristics of the sampling location do not allow for a 70 meter buffer from the sampling location that facilitates access or the location does not allow for the installation of three monitoring sites, including platforms 30 feet in length.

Characteristics Evaluated in the Field

Sampling locations are also excluded if upon inspection in the field:

- Verification that the GIS evaluation was imprecise, inappropriate resolution, or incorrect, thus precluding the location from being selected.
- Sites are not regularly inundated by tidal water, defined as at least one inundation event during any 24-hour period.
- Sites are visible from normal public view within park lands.
- Sites are not vegetated with typical salt marsh species (e.g., *Juncus roemerianus*, *Spartina alterniflora*).
- Sites are not accessible by boat at low tide. The boat should be able to bow into shore, and contact all three 30-foot platform established as part of site preparation. Low tide is defined as two hours either side of mean low water.
- The sampling location is potentially unsafe.
- Signs of recent impacts or stressors such as by prescribed fire or wildlife disturbance or trampling are present.

- The sampling location is located within 25 m of human alterations such as levees, roads, spoils, etc.

In the event a sampling location is omitted, the first alternate sampling location is selected, the aforementioned criteria are applied, the sampling location is accepted or rejected, and if rejected the next consecutive alternate sampling location is evaluated with the same process.

Response Designs

Implementation of the SECN Coastal Salt Marsh Elevation and Vegetation Community Monitoring Protocol requires the use of several response designs implemented at various plots around a permanently-installed monitoring platform (Figure 12, Table 5, Table 6). Each sampling location consists of three permanent monitoring platforms, each of which has a permanent Rod-Surface Elevation Table (RSET) monitoring benchmark, and a series of accretion plots, soil porewater monitoring plots, and vegetation photoplots at which various components of this protocol are implemented (see Figure 12 for schematic). The RSET benchmark consists of a vertical rod installed to refusal (so that the elevation of the top of the rod is stable) with a receiver to which the surface elevation table can be attached (Figure 13).

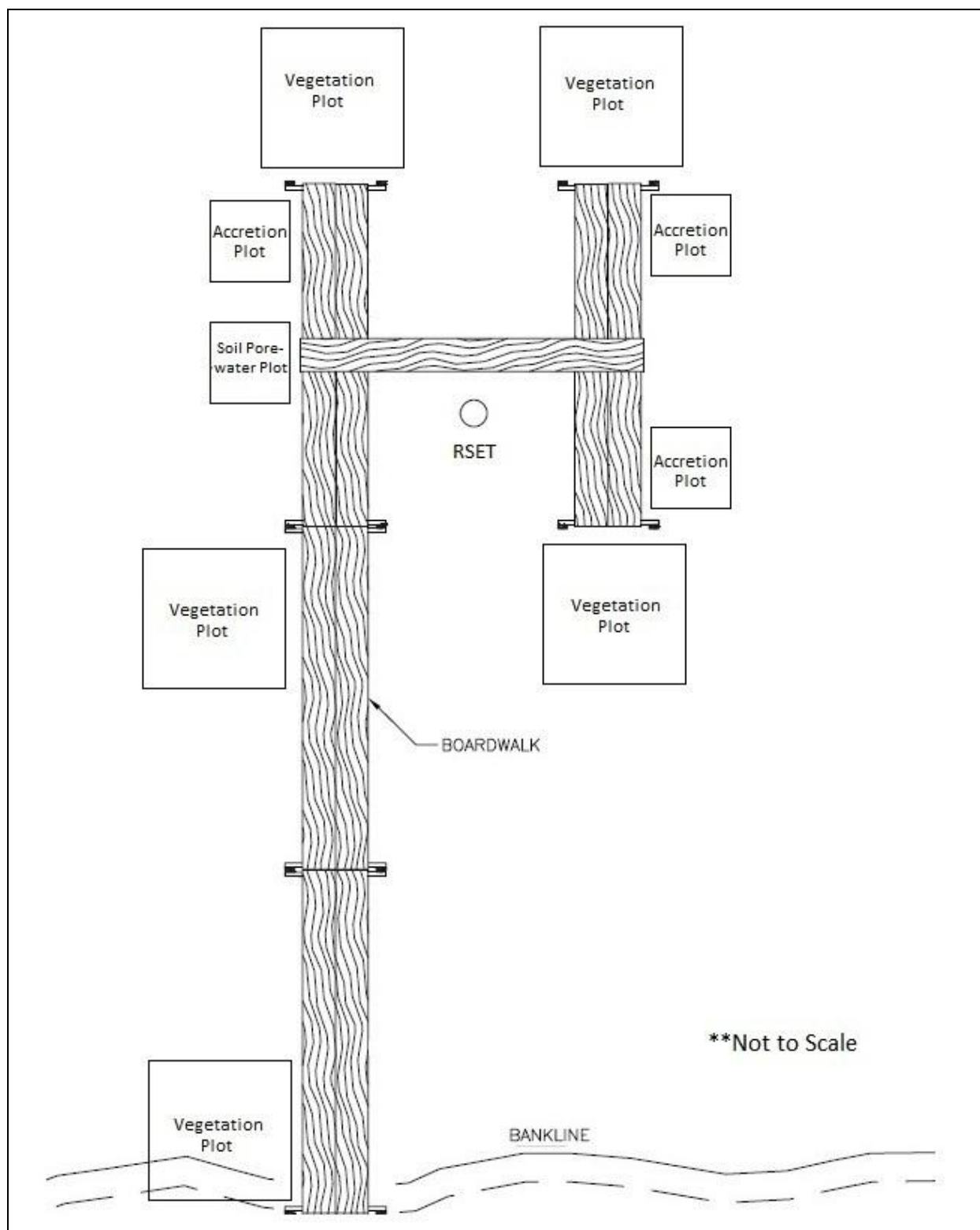


Figure 12. Schematic for monitoring platform, accretion plots, soil porewater monitoring locations, and vegetation plots. Modified from (Folse and West 2004).

Table 5. Relationship between monitoring objectives, sampling methods, and variables measured at SECN parks as a part of the Protocol for Monitoring Salt Marsh Elevation and Vegetation Communities.

	Objective	Sampling Method	Locations	Variables Measured	Parks
Core Site Monitoring	1 Surface Elevation Change	RSETs	RSET stations	Pin height to ground surface	CAHA, CALO, TIMU, CANA, CUIS, FOMA-GTMNERR, FOFR, FOPU
	2 Accretion / Erosion Rates	Sediment coring	RSET stations	Depth to marker horizon	CAHA, CALO, TIMU, CANA, CUIS, FOMA-GTMNERR, FOFR, FOPU
	3 Deep Subsurface Subsidence	Surveys of NGS benchmarks	RSET stations	Absolute Elevation	TIMU, FOMA-GTMNERR
	4 Vegetation Changes	Photoplots	Vegetation Photoplots	count/area; % Species Cover	CAHA, CALO, TIMU, CANA, CUIS, FOMA-GTMNERR, FOFR, FOPU
	5 Non-vegetation characteristics	Photoplots	Vegetation Photoplots	count/area; % cover	CAHA, CALO, TIMU, CANA, CUIS, FOMA-GTMNERR, FOFR, FOPU
	6 Soil Salinity	Soil Porewater Salinity Measure	Porewater Plots	Porewater salinity	CAHA, CALO, TIMU, CANA, CUIS, FOMA-GTMNERR, FOFR, FOPU
Enhanced Climate Change	7 Within-park surface variability	RSETs	RSET stations	stdev of site location elevations	TIMU FOMA-GTMNERR
	8 Within-park accretion variability	Sediment coring	RSET stations	stdev of site location accretion	TIMU, FOMA-GTMNERR

Table 6. Number of replicate samples for each field measure as a part of the SECN Coastal Salt Marsh Elevation and Vegetation Community Monitoring Protocol.

Park	Surface	Accretion	Benchmark Elevation ¹	Photoplots
CAHA	3	9	3	15
CALO	3	9	3	15
FOPU	3	9	3	15
FOFR	3	9	3	15
CUIS	3	9	3	15
TIMU	18	18	24	90
FOMA-GTMNERR	18	18	24	90
CANA	3	9	3	15

¹Number of benchmarks is based on one benchmark per platform, subject to change based on the surveying plan to be developed in the first two years of protocol implementation.

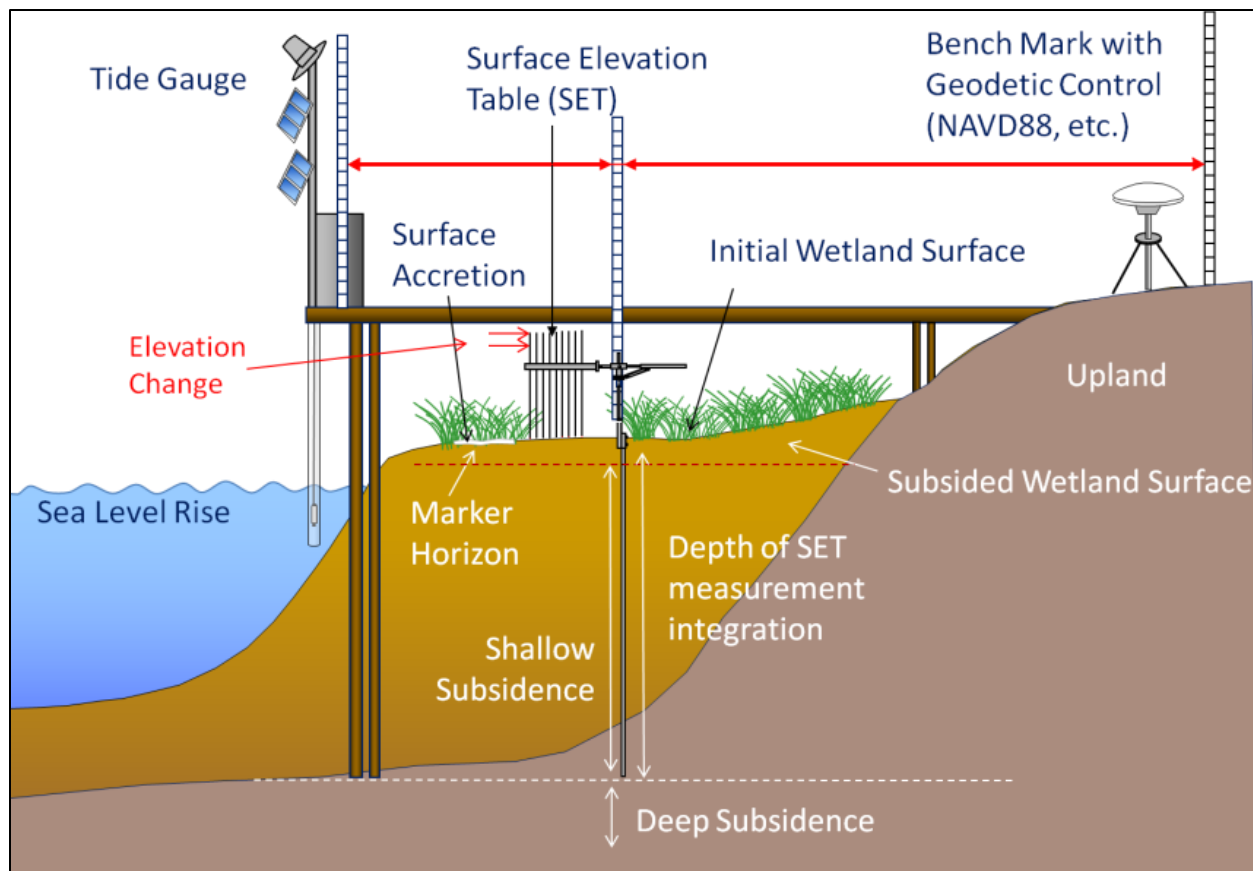


Figure 13. Schematic of combined Rod-Surface Elevation Table (RSET) and tidal gaging stations to allow for measurement of both salt marsh accretion and subsidence and sea level rise in a manner that provides measurement of relative sea level rise (NGS, P. Hensel, personal communication).

Surface Elevation Measurements

Station Instrumentation and Plot Layout

Sampling designs for evaluating changes in wetland elevation can be divided into two major types: sampling for monitoring and sampling for hypothesis testing (Lynch et al. 2012). Sampling to address monitoring objectives will generally involve sample stations that are dispersed throughout the area of interest (sample space), to ensure that a representative sample is obtained, or in critical areas, to provide an early warning of change. Hypothesis testing involves the investigation of specific factors that affect the variables being measured (e.g., elevation change). Examples include comparing elevation trajectories between a restored marsh and a reference marsh, or between burned plots and non-burned plots. Sampling designs for such studies are aimed at focusing on these factors and excluding (or explaining) other, non-targeted factors. This often leads to clustering sample stations within a marsh or within specific marsh habitats to reduce unwanted variability. Although the primary question(s) in a study may steer toward a specific study design for monitoring or hypothesis testing, it is important to note that these two approaches are never mutually exclusive. A hypothesis testing design can also inform long-term monitoring, even if its design is not ideally suited for it. Similarly, a long-term monitoring effort can also test certain hypotheses (e.g., comparing the elevation change rate to rates of surface accretion or local sea level rise).

The response design to be employed by the SECN includes a balance of both approaches. To statistically evaluate the elevation change rate for a given sample area, at least three RSETs are required (the mean and variance being used in the evaluation). This is an absolute minimum: larger sample sizes greatly increase the power of an analysis.

This discussion of minimum sample size is the backdrop for RSET sampling designs because in most cases, RSET-based investigations are constrained by small sample sizes. This constraint arises because of:

- Installation: the high cost of establishing RSET stations,
- Sampling: logistic constraints involved with getting to each station and performing all the necessary measurements within a reasonable time period.

Additionally, RSET sample plots in this protocol are coupled with marker horizon plots to measure accretion rates (Cahoon and Turner 1989); additional costs and logistic constraints (including materials and time) arise with the addition of accretion sampling (e.g., cryogenic coring) further restricting sample sizes that can be realized in the field. Although these constraints are common among field-based investigations, the degree to which they affect sample design in a RSET-based study is substantial. All of these issues reinforce the outcome that sample sizes tend to be small, placing important demands on the sampling design to achieve desired data outcomes.

The specific design to be implemented at each park will vary based on the size and logistic challenges unique to each park coupled with the specific monitoring objectives to be addressed. In general the designs will be a hybrid of the three options presented in Table 7 (modified from Lynch et al. 2012). As described above, one to six sampling locations are selected per park, with three replicate stations being installed at each sampling location. This will provide all parks with some estimate of spatial variance, while concentrating intensive sampling efforts to address questions related to within-park variability to those sites where climate change effects are to be studied within a modeling/ hypothesis testing framework.

Table 7. Four general scenarios for distribution of sampling locations within a sample space. Modified from Lynch et al. (2012).

Sample Design	Application	Cost	Difficulty	Prior Knowledge of Site Necessary	Spatial Coverage / Inference	Use of Data
Single RSET at a sample location w/o Replication.	Sentinel monitoring	Low	Low	High	Low / Minimal	Single point trend; Low site-specific knowledge No variance estimate for space. No variance estimate for sites.
Multiple randomly-distributed RSET stations throughout sample space.	Inference Monitoring	Moderate	High	Low	High / High	High spatial coverage. Low site-specific knowledge Good variance estimate for sample space. No site variance.
Cluster of RSET stations at one sampling location.	Hypothesis testing	Moderate	Moderate	Moderate	Moderate / Moderate	Moderate spatial coverage. High site-specific knowledge. Some estimate of variance among sites.
Clusters of RSET stations distributed throughout sample space.	Hypothesis testing / Modeling	High	High	Moderate	High / High	High spatial coverage. High site-specific knowledge. Good estimate of variance among sites.

Mirroring the approach of other agencies (NPS, NOAA, Louisiana DNR, USFWS, and USGS), SECN monitoring stations serve as permanent sites after they have been selected and installed regardless of the number of stations installed at a park or sampling location. The RSET sample station (RSET reference mark) is considered the experimental unit (the basic unit within a sample). This means that most statistical models (e.g., analysis of variance) should have the RSET identified as the replicate making up the sample. Marker horizons grouped around a RSET would also be expected to show some correlation, so the RSET would likewise be identified as the experimental unit in a statistical model. Where cluster-based sampling designs are employed, each sampling location will typically include three replicate stations where data are collected as described below.

Surface Elevation Measurements

Nine surface elevation measurements are taken in each of four cardinal directions from the top of the rod for a total of 36 measurements. Because the measurements in each direction are not independent, these can be considered subsamples of an approximate 2-m² area surrounding the RSET rod Figure 14. A sample size of three (used when comparing sampling locations over time) is expected to achieve 80% power to detect a mean of paired differences of 2.0 mm with an estimated standard

deviation of differences of 0.6 and with a significance level (alpha) of 0.05 using a two-sided paired *t*-test (see Appendix F for power analyses). However, at any given station, the method is expected to achieve 80% power to detect a mean of paired differences of 1.3 mm (using four averages of measurements taken in the cardinal directions as replicates) or 0.3 mm (if 36 individual pin measurements are used as replicate measures) with an estimated standard deviation of differences of 0.6 and with a significance level (alpha) of 0.05 using a two-sided paired *t*-test.

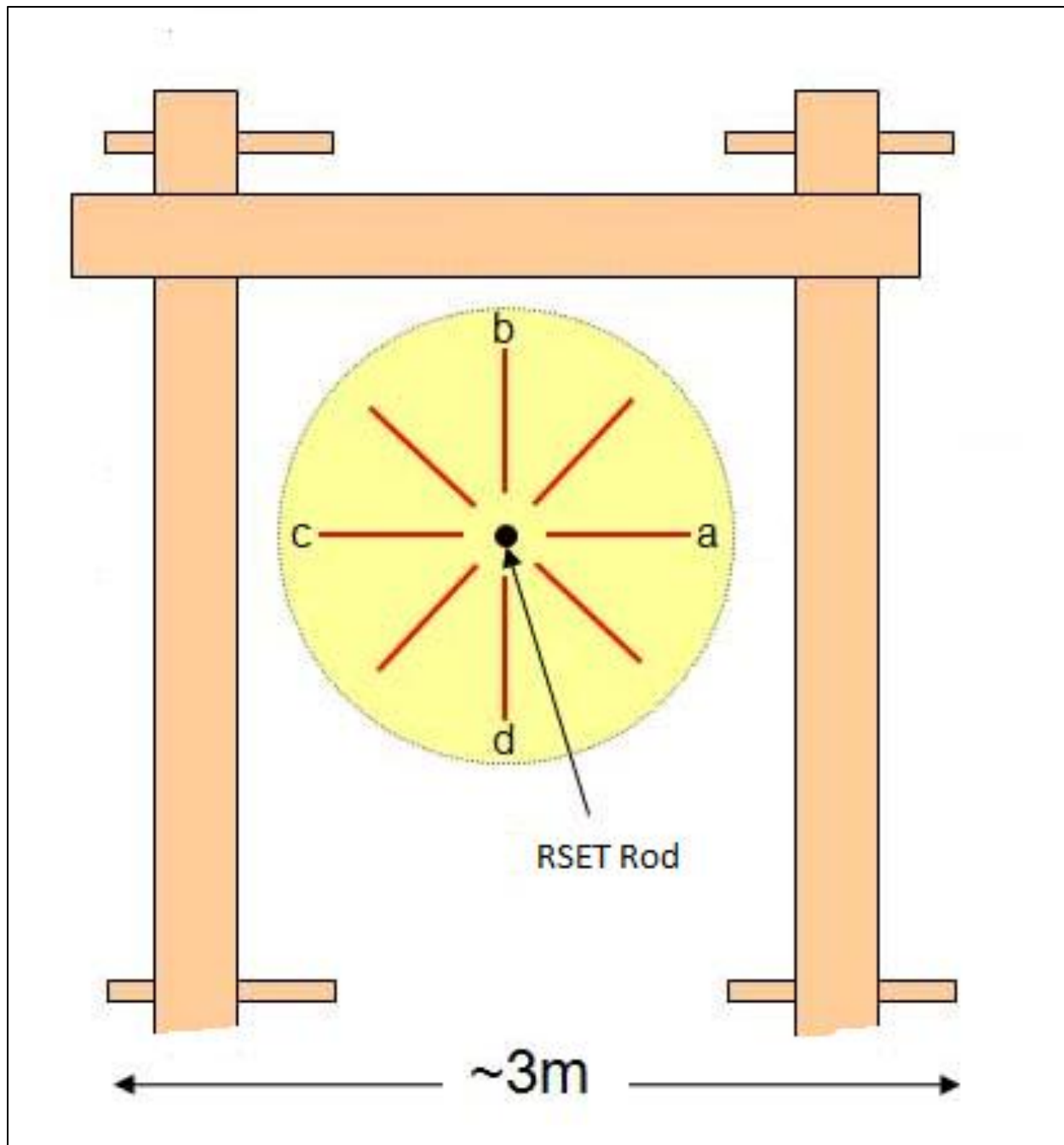


Figure 14. Schematic of permanent monitoring platform showing plot layout and potential directions for the Rod-Surface Elevation Table (RSET). (Modified from USGS Taking your SET readings page: <http://www.pwrc.usgs.gov/>)

Accretion Measurements from Marker Horizons

Marsh surface change measured by the RSET is influenced by both surface and subsurface processes occurring in the soil profile whereas depth to the feldspar marker horizon measures only surface processes (Cahoon et al. 1996). When these two techniques are used in conjunction, they can provide information on below-ground processes that influence surface change. Accretion will be measured by the establishment of three 0.5 m × 0.5 m marker horizon plots systematically placed around a platform (Figure 12). The marker horizon is white feldspar clay that is evenly sprinkled on the surface of the wetland upon which sediments are allowed to naturally settle and accrete. Depth to the marker horizon is then measured at the three replicate plots annually using a cryogenic method developed by Cahoon et al. (1996).

A sample size of three (used when comparing rates at individual stations between two sampling events) achieves 80% power to detect a mean of paired differences of 19.6 mm with an estimated standard deviation of differences of 6.0 and with a significance level (alpha) of 0.05 using a two-sided paired *t*-test (see Appendix F for power analyses). A sample size of nine (used when comparing rates at sampling locations between two sampling events) achieves 80% power to detect a mean of paired differences of 6.4 mm with an estimated standard deviation of differences of 6.0 and with a significance level (alpha) of 0.05 using a two-sided paired *t*-test.

Benchmark Elevation

Accurate elevations need to be obtained for each RSET reference mark so that the wetland surface that the RSET is measuring can be expressed with respect to the same vertical datum as local water-level records and tidal datums. Accurate elevations will convert the RSET from a relative elevation change instrument to one that can measure absolute elevation.

During the first two years of protocol implementation, an evaluation of the existing geodetic infrastructure will be completed and a survey plan developed for each park to determine accurate elevations for RSET benchmarks. This will include an evaluation of existing geodetic infrastructure including benchmarks, Continuously Operating GPS Reference Stations (CORS), and tide or water-level stations, and a determination of requisite additional geodetic infrastructure or surveying required to establish elevations of monitoring stations installed as a part of this protocol. The Network will follow recent guidelines that provide information required to adequately construct local geodetic control networks and establish geodetic connections among observing systems within the Network (Hensel et al. 2012). Selected stations will be surveyed at a minimum of once every 10 years.

Soil Porewater

Soil porewater salinity is measured at two depths at three subsample locations within the designated soil porewater plot within the monitoring array (Figure 12). A sample size of three (used when comparing rates at individual stations between two sampling events) achieves 80% power to detect a mean of paired differences of 9.8 ppt with an estimated standard deviation of differences of 3.0 and with a significance level (alpha) of 0.05 using a two-sided paired *t*-test (see Appendix F for power analyses). A sample size of nine (used when comparing rates at sampling locations between two sampling events) achieves 80% power to detect a mean of paired differences of 3.2 ppt with an

estimated standard deviation of differences of 6.0 and with a significance level (alpha) of 0.05 using a two-sided paired *t*-test.

Vegetation and Surface Characteristic Sampling

The percent cover will be estimated for vegetation species as well as key surface characteristics such as bare ground, detritus, or crab burrows. Species composition and abundance of each species within each sampled quadrat must be determined. Cover is a common measure of species abundance in vegetation studies. This will be performed using point-intercept counts of digital imagery (100 points per 1-m² images). In brief, for the point-intercept method the observer records each species/surface characteristic that is intercepted by each point at 100 points within each quadrat. Photoplots are conducted at five quadrats at designated points around the platforms at each of the monitoring stations, providing a minimum of 15 replicate samples of percent cover during every sampling event.

A sample size of 15 is expected to achieve 80% power to detect a mean of paired differences of 20% in percent cover with an estimated standard deviation of differences of 0.2 and with a significance level (alpha) of 0.05 using a two-sided paired *t*-test (see Appendix F for power analyses). This is consistent with James-Pirri et al. (2007) who found that sample sizes of 15–20 1-m² plots are adequate to detect actual differences between vegetation communities among marshes (although their analyses were based on non-parametric methods).

At two GTMNERR sampling locations, transects have also been established to address several of the research objectives listed above. Given their position within the watershed and the orientation and proximity to terrestrial land mass, emergent vegetation transects were extended from the stations at Moses Creek and Pellicer Creek from the subtidal to the terrestrial transition zones (Figure 15). Transects were established perpendicular to the water edge and extended to the edge of the marsh vegetation community. At each of three replicate transects at each site, ten permanent 1-m² vegetation plots were established where both photoplot and additional structural data are collected (canopy height, stem density, and visual estimation of percent cover) as per NERR methods in Moore (2009).



Figure 15. Aerial imagery of vegetation monitoring transects. Figure shows the position of three replicate 370-m intensive vegetation monitoring transects (red lines) at Pellicer Creek (left) and 140-m transects at Moses Creek (right) sites within the FOMA-GTMNERR study area.

Sampling Over Time

The strength of the RSET device is that the same patches of wetland surface are re-measured over time. This means that RSET data are always a time series. Elevation and accretion measurements will be collected annually during the late spring / early summer months (May–June) to reduce the likelihood of introducing seasonal variability into the data. This period was chosen so that sampling events will occur during peak vegetation growing periods and coincide with vegetation monitoring efforts being conducted by the SECN in terrestrial ecosystems.

4. Field Procedures: Installation and Data Collection Methods

For more than a decade, coastal researchers have been investigating and monitoring millimeter-scale changes in wetland and shallow bottom surface elevation using RSET technology. Such high-precision measurements are required to understand fundamental processes leading to elevation change over time. Sediment surface accretion, erosion, shallow subsidence and organic soil formation generally occur on the scale of millimeters per year. Eustatic sea level rise also occurs at this scale (currently estimated at about 2 mm yr⁻¹). In addition, RSET technology allows one to estimate rates of these processes with good statistical confidence. High-precision measurements of surface elevation change are especially important in the coastal zone because by the time larger, more noticeable changes have occurred, the coastal habitats may have already changed beyond the point of natural recovery.

High accuracy elevation change data have also proven useful to measure and understand seasonal fluctuations in elevation due to processes such as groundwater storage and seasonal sea-level changes. The RSET technique integrates all processes acting on surface elevation change over the depth of the benchmark (generally between 7 and 25 meters). In this regard, the technique differs from other high accuracy measurements of surface elevation change, because it includes below-ground processes as well. No other technique has proven itself reliable and consistent in providing millimeter-level precision for wetland elevation change.

The SECN is using several methods to assess the health of the salt marsh. These include the RSET, feldspar marker horizons, soil porewater, and vegetation change-over-time monitoring. These elements are designed for both measuring overall marsh health and local effects of relative sea level rise. Refer to Pre-Field Check List and Sampling Brief (Appendix A) for a brief outline of data collection procedure and notes for sampling RSET, Accretion Plots, and porewater.

Installation of Monitoring Station and Sampling Infrastructure

Long-term monitoring of marsh surface elevation change and vertical accretion requires repeated sampling of the marsh surface. A small permanent platform is constructed to minimize disruption of the marsh surface during sampling from which all elevation and accretion measurements are taken. One RSET benchmark is established in the center of the platform and a minimum of three artificial soil marker horizons are established around the outer perimeter of the platform to provide a minimum of two degrees of freedom for statistical analyses (Figure 12).

Establishment of monitoring sites is accomplished following SOPs for site platform installation (SOP 1.3.2; Asper and Curtis 2013a), and RSET Benchmark Installation (SOP 1.3.19; Asper and Curtis 2012b). The SECN is using the cluster of RSETs, where three platforms, each containing 1 RSET, are installed at a sampling location. The three platform locations were placed within the 70 m buffer around the randomly-selected point, as outlined in SOP 1.3.1 (Asper and Curtis 2012a). Accessibility to the platform location and site variability within the 70 m buffered area were used to determine the three platform locations at each sampling location. The platforms are constructed so that RSET and accretion data collection can be performed without disturbing the surface of the marsh. The platform also allows monitoring of vegetation and soil porewater with exceedingly minimal site disturbance. It

is very important to maintain the integrity of the study; consequently, any surface alteration that occurs during the construction or monitoring phase will result in an unacceptable site and may require relocation.

Rod-Surface Elevation Table (RSET) Measurements

The SECN has implemented the use of the RSET technique that has been developed by Cahoon et al. (2002a) and Cahoon et al. (2002b). The RSET is the preferred version of the SET that will be established at specified locations in attached, herbaceous marsh and mangrove scrub/shrub ecosystems. The RSET method provides a non-destructive process that precisely measures the sediment elevation over a long period of time relative to a fixed subsurface datum. Briefly, a series of 4-ft stainless steel rods are driven through the root zone, the organic matter, and any soft underlying materials until refusal is encountered from a driving force on the rod. Near the surface, a receiver is attached to the rod that is stabilized by a six-inch diameter PVC pipe that is cemented at the surface. A stainless steel receiver provides a constant horizontal reference plane as well as long-term repeatability as the table remains fixed for each sampling period. Detailed RSET installation procedures are provided in SOP 1.3.19 (Asper and Curtis 2012b).

Data collection occurs by attaching a custom made RSET arm (Figure 16) to the collar and nine fiberglass pins are pushed through the table from above to the marsh surface. The height (measured in millimeters) that each pin extends above the table is used to calculate vertical changes of the marsh surface over time. Using data that was collected previously, the rate of change can be calculated to provide status and trends with respect to changes occurring between the surface and the bottom of the stainless steel rod.

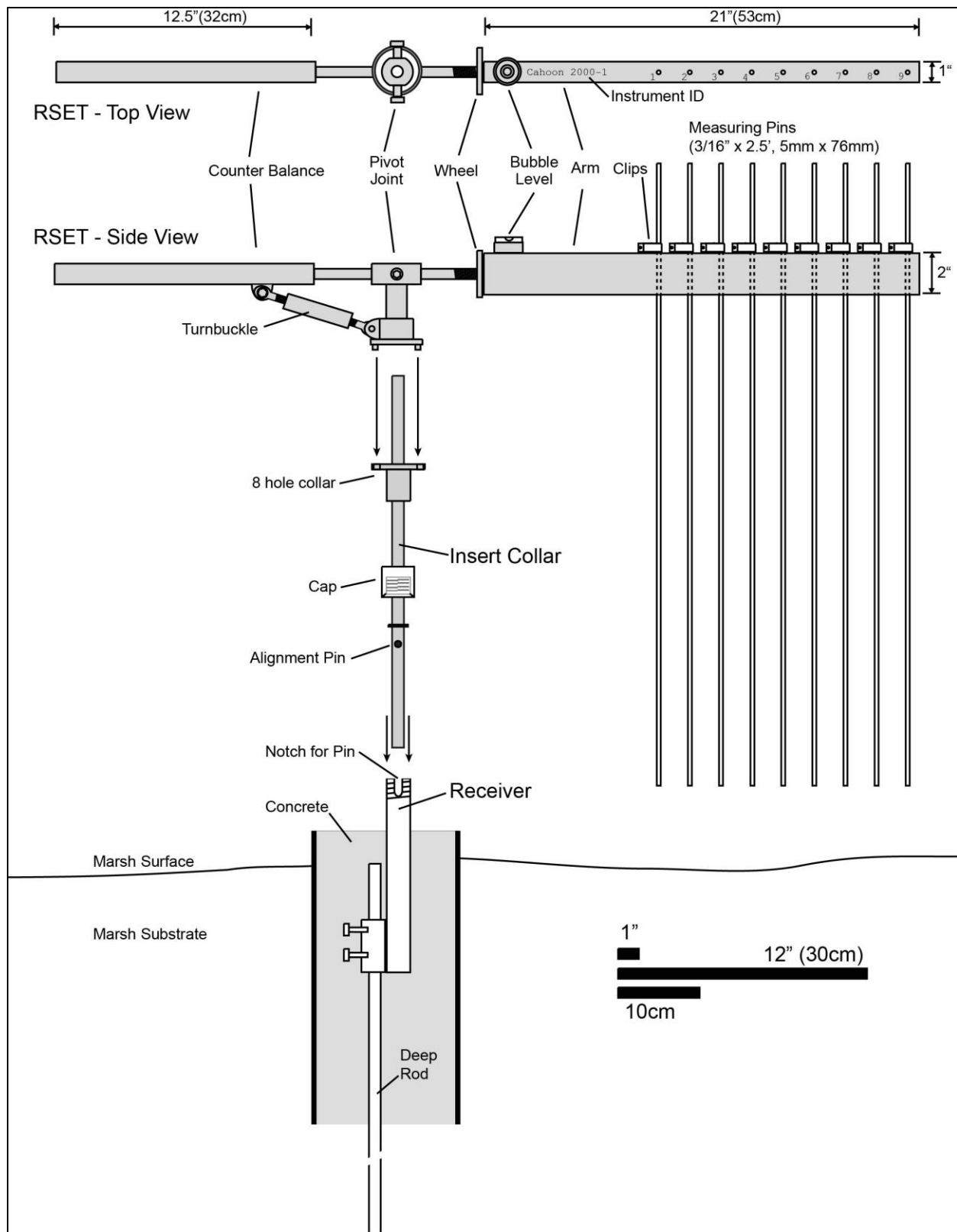


Figure 16. Detailed construction drawing of a typical RSET. Insert: collar detail From Callaway et al. (2014).

The RSET arm is repositioned to measure the marsh surface in the four cardinal points from the benchmark rod for a total of 36 measurements. Detailed instructions for collecting surface elevation measurements using the RSET device are found in SOP 1.3.6 (Asper and Curtis 2013c).

Accretion Measurements Using Marker Horizons

Differences between the rates of vertical accretion and surface change can be attributed to processes occurring below the feldspar layer and above the bottom of the RSET benchmark rod. Consequently, it is imperative that the first RSET measurements occur on the same day as the establishment of the accretion plots. The information derived from these two methods does not account for any process that occurs beneath the rod.

Accretion stations are to be established on the same day that the initial RSET readings are recorded. This gives the best known baseline for both the accretion and RSET data sets to be interpreted when analysis occurs.

Three stations will be established along the boardwalk (SOP 1.3.2; Asper and Curtis 2013b) as shown in Figure 12 in a manner that will be sampled at a later date from the platform.

Soil Porewater Salinity

Because saltwater intrusion is an important concern in coastal marshes, field personnel will measure soil porewater salinity at specific stations at 10- and 30-cm depths on an annual basis. Soil porewater constituents are relatively uniform above 20–25 cm (Feijtel et al. 1988) and these depths represent the approximate mean and maximum depth of the root zone (Mitsch and Gosselink 2007). The procedures for soil porewater installation and sampling are adapted from Louisiana DNR Coastal Resource Division procedures (Folse and West 2004, Folse et al. 2008).

Soil porewater stations are to be established on the same day that the initial RSET readings are recorded. One station will be established along the boardwalk in a manner that can be sampled at a later date from the platform. The 0.5-m² station will be placed parallel to the platform; the nearest corner will be established mid-way between the two third section (from water) platform teeth, outside the RSET sampling area, and approximately 125 cm from the fourth tooth assembly, and 15 cm from the platform edge (Figure 12).

Field measurements are collected using a soil porewater “sipper” to extract water from the marsh substrate, and then analyzed in the field using an YSI Model 30 handheld conductivity, salinity, and temperature instrument. Sample collection and analysis procedures are outlined in SOP 1.3.8 (Curtis and DeVivo 2013), with samples being taken at depths of 10 and 30 cm. Three replicates are collected at each depth being taken successively 5 cm to the right of the previous sample.

Vegetation Community Composition and Non-Vegetation Surface Characteristics

The vegetation plots are positioned external to both the long and short platforms at each station. A total of five plots are established as illustrated in Figure 12. The area within the 1-m² plots is sampled using a frame-mounted digital camera (Figure 17) and images are analyzed in the office following the methods of Booth et al. (2004) as described in SOP 1.3.9 (Figure 18; Curtis et al. 2013). Images are analyzed in SamplePoint software (Figure 18), in which a minimum of 100 pixels are randomly selected and manually classified into one of several pre-determined classes (Table 8).



Figure 17. Frame-mounted digital camera being used for vegetation and surface substrate classification.

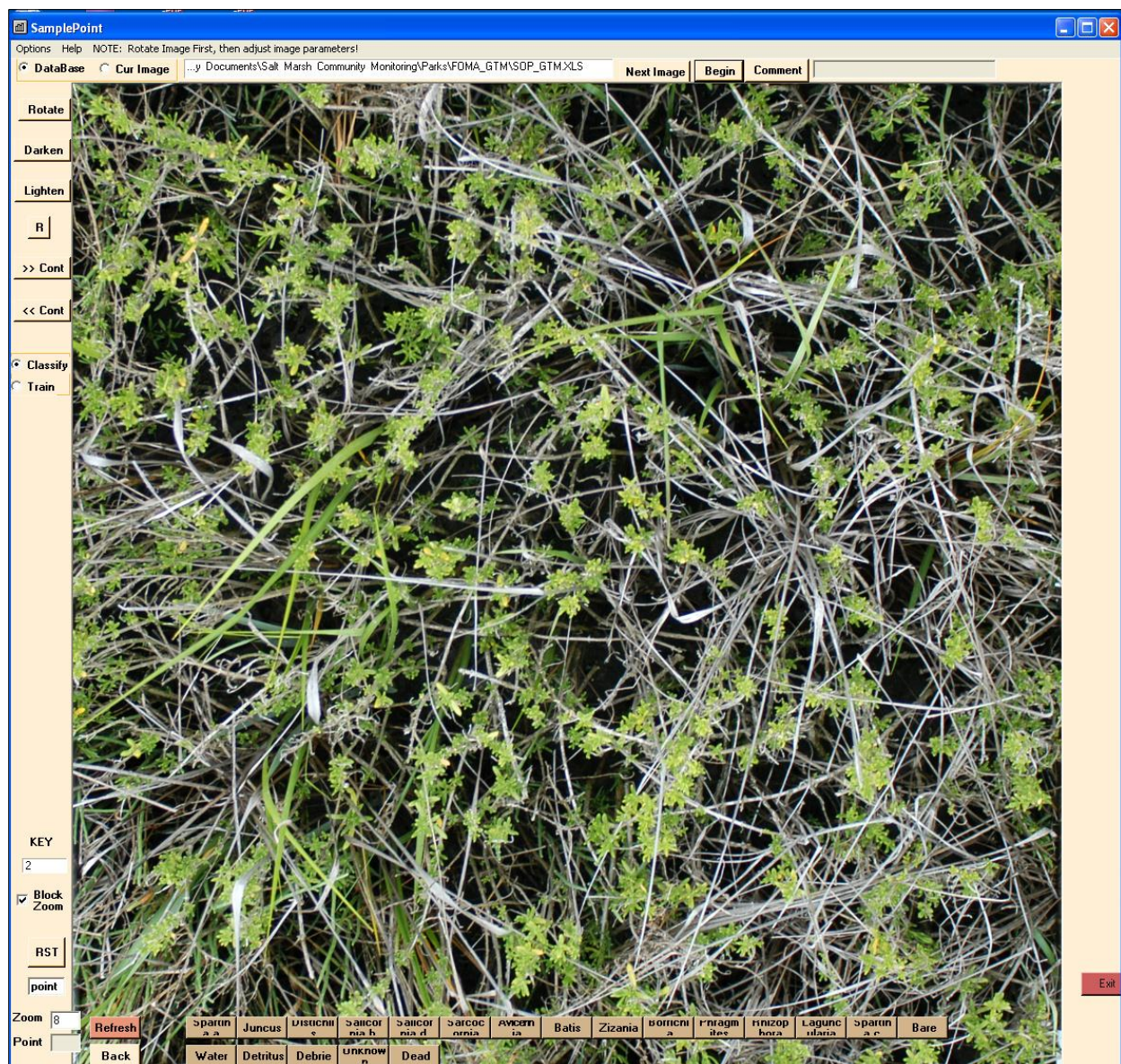


Figure 18. Example of a SamplePoint classification screen with options for pixel classification.

Table 8. Vegetation and non-vegetation classes for use in salt marsh cover analysis using SamplePoint software.

Button Label	Button Description
Spartina a.	<i>Spartina alterniflora</i> (smooth cordgrass)
Juncus	<i>Juncus roemerianus</i> (black needle rush)
Distichlis	<i>Distichlis spicata</i> (saltgrass)
Salicornia b.	<i>Salicornia bigelovii</i> (dwarf saltwort)
Salicornia d.	<i>Salicornia depressa</i> (Virginia glasswort)
Sarcocornia	<i>Sarcocornia perennis</i> (chickenclaws)
Avicennia	<i>Avicennia germinans</i> (black mangrove)
Batis	<i>Batis maritima</i> (saltwort or turtleweed)
Zizania	<i>Zizania aquatica</i> (annual wild rice)
Borrichia	<i>Borrichia frutescens</i> (bushy seaside oxeye)
Phragmites	<i>Phragmites australis</i> (common reed)
Rhizophora	<i>Rhizophora mangle</i> (red mangrove)
Laguncularia	<i>Laguncularia racemosa</i> (white mangrove)
Spartina c.	<i>Spartina cynosuroides</i> (big cordgrass)
Bare	Bare soil
Water	Water
Detritus	Detritus or leaf litter
Debris	Debris, litter or other non-natural substance, such as paper.
Unknown	Unknown or unidentifiable.
Dead	Standing dead vegetation.

Additionally, species present in each plot are recorded, and the maximum canopy height of each dominant species is recorded. Maximum canopy height is determined by measuring with a flexible meter stick and averaging the tallest five individuals of each dominant species (Moore 2009, Curtis et al. 2013).

Additional Site-specific Vegetation Survey Methods

For sites located in higher (non-soft-bottomed) marshes (typical of those found in marshes where the USFWS SAIM monitoring will occur; see below), or where additional objectives are to be met, other methods of determining vegetation composition and structure might be more appropriate (such as Peet et al. 1998, Lee et al. 2008, Moore 2009). For example, within SAIM locations monitoring methods are similar to those used in other vegetation communities using nested plot designs. In such cases the standard sampling unit is a 10 × 10 m module or plot, and using this method, there are five different types of plot records. Level 5 plots (with nested subplots) are used to assess the number of species across multiple spatial scales (0.01 m² to 100 m²).

5. Data Handling Procedures

As part of developing a long-term monitoring program, the SECN conducted an information needs assessment that achieved the following goals within the context of previously developed monitoring priorities: (1) identified critical information needs of Network parks, the SECN Inventory and Monitoring Program, and for key partners; (2) developed a conceptual object model that, in combination with SECN monitoring protocols, will serve as the foundation for SECN database and application development; and (3) identified a suite of information products necessary to support park, programmatic and partner needs within the context of SECN long-term monitoring objectives.

The general data model for coastal wetland monitoring consists of metadata, field data, calibration data, and maintenance data. The data model used to support the SECN Coastal Salt Marsh Elevation and Vegetation Community Monitoring Protocol data is part of an SECN program-wide object model in use to guide the development of data management applications for all Network Vital Signs Monitoring efforts (Wright et al. 2008). Proper linking of multiple Vital Signs Monitoring data sets is critical for effective long-term monitoring and analysis of water quality, and will provide researchers and policy makers with information necessary for making decisions regarding the use and conservation of the park natural resources. Extensive documentation in the form of detailed user manuals (SOP 2.3.6; Wright and Thompson 2013) and database technical documentation (SOP 2.3.7; Wright and Thompson 2012) have been published for the Coastal Salt Marsh Elevation and Vegetation Community monitoring protocol.

Data Entry

Where manual data entry is required, data are entered by the SECN Coastal Ecologist or other designated personnel. Paper field forms are scanned and saved to SECN file server. Paper field forms are then archived by the Coastal Ecologist after data entry has been completed. After data have been entered, data verification and certification are completed by the Protocol Lead.

Quality Control of Data

After data are checked for correct entry, they have to be evaluated for the information they represent within the existing time series. This step relies on comparisons to prior data as well as attention to any additional notes taken in the field. If something occurred to damage or alter a position of the RSET or a specific marker horizon, this should have been noted. Some impacts may not be seen in the field, but only noticed after the data have been entered in the spreadsheet and compared. One has to be very careful in rejecting any data, as data not fitting the prior trend can actually represent a very important component of vertical dynamics at the particular plot (Callaway et al. 2014).

Incremental data are very useful in this process: it might be hard to evaluate a given pin height (RSET) or marker horizon depth, even in a series over time. Incremental data, however, make any big jump (or fall) in the data stand out. Incremental data is straightforward for RSET data, as individual pin heights are compared to their previous readings over time. For marker horizons, the data have to be averaged to the plot and then to the station. Because the same core was not sampled repeatedly over time, there will be additional variability due to different parts of the marked sediment surface being measured. Suspect data, including sediment disturbance by biota or other surface

features not corresponding to the representative sediment surface (e.g., a branch lying on the sediment surface) are generally flagged and excluded from subsequent analysis. After quality control, the original data (pin heights and marker depths) can be exported into a more traditional data frame for analyses (Callaway et al. 2014).

Data Verification

Data are verified during data entry in a process which involves checking the accuracy of computerized records against the original source, mainly paper field records. Data entry personnel (typically the Coastal Ecologist or Coastal Technician) will check 100% of the records with the original field forms. The primary goal of data entry verification is to determine where errors are being introduced. To the greatest extent possible, data entry errors are minimized through the use of automated methods within the InfoPath forms (e.g., range limits, pick lists, calendars etc.). After the computerized data are verified to accurately reflect the original field data, the paper forms are archived and the electronic version is used for all subsequent data activities.

Data Certification

Prior to data publication the Protocol Lead must certify that all data have been validated and meet quality standards. Manual data certification is also performed during the verification process described above. The Protocol Lead will certify the data after verification is complete. Certification procedures seek to identify generic errors (e.g., missing, mismatched, or duplicate records and comparison of QA/QC data with corresponding sample data).

Overview of Database Design

The conceptual object model, developed during the information needs assessment process, combined with SECN monitoring protocols, provide the starting point for database and application development. The conceptual object model has been expanded upon and refined and long-term monitoring protocols have been fully implemented over time (DataLOGIC Inc 2006).

Because one of the goals of the I&M Program is to provide scientific knowledge on which to base management decisions, it is incumbent upon the SECN to develop tools that allow managers to make decisions on the most recent data available from as many relevant sources as possible. This necessitates the development of a single, integrated data management system that (a) efficiently and cost-effectively allows for concurrent analysis of data from multiple Vital Signs (such as water quality and weather data), and (b) accommodates rapid retrieval of subsets of the Network's data to support hypothesis testing, modeling, reporting, and decision-making by managers and policymakers.

All work on the SECN data management system has been within the following programmatic guidelines:

- Database and application development are compatible with NPS standards/requirements, and built upon the SECN conceptual object model. To the greatest degree possible, the SECN conceptual object model has followed the NPS Inventory and Monitoring database standard - the Natural Resource Database Template (NRDT: <http://science.nps.gov/im/datamgmt/applications/template/index.cfm>). Even though

the NRDT standard was developed for MS Access, the majority of the standard can be—and has been—applied to the SECN database in SQL Server.

- Database and applications must support both spatial (e.g., GIS data) and non-spatial (tabular) data. Currently all spatial components of the data management system are housed in the database using the geographic data type and/or linked to web-based mapping in NPMMap (<http://insidemaps.nps.gov/secnviewer/secn>) or analyzed using ESRI ArcGIS software.
- SQL server serves as the primary database repository. The current SECN development tools are Microsoft Office InfoPath 2007, Microsoft Visual Studio 2010 and Microsoft SQL Server 2008.
- User-friendly, front end applications are available for users on the SECN SharePoint portal (NPS-only for approved users at <http://inpserosecn2/DataReports/default.aspx>).

As each network protocol is implemented, it is added to the SECN data management system—beginning with data entry components and then analysis and reporting functions (which typically grow over time). There are three primary data management documents developed to assist current and future users: the database user manual, the database technical documentation and the protocol reporting manual. The database user manual provides SECN and park staff instructions on the use of data entry applications (getting data into the database) while data analysis and reporting are covered in the reporting SOP. The database technical documentation provides the data dictionary and entity relationship diagram for the module pertaining to the protocol in question. The protocol reporting manual describes, in detail, how annual data summary reports are produced. The following SOPs are available for the SECN Coastal Salt Marsh Elevation and Vegetation Community Monitoring Protocol:

1. Salt Marsh Database User Manual (SOP 2.3.6; in development).
2. Salt Marsh Data Management and Database Technical Documentation in development).
3. Digital Photo Management (SOP 2.1.7; SECN 2013b).
4. Geospatial data archival and publication (SOP 2.1.8; SECN 2013a).
5. Data summary reporting guidelines (SOP 2.1.2; SECN 2012).

In addition to the standard reports available to NPS staff through the SECN data management system (<http://inpserosecn2/DataReports/default.aspx>), users may also utilize the SECN data exploration tool which allows users to build simple or complex queries of the SECN data from multiple Vital Signs for analysis or visualization in other software, or to create custom user-defined reports. Another tool available to users is the SECN metadata editor, which uses information gleaned directly from the SECN data management system to facilitate the rapid development of FGDC-compliant metadata to accompany data sets posted to the National Park Service's Integrated Resource Management Application (IRMA; <https://irma.nps.gov/App/>)—for both internal and external (non-NPS) use, as appropriate.

Metadata

A description of a particular data set, in a standardized format, ensures the proper use and utility of the data set. Although metadata development may be complex and time-consuming, the benefits for future data users are substantial. All data sets are accompanied by metadata documentation that includes the following components: data set identification information, data quality information, entity and attribute information, spatial reference information (if applicable), distribution information, and contact information. Complete metadata facilitate data longevity, help publicize the existence of all data sets produced, and facilitate access and use of data by others in the future.

Metadata attributes are incorporated into the database design, and are a required component of data entry and/or data uploading into the SECN information management system. By including metadata tools in the database design, there should be minimal additional effort required of project personnel to adequately and properly document data sets being collected and analyzed as part of the protocol for Monitoring Coastal Salt Marsh Elevation and Vegetation Communities.

Data Archiving

Static, milestone products are electronically archived by one or more of these methods: SECN website or other online archives, offline archives (e.g., archival quality CDs and DVDs) or in the SECN bibliographic database (reports) or photo database (images). Static products may include items such as annual data summary reports. Ongoing data sets will go through the protocol-specific QA/QC procedures and then be migrated into the SECN master (SQL server) database—including the standard archiving and backup procedures of the SECN data server. The SECN master database is write-protected so that users may access and copy records but cannot make inadvertent changes. Raw data will be archived on a local server at the Network's Athens headquarters.

All paper (hard copy) field forms will be stored in collections of field forms, immediately following data entry. Data entry of all field forms will produce an electronic copy of the field form which will also be archived (digitally) within the database—thus allowing future comparisons with the hard copy field form originals. Additionally, scanned color copies of the paper field data forms will be stored on a local server at the Network's Athens headquarters.

6. Reporting and Analysis

Annual Data Reports

Data reports will be published as short, concise reports that highlight the most recent data collection efforts as well as highlight any issues or areas of potential concern. Reports will summarize known conditions and/or major issues present in or near the park that may have influenced results, and will provide a brief outline of methods used to collect samples and process data. Citations for detailed methods documents will be provided as well as updated links to sources of digital data. All data reports will contain a bulleted list of significant findings as part of the executive summary section and will be published in conjunction with a two-page resource brief containing an abbreviated subset of significant findings along with some limited project information including broader programmatic overview of the sampling effort.

At a minimum, annual data reports will:

- Provide a summary history of the samples taken during each year of the study, tabulating numbers of samples for each sampling frame and showing these locations on maps of the parks.
- Provide summary status statistics of the results relative to management goals.
- Provide a summary table for use in park reporting and resource stewardship strategies.
- Evaluate data quality and identify any data quality concerns and/or deviations from the protocol that affect data quality and interpretation.

RSET Data Analysis

The data analysis selected for a RSET or marker horizon dataset is determined by the purpose and specific question(s) of the study. Analyses can be separated into two main groups:

- 1) The estimation of cumulative trends over the entire time series, or
- 2) The comparison of incremental change rates as a function of a time-dependent factor.

The first scenario is clearly applicable to a monitoring program, but it is also routinely used to support hypothesis testing. The second scenario is generally limited to hypotheses testing time-dependent factors such as seasonality, before/after impact, etc. Analyses for RSET and marker horizon data will first be presented separately, but they will also be brought together in a combined RSET-marker horizon analysis to test for the significance of shallow subsidence, which is the difference between surface accretion and elevation change over the depth of the RSET reference mark (Cahoon et al. 1995).

Individual pin data can be tracked over time: this is one of the main strengths of the RSET. Small scale vertical heterogeneity exists both within a RSET (among the positions) and within any particular position (among the pins). If one were to average the pin heights within a position—or worse, within a RSET—this variability could create enough “noise” to drown out the signal of

millimeter-scale trends occurring at any given pin. Therefore, at the heart of any RSET data analysis is the careful tracking of vertical change for each pin over time. Although marker horizon measurements come from the same marker surfaces through time, the likelihood that any particular sediment plug/core is measured twice over the time course of a study is quite low.

Therefore, there is no way to follow vertical change at the level at which the data are recorded. Furthermore, multiple readings are taken from each plug, and these are arbitrary (subject to the reader's ability to identify a "clean" marker trace). Marker horizon data are therefore expressed at the plot level, and it is the plot (marker horizon layer) which is followed through time.

Cumulative Trends

Cumulative RSET analysis. The best way to maximize the information content of RSET data is to conduct trend analysis at the individual pin level. The recommended technique is simple linear regression, as the desired output is a linear trend estimate (e.g., X mm/yr). Although regression theory assumes that a sample of independent observations is taken at each time period, it is practically impossible with RSET data, as correlation is expected among the nine pins within a position, or among the positions within a RSET. Furthermore, regressing over multiple pins loses the ability to follow the trajectory of each pin over time. The benefit of regressing over each pin is that the serial correlation induced by repeatedly re-measuring the same wetland surface is modeled by the regression: it is therefore explained, and not confounded within a larger analysis. In addition, this technique keeps the data in its original form; there is no need to introduce an additional step of computing incremental or cumulative change (although incremental change is computed in the quality control step).

Therefore, the procedures call for running simple linear regressions on raw pin measurements. The dataset required to run such an analysis in typical statistical software packages has the following format:

- Each pin observation on its own row.
- Separate columns identifying pin:
 - Sample site
 - Sample station (RSET reference mark)
 - RSET position
 - RSET pin
- Separate columns identifying sampling date and the decimal years since the first observation.
- Separate columns identifying any treatment factors and covariates.

If pin data are expressed in centimeters, an additional column may be used to convert to millimeters, so the regression slope will be in mm/yr. A sample R code can be used to compute the slope (linear trend) for each pin. The code also averages the slope across the nine pins within each position, and then across the four positions that are typically used around the RSET. The average linear trend for each RSET can then be averaged across a sample space designed for long-term monitoring, or can be used as the input data for subsequent analysis of variance models used to test specific hypotheses.

Cumulative accretion data. Accretion data as recorded from marker horizons comes in the form of cumulative thickness of deposits (e.g., millimeters)—so the data are already expressing cumulative change. For linear trend analysis, the main considerations are the level at which regressions are run. Because each marker horizon plot is itself repeatedly sampled, the regression has to be run at the marker horizon plot level (running a regression on the different marker plots would be confounding serial correlation). Therefore, prior to the analysis, the marker horizon data are averaged among the various replicate measurements per sediment core. If multiple cores have been taken at any measurement interval, these can serve as replicates within the regression. If a note has been made that the marker horizon layer is still visible at the sediment surface, then this can be treated as an observation, similar to a sediment core. Unfortunately, there is no way to account for missing marker horizon layers in the regression analysis. The end result of the analysis will be a set of slope estimates for the different marker horizon plots located within a sampling station (often there are three). These can be averaged to yield an estimated accretion trend for the sample station: this trend can then be averaged over the sample space in the case of a monitoring design, or can serve as the input data for an analysis of variance model testing a hypothesis.

Combining RSET and marker horizon data. A combined RSET-MH data analysis tests whether the two trends are equal. Due to the different levels at which serial correlation may exist in the different data sets (pins and marker horizon plots), it is not recommended to run regressions combining the two together. Instead, average elevation and accretion trends are computed separately—RSET trends are averaged to the RSET level, and accretion trends are expressed at the marker horizon plot level. Average values then serve as input into an analysis of variance model comparing the two data types.

Incremental Change Analysis. Incremental analyses are required when testing the effect of a time-dependent factor, specific years (e.g. El Niño vs. non-El Niño), pre- and post-impact, etc. A main concern with incremental data is the length of time over which each factor level occurs, and the consistency of these intervals over the course of the study. For example, if considering growing vs. dormant seasons, and the growing season is nine months long (dormant season only three months long), then the analysis will be heavily biased toward the growing season dynamics. A remedy for unequal time intervals is to compute linear rates of change for each time interval. If multiple observations are taken within each time period of interest (e.g., pre- and post-impact), then cumulative trend analysis is conducted for each time period. If only one observation is taken within each time period, then a simple rate of change is computed.

Incremental RSET data. Incremental RSET analysis is based on computing elevation change rates at the pin level. RSET data can be kept in its raw form (pin heights): if only one observation is taken within a time period of interest, a simple rate of change (expressed in mm/yr) is computed for each pin. If multiple observations are taken within the time period, then simple linear regression is used. The main difference is that rates are computed on different subsets of the entire time series. Change rates are averaged across the nine pins per position, and then across the different positions around the RSET reference mark. These rate estimates are then used as input data into an analysis of variance model testing for the time-dependent effect.

Incremental accretion data. Incremental accretion data is expressed as rates of change computed at the marker plot level. In other words, accretion data are averaged over the replicate observations taken on an individual sediment plug (core) taken within a given marker horizon plot. If multiple plugs are taken per sampling event, or multiple sampling events occur within a time period of interest, then simple linear regression can be used to estimate the accretion rate over the interval (similar to cumulative trends). If only one plug is taken, and only one sample event occurs within a time period of interest, then a simple rate calculation is made for each marker plot. These accretion rates, expressed at the marker plot level, are the input data in an analysis of variance model testing for the time-dependent effect.

Combining RSET and marker horizon data. Testing the different responses of accretion and elevation change to a time-dependent factor involves the same procedures as outlined above for determining incremental rates for accretion and elevation change. The input data set for the analysis of variance model contains the rate estimates for both RSETs and marker horizons (with separate rate estimates on each line), with an additional variable (a new column in the data sheet) identifying the source of the data (RSET vs. marker; Callaway et al. 2014).

Analysis of Other Data

To reduce the importance of dominant species or cover classes, the percent cover data can be coded according to the Braun-Blanquet cover scale (0, 1: <1–5%, 2: 6–25%, 3: 26–50%, 4: 51–75%, 5: 76–100%) (Kent and Coker 1992, Elzinga et al. 2001, Roman et al. 2001). Conversion to cover ranks is strongly suggested for similarity testing and ordination procedures.

Non-parametric permutation testing procedures can be effectively used to evaluate dissimilarity or similarity in vegetation communities between marshes or between sample years. ANOSIM, part of the PRIMER statistical package is just one example of a non-parametric test, similar to multivariate analysis of variance (MANOVA) but without the generally unattainable assumptions (Clark and Warwick 1994, Carr 1997). Non-parametric permutation similarity procedures use a similarity metric and we suggest using Euclidean Distance following the recommendations of Roman et al. (2001).

If additional data are collected, these data can be analyzed by analysis of variance to determine if there are differences in height between marshes (among HUCs within a park) or between years; salinity data, and sediment accretion data are best analyzed by analysis of variance (ANOVA) to detect differences among marshes, seasons, and years.

Synthesis Reports

In-depth synthesis reports may be completed through external contracts with universities or other agencies or by a collaborative effort of staff among key partners within the region. The SECN Program Manager will initiate discussion of the first regional synthesis report, and Program Managers from other programs will collaborate to secure funding, establish partnerships as needed with other agency staff, to produce the report, and provide programmatic oversight.

Analysis of Trends

To determine the extent to which conditions or measures are changing coastal salt marsh, synthesis reports will use specific and appropriate tests for trends at each site including the Mann-Kendall method, which is appropriate for a step-wise trend comparison of data collected on an annual or seasonal basis. The Mann-Kendall test computes Kendall's tau non-parametric correlation coefficient and its test of significance (Helsel and Hirsch 2002) for any pair of X,Y data. Various other methods may be used to detect trends and or progressive changes of conditions in the coastal marsh wetlands of SECN parks including methods that are optimized for parametric and non-parametric data sets.

Evaluating Changes in Marsh Condition

Where appropriate, data will be interpreted in the context of existing resource condition criteria as defined by appropriate regulatory agencies at the national, regional, and state level. In time and in cooperation with partners (other networks, agencies, and academic institutions), and with a robust dataset in place, an explicit assessment component of this protocol based upon reference conditions in coastal marsh wetlands will be developed. The Network will use findings to define park-based reference conditions (Stoddard et al. 2006) for biotic and abiotic response variables using data collected under this protocol, data collected from other Vital Signs Monitoring efforts, and related research. In small SECN parks, reference conditions might, in some cases, be derived from data collected across the adjacent landscape including those data collected at other SECN parks, or by cooperating agencies also implementing this protocol. After reference conditions are established, the Network can assess coastal wetland system integrity based on comparison of park estimates to reference conditions.

Most parks are currently developing one or more Natural Resource Condition Assessments, Resource Stewardship Strategies, or State of the Park reports. These various NPS planning and assessment

reports are science-based efforts and are specifically designed to help park staff maintain and improve the condition of fundamental resources as spelled out in General Management Plans or supporting Resource Management Plans, and in most cases include indicators of resource condition. In cases where these reports have been completed, measures from Vital Signs Monitoring are typically used as a subset of the indicators of resource condition, facilitating the use of Vital Signs Monitoring data when reporting on a park's progress toward attaining management goals. Summary condition assessment tables will be included in the periodic data summary reports, synthesis reports, or other reports as appropriate.

Landscape-Scale Integration and Analysis

A landscape-scale synthesis report will be produced in partnership with other agencies within the South Atlantic Landscape Conservation Cooperative five years after all plots have been installed and will summarize data at the regional scale, including changes in marsh extent at both the management unit (Park, Refuge, NERR) and regional scale. It will provide greater analytical and interpretive detail than the annual reports and will evaluate the relevance of findings to long-term management and restoration goals.

Protocol Review and Revision

Additional synthesis reports will evaluate operational aspects of the monitoring program, such as whether sample frame boundaries need to be changed or whether the sampling period remains appropriate (the optimal sampling season could conceivably change over time in response to climate change). The protocol review will also evaluate the design aspects of the monitoring protocol. For instance, does allocation of samples among parks appear to be adequate for all parks? Are there new management concerns that might dictate some reallocation of effort or additions to the indicator metrics that are routinely examined annually? Is the sampling time still appropriate?

Scientific Journal Articles and Conference Presentations

Other types of reports may be published by the SECN and will depend on resource management or monitoring issues and the nature of the target audience interested in the Network's monitoring effort. Publication of findings in scientific journals will allow the Network to reach a broader scientific community and promote investigation by members of the scientific community, either independently or in cooperation with the Network. Ultimately, publication in peer-reviewed publications and the collaboration that ensues will foster a greater understanding of coastal wetland conditions and processes in Network parks. Similarly, the presentation of findings or subsets of data at conferences will allow the Network to reach the broader scientific community even at smaller regional venues. Attendance and presentation of data at these conferences often fosters partnership efforts. All journal article and conference presentations developed by the SECN will be made available to parks whose data are included with the report or presentation.

Data Integration and Publication

As a part of the SECN's Climate Science Strategy, the Network is committed to facilitating the standardization of monitoring methods and data management among partners within the South Atlantic LCC and Atlantic coast geographies so that data can be rapidly found, merged, explored, and analyzed for the purposes of adaptation planning and conservation design. To that end, the SECN

data management system has been expanded for storage management of data from USFWS South Atlantic NWR units in addition to park units, and the Network is working with the Southeast Climate Science Center to make data available to USGS and LCC partners to incorporate SECN and SANRS data in climate change forecasting models.

Publication Standards

Annual reports will use the NPS Natural Resource Publications Natural Resource Data Series template, a pre-formatted Microsoft Word template document based on current NPS formatting standards. Periodic comprehensive reports and regional synthesis reports will use the Natural Resources Report template. Template guidelines and documentation of the NPS publication standards are available at the following address: <http://www.nature.nps.gov/publications/NRPM/>.

Current versions of the protocol, resource briefs, annual reports, comprehensive reports, and regional synthesis reports will be made available on the SECN website. The protocol and technical reports will also be available from the national IRMA portal (<https://irma.nps.gov>). All NPS protocols are available at (<https://irma.nps.gov/App/ProtocolTracking>).

7. Personnel Requirements and Training

Personnel and Qualifications

The staffing strategy currently in place by the SECN Coastal Ecology for salt marsh community monitoring relies primarily on Network staff to install, maintain, and collect data from the field, with the exception of the FOMA-GTMNERR study area where GTMNERR staff will conduct monitoring and data management tasks. Local partnerships may require customized arrangements and/or agreements that may vary from park to park and will require additional involvement by Network staff. Network staff will be fully responsible for all work elements related to salt marsh community monitoring, but will take advantage of opportunities in parks they may have an interest in becoming more involved.

Site installation and data collection can be labor intensive operations. Primary staff responsible for the implementation includes the Protocol Lead, which is responsible for supervising all protocol activities and ensuring that data, analyses, and reports meet guidelines and expectations as described in the protocol, and a Coastal Ecologist, who is responsible for all operational aspects of the implementation of the protocol. These personnel are supported by several field and data management personnel whose responsibilities span various portions of the workflow.

Protocol Lead: SECN Coastal Ecologist

The SECN Protocol Lead is responsible for technical and supervisory oversight of the implementation of the protocol, including the certification and analysis of data, revisions to SOPs as needed, and assisting Network, park and partner staff with the interpretation of findings and incorporation of results into park management. The incumbent must have the knowledge, skill, and ability to apply known theories, principles and concepts of coastal ecology sufficient to design and implement scientific studies; as well as the ability to statistically analyze data, synthesize information, write reports, and publish papers related to monitoring results. The incumbent is also responsible for ensuring the collection of high-quality data and interpretation of findings within the context of established assessment criteria, regulatory requirements, and management targets. The Protocol Lead will routinely be required to perform statistical tests and analysis, use geographic information systems and modeling procedures to analyze and synthesize data, and communicate and interact effectively with a wide variety of audiences, in both technical and non-technical language, for the presentation and preparation of complex letters, memoranda, reports, management plans, environmental assessments, briefings, and peer-reviewed scientific papers. The SECN Coastal Ecologist serves as the lead for all field operations including the collection of data and the management and maintenance of existing network of permanent coastal wetland monitoring stations to ensure consistent collection of scientifically credible data that meet programmatic standards as outlined in SOPs. The incumbent must have the knowledge and ability to use, maintain, and troubleshoot equipment in use by the Network, including all boats, vehicles, and monitoring equipment required for implementation of the protocol. The SECN Coastal Ecologist is responsible for providing technical support to NPS and external agency partners who are collaborating on protocol implementation, is the lead on analyzing photoplot imagery, is responsible for ensuring that data are entered checked for accuracy and completeness, and determining reasons for flagging or

excluding data from analyses based on experience with protocol implementation or based on field conditions while collecting data. The SECN Coastal Ecologist will be required to conduct analysis and synthesis of data, and communicate findings in presentations, reports, management plans, environmental assessments, briefings, and peer-reviewed scientific papers.

Coastal Technician

The principal duties of the Coastal Technician are to assist with annual station maintenance and data collection, processing and coding of vegetation photoplot imagery, perform routine data entry of elevation, soil chemistry, and vegetation data into SECN databases, perform basic quality reviews of data to ensure they are complete and within expected ranges, retrieve standardized analyses from the NPS data system and draft standardized data reports for senior staff. The incumbent should have some background working with the identification of plants sufficient to learn to identify species found in South Atlantic coast marsh ecosystems, as well as experience with data entry using databases. The Coastal Technician will also be responsible for routine maintenance of vehicles and boats required to implement the protocol.

SECN Data Manager

The SECN Data Manager is responsible for ensuring that the SECN data management meets NPS and federal information management standards, including but not limited to: security, data quality, data documentation, database structure, reporting and linkages to other NPS information management systems. The incumbent applies knowledge of programming, data management, database applications, GIS, Network priorities, and national I&M guidelines and directives, to plan, develop, and support application programs and systems to meet Network I&M needs. The incumbent synthesizes a wide range of data types including biological, physical, and bibliographical in both tabular and spatial formats to assure that metadata for these data sets is complete, current, and in compliance with FGDC standards. The incumbent also provides coordination and oversight for the population and maintenance of national information management systems (e.g., IRMA). Finally, the incumbent develops documentation for current and future users of the Network's information management system, in the form of user manuals and overall technical documentation (e.g., roles and responsibilities, work flows, data dictionaries and entity relationship diagrams).

Training

Every March, all personnel responsible for protocol implementation should review the entire protocol and associated SOPs. Refreshing plant identification skills is particularly important. The following list includes key points to consider in preparing for the upcoming field season. SOP 1.3.10 (Curtis 2013) outlines information to prepare for each field season, including a detailed list of field equipment needed, as well as the preferred training procedures for all vegetation monitoring crew members. Pre-season and during-season procedures are described that promote (a) the accurate identification of commonly-encountered plant species in both vegetative and flowering forms, and (b) consistent estimates of foliar cover. Details on standardizing plant identification for problematic plants and foliar cover estimates are also provided.

In addition to training to maintain technical competencies, the Coastal Ecologist and Coastal Technician are required to maintain their training certification for motorboat operation. This requires

completion of the DOI Motorboat Operator Certification Course and recertification every five years. This training is further defined in the SOP for safe boat operations (SOP 3.1.2; Asper and Curtis 2013d). Field staff should also receive safety training in accordance with NPS safety guidelines that includes obtaining active American Red Cross or equivalent first aid and CPR certification.

Additional annual training is further spelled out in the Seasonal Preparation and Training SOP (SOP 1.3.10; Curtis 2013).

Key Partnerships

US Fish and Wildlife Service Southeast Inventory & Monitoring Network

The Southeast Region Inventory & Monitoring Network is part of the National Wildlife Refuge System (NWRS) Inventory & Monitoring Initiative. The Network works closely with refuges and partners to address critical information needs and to help plan and evaluate the effectiveness of conservation strategies implemented by the U.S. Fish and Wildlife Service and conservation partners in the face of accelerating climate change and threats from other environmental stressors. Within the Southeast region, there are 129 National Wildlife Refuges, totaling roughly 4 million acres, spread across ten states. The SECN and SAIM (Curtis 2013) will be jointly housing and managing salt marsh elevation data collected under this protocol to allow for rapid integration and synthesis of trends at the landscape scale.

Guana Tolomato Matanzas National Estuarine Research Reserve

The hallmark of the NERR system is that each reserve's management efforts are in direct response to, and designed for unique local and regional issues. The purpose of this plan is to incorporate, evaluate, and prioritize all relevant information about the GTM Research Reserve into management strategies, allowing for compatible public access to the managed areas while sustaining the long-term quality of its ecosystems and cultural resources. Joint implementation of this protocol at locations within the GTMNERR and FOMA study area allows for coordination of monitoring efforts as well as integration of each program's monitoring and research missions.

Southeast Climate Science Center

The Southeast Climate Science Center is developing a metadata-level database to support the efforts of multiple federal, state, and other organizations in the development of a comprehensive and integrated assessment of monitoring programs associated with atmospheric, stream, and terrestrial ecosystems. Components of this effort will include compiling and mapping current sources of existing ecosystem quality and quantity data—including salt marsh elevation data—and assessing the available information from these sources. Results from this proposed work will provide the region's scientists and decision makers with accurate and comprehensive information about monitoring programs that can be used to assess the potential effects of climate change in the southeastern United States. The Southeast Coast Network is committed to making data collected under this protocol available to the SECSC in support of this and other projects.

8. Operational Requirements

Annual Workload

Field work for this protocol is conducted primarily in late spring and early summer to maximize vegetation sampling during peak leaf-out season, requiring close coordination among staff within the Network due to periods where tasks (and equipment use requirements) overlap (Figure 19). Major tasks include a period in March to perform station maintenance visits and collect surface elevation measurements, a May–June period when vegetation, accretion, and soil porewater monitoring will occur, and a period from July through November during which data are analyzed, checked for QA/QC, and reported.

The workload for the Coastal Ecologist will consist of tasks and subtasks related to collecting data, performing QA/QC of data, procuring equipment, and performing basic maintenance on monitoring platforms. Data entry tasks will be split between the Coastal Ecologist and the Coastal Technician.

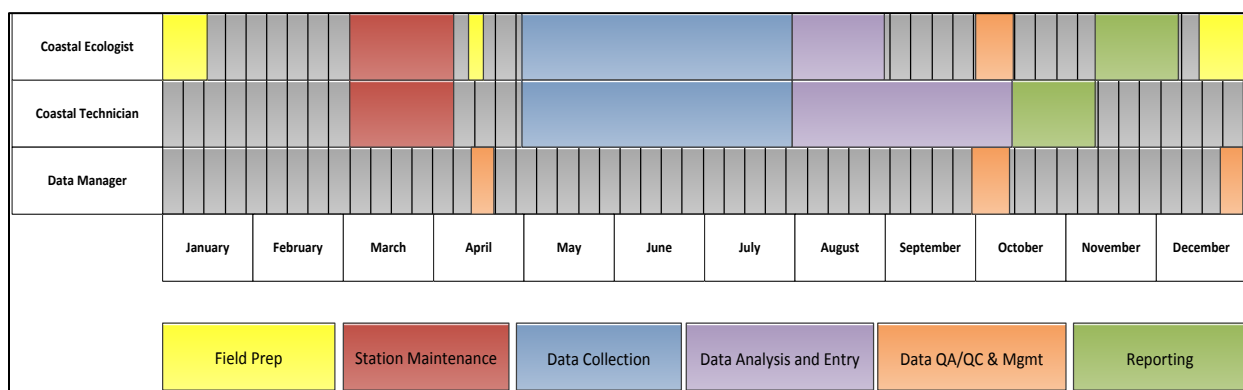


Figure 19. General staffing matrix for the Coastal Salt Marsh Elevation and Vegetation Community Monitoring protocol with approximate time periods required to complete major tasks associated with sampling events. Time periods for specific tasks associated with key personnel are outlined in color.

Permitting Requirements

Georgia: US Army Corps of Engineers (USACE) and GA Department of Natural Resources / Georgia Marshland Protection permits were required prior to installation of monitoring platforms and RSET benchmarks. A combined GA-DNR/USACE Permit was submitted for installation of stations at CUIS, FOFR, and FOPU on October 17, 2011, with approval being granted on February 10, 2012.

North Carolina: In addition to a USACE permit, North Carolina requires a unified Nationwide Permit Number 05 (NWP05), Scientific Measurement Devices and Coastal Area Management Act (CAMA) Minor Development Permit. Approval was granted to the NPS on May 1, 2013 for installation of platforms at CALO and CAHA.

Florida: Upon consultation with Florida Department of Environmental Protection, they determined that the planned installations were exempted from state permitting requirements; a NWP05 permit was issued by USACE for installations in FL parks on June 7, 2011 (See Appendix G).

National Park Service: No NPS permits are required for installation of stations as the action is covered under the Agency's programmatic categorical exclusion for installation of monitoring equipment. The Network will apply for annual park science permits as per park policies.

Facilities and Equipment

During installation and maintenance phases of work, field crews will need a boat capable of transporting lumber, tools, and personnel necessary to build monitoring platforms. During routine monitoring visits, lighter-duty watercraft may be used to transport personnel and monitoring equipment to and from the field site. Boats must be equipped with all requisite safety gear as well as GPS navigational tools to allow for rapid navigation to sampling locations. The SECN maintains two boats for use with salt marsh monitoring:

- One 18-foot aluminum-hull, flat-bottom boat with Honda 150 hp motor with a jet drive used for installation and data collection for marsh monitoring, and for collection of water and sediment water quality samples as a part of the Network's coastal assessment protocol.
- One 16-foot aluminum SeaArk Jon boat with Honda 50 hp motor with a jet drive used for collection of salt marsh elevation/vegetation data as well as stream habitat monitoring.

Transportation to and from parks requires a vehicle with towing capacity sufficient to carry the boat to be used as well as all field gear and building materials to be used. The SECN maintains several such vehicles in its fleet that are available for use during scheduled monitoring events.

Several pieces of equipment are required to conduct routine monitoring.

- RSET measurement apparatus (see SOP 1.3.6; Asper and Curtis 2013c).
- Cryogenic coring device for measurement of sediment accretion rates (see SOP 1.3.7; Asper and Curtis 2013b).
- Soil porewater measurement apparatus (see SOP 1.3.8; Curtis and DeVivo 2013).
- Camera frame and photographic equipment required for conducting photoplot monitoring (see SOP 1.3.9; Curtis et al. 2013).

Operation Costs

Operational costs include roughly one FTE split among four federal positions and a part-time intern with the SECN Coastal Technician being 50% dedicated to day-to-day protocol activities (Table 9). An additional \$7,750 in non-personnel costs related to equipment maintenance, station maintenance, and travel to and from monitoring locations is required.

Table 9. Estimated annual operating cost for implementation of the SECN Coastal Salt Marsh Elevation and Vegetation Community Monitoring Protocol (based on FY2015 dollars). Budget does not include support provided by parks or partners.

Category	Costs (FY 2015)	Notes
Personnel		
SECN Coastal Ecologist	37,626	0.40 FTE GS-11
SECN Coastal Technician	27,270	0.40 FTE GS-5
SECN Aquatic Technician	6,114	0.10 FTE GS-7
SECN Data Manager 1	9,102	0.10 FTE GS-12
Total Personnel Costs	\$80,112	
Salt Marsh Community Monitoring		
Platform Repairs	3,000	Replacement of three platforms per year
Equipment Maintenance	2,500	Replacement or procurement of additional salinity probes, photographic equipment, or RSET devices; routine filling of N ₂ tank
Boat Maintenance	1,500	Boat maintenance costs shared with other programs
Travel: FOFR and FOPU	1,715	FOMA-GTMNERR monitored by GTMNERR Staff
Travel: CANA and south TIMU	2,430	Park lodging provided at TIMU & CANA
Travel: CUIS, north TIMU	2,400	No GOV lodging available at FOFR and FOPU
Travel: CALO and CAHA	1,610	No GOV lodging on site during data collection
Total Non-personnel Costs	\$15,155	
Total Protocol Implementation Cost	\$95,267	

¹A portion of all personnel's time is devoted to data management activities including data entry, analysis, and QA/QC as indicated in Figure 19. This is in accordance with NPS I&M policies recommending that at least 30% of monitoring resources be allocated to data management.

Other Costs

It is anticipated that other costs will be required to fully meet all monitoring objectives over time, including implementation of a survey plan and potentially the installation of additional RSET monitoring stations at one or more parks. Costs associated with surveying will be determined as a part of the surveying plan; installation costs (assuming the work is performed via a third-party contractor) are estimated to be roughly \$7,500 per sampling location.

Safety

Implementation of this protocol has multiple complex risks. Staff will continuously evaluate all risks at the programmatic, personnel, and site level. Programmatic-level safety information is presented here and procedures to mitigate risks associated with specific activities related to protocol implementation (such as safe operations of watercraft, vehicle use and operation, injury reporting and accident reporting) are presented in Appendix C.

Job Hazard Analyses (JHA) were completed for all personnel who implement portions of the protocol in which risks and risk abatement strategies (including training needs) were identified. Risks and abatement strategies for all staff were synthesized to develop a protocol-level JHA. The protocol JHA was then used to perform a programmatic-level Green-Amber-Red (GAR) risk analysis to

assess whether implementation of this protocol could be accomplished within an acceptable level of risk (See Appendix C for details).

Specific safety concerns include:

- Crew members will spend many hours (and miles) driving to, between, and from sampling locations to conduct the requisite sampling.
- Crew members will be regularly working in park areas outside of communications range (either by park radio or by cell phone).
- During installation and maintenance phases of protocol implementation crews will be using power equipment such as jackhammers in remote areas in challenging environments (from platforms).
- During annual maintenance and data collection visits personnel are required to perform tasks that utilize repeated awkward body positioning, climbing, and precarious body position.

Injury or loss of life while in transit to and from field sites—as well as while in transit to or to perform data collection activities from watercraft—are the most significant risks encountered when conducting this activity.

Based on the JHA and associated risk abatement measures it was determined that this protocol can be safely implemented provided that SECN and partner staff implement it in accordance with the referenced SOPs and recommended risk abatement strategies (Asper and Curtis 2013d, Appendix C; Corbett and Smrekar 2013, Corbett et al. 2013, DeVivo and Corbett 2013, SECN 2013c). In addition to SOPs that have been developed to safely implement this protocol, specific training needs for all staff have been identified including certification in basic first aid and motor boat operation training. To increase the overall level of safety and awareness, obtaining additional levels of training beyond basic certifications will be encouraged.

Safety procedures will be routinely reviewed with Network staff and partners before field operations as prescribed in SOPs. Personnel-level JHAs for staff will be reviewed and revised annually as a part of the performance review cycle. Safety SOPs are reviewed at least annually and updated as necessary to ensure that they adequately mitigate risks to personnel, property, and the public.

In addition to protocol-specific safety procedures and guidelines, SECN staff will follow the general guidelines set forth in the NPS Occupational Safety and Health Program (Directors Order #50B, September 2008). These procedures are generally outlined below.

1. Adhere to established occupational safety and health procedures, including those contained within Reference Manual 50B.
2. Work collaboratively with supervisors to develop and use JHAs or equivalent for all routine tasks, and help develop and use site-specific safety plans for non-routine, complex, multi-phase jobs.

3. Properly use and maintain required clothing and/or personal protective equipment.
4. Maintain a level of personal wellness and fitness as needed for assigned work tasks.
5. Identify and, where appropriate, correct unsafe conditions and work practices.
6. Report unsafe/unhealthful conditions and/or operations to his or her immediate supervisor or the appropriate chain of command.
7. Report mishaps, including minor accidents and "near-hits," to a supervisor as soon as possible, but in no case later than the end of the work shift.
8. Participate in establishing a safe working culture, and practice safe work procedures, even when working alone.

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Wright, C. J., and E. Thompson. 2013. Southeast Coast Network salt marsh elevation monitoring database user manual. Standard Operating Procedure NPS/SECN/SOP-2.3.6. National Park Service, Athens, Georgia.

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Appendix A. Field Monitoring Cheat Sheet

Pre-Field Check List

- Print out the site sheet to take into the field
- Print field forms on rite in the rain paper
- Print the protocol and take into the field
- Check to make sure everything is in the RSET unit, RSET kit, and YSI pelican cases

RSET Sampling

- Determine the compass declination (<http://www.ngdc.noaa.gov/geomag-web/#declination>) and set the compass before going into the field.
- The same person will perform the RSET sampling – every time.
- All RSET work is performed from the platform. Do not walk within the RSET benchmark site.
- In the field, count the visible threads and hand tighten all bolts on the RSET arm.
- Insert and remove the fiberglass pins through the bottom of the RSET arm.
- Use the site sheet and compass to determine platform placement.
- Determine the compass bearing from the center of the RSET and out along the arm. Look for red arrows on the compass to ensure you are in fact facing the compass correctly.
- Remember—check the level, check the level, and check the level.
- It is best to take readings and record data starting from pin 1 and working to pin 9.
- When recording data, make sure to record the measurement in the correct column.
- Make notes about what the fiberglass pins is resting upon. This will help with data analysis as well as data interpretation.

Accretion Plot Sampling

- Use the site sheet to determine accretion plot locations.
- Take necessary PPE: gloves and eye protection.
- When taking sediment cores, make sure to capture the top layer of the surface - so leave at least ½ inch of the top of the flange/blade above the sediment surface.
- Zeroes mean the feldspar layer is visible on the surface with no measurable sediment on top of the feldspar layer NOT that you cannot see the feldspar layer within the sediment core.
- The same person will perform the accretion plot sampling—every time.

Porewater Sampling

- Calibrate the YSI unit and fill out the calibration sheet.
- Inspect the sipper tube holes for blockage and unclog as necessary.
- Make sure to rinse, with sample porewater or distilled water, the sipper tube and YSI probe before each measurement is taken.

- Record the temperature (°C), salinity (ppt), and specific conductance (SPC-uS/cm) onto the field form.
- Record surface water temperature, specific conductance, and salinity, if there is surface water on the marsh surface.

Appendix B. Standard Operating Procedures

To ensure consistent procedures Network-wide as Standard Operating Procedures (SOPs) are revised, updated, and re-published, the Southeast Coast Network maintains a single library of SOPs that are shared across all Network protocols and operations. All approved SOPs are published in the NPS Natural Resource Report series and the latest approved versions of operational SOPs are always available for download at the NPS Integrated Resource Management Applications portal at <http://irma.nps.gov>.

All SECN SOPs conform to a standard three-part numbering system to aid in the identification of the portion(s) of the program to which the procedures apply (Table B-1). Because SOPs are regularly updated, the SECN maintains the complete collection of the most recent and working versions of all SOPs in the SECN Operations Manual, housed on the SECN SharePoint at: <http://inpserosecn2/staff/Lists/Network%20Operations%20Manual/Tree.aspx>.

Table B-1. Numbering system and categories for Standard Operating Procedures (SOPs) used by the Southeast Coast Network. Within each category, SOPs are numbered sequentially as they are produced.

Level 1	Level 2	Topic
1	1.1.x	General field methods shared by multiple branches of the SECN. Typically those related to GIS, GPS location, photopoints, or use of shared instrumentation.
	1.2.x	Field methods for water resource monitoring.
	1.3.x	Field methods for coastal resource monitoring.
	1.4.x	Field methods for terrestrial resource monitoring (plants and animals).
2	2.1.x	Data management procedures shared by multiple branches of the SECN, such as those pertaining to reporting, file management.
	2.2.x	Data management procedures related to water resource monitoring.
	2.3.x	Data management procedures related to coastal resource monitoring.
	2.4.x	Data management procedures related to terrestrial resource monitoring (plants and animals).
3	3.1.x	Field Safety.
	3.2.x	Equipment use and maintenance.
4	4.1.x	Network administration.
5	5.1.x	User Manuals.

The following subset of the SECN's SOPs is included/ referenced in the implementation of the SECN Coastal Salt Marsh Elevation and Vegetation Community Monitoring Protocol (Table B-2). All SOPs are subject to modification in accordance with standard procedures documented in SECN-SOP 2.1.2 (SECN 2012).

Table B-2. Standard Operating Procedures required to implement SECN Coastal Salt Marsh Elevation and Vegetation Community Monitoring Protocol. Table lists SOPs by task category, SOP number, title and Integrated Resources Management Applications (IRMA) Record Numbers.

Subject	SOP#	Citation	IRMA Record Number
Monitoring	1.1.1	Byrne, M. W. 2013. Generating a spatially-balanced random sample with the RRQRR tool in ArcGIS 9.1 and ArcGIS 9.3.1 and applying selection criteria to select sampling locations, Version 2. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP-1.1.1. National Park Service, Athens, Georgia.	2215882
	1.1.7	Byrne, M. W. and B. A. Blankley. 2012. Sampling-grid creation, grid-cell surface analysis, and two-class image classification for Southeast Coast Network parks. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP-1.1.7. National Park Service, Athens, Georgia.	2188654
	1.2.1	Asper, J. R. 2013. Generating Spatially-Balanced Sampling Locations for Coastal Assessments Using ArcGIS 10. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP-1.2.1. National Park Service, Athens, Georgia.	2192645
	1.3.1	Asper, J. R. and A. C. Curtis. 2012. Salt Marsh Community Monitoring: Conducting Field Site Suitability Assessments. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP-1.3.1. National Park Service, Athens, Georgia.	2184392
	1.3.2	Asper, J. and T. Curtis. 2013. Salt marsh elevation and vegetation community monitoring site platform construction and installation. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP-1.3.2. National Park Service, Athens, Georgia.	2215884
	1.3.6	Asper, J. R. and A. C. Curtis. 2013. Salt Marsh Elevation Monitoring. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP-1.3.6. National Park Service, Athens, Georgia.	2215885
	1.3.7	Asper, J. R. and A. C. Curtis. 2013. Accretion and erosion measurement with a feldspar marker horizon. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP-1.3.7. National Park Service, Athens, Georgia.	2184804
	1.3.8	Curtis, A. C. and J. C. DeVivo. 2013. Soil Porewater Equipment Construction and data collection. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP-1.3.8. National Park Service, Athens, Georgia.	2215886
	1.3.9	Curtis, A. C., J. R. Asper, and S. Eastman. 2013. Photoplot-based monitoring of salt marsh vegetation. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP-1.3.9. National Park Service, Athens, Georgia.	2215899
	1.3.10	Curtis, A. C. 2013. Requirements for SECN salt marsh elevation and vegetation community monitoring: field season preparation, equipment, and training. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP-1.3.10. National Park Service, Athens, Georgia.	2215900
	1.3.19	Asper, J. R. and A. C. Curtis. 2012. Salt Marsh Community Rod-Surface Elevation Table (RSET) Installation. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP-1.3.19. National Park Service, Athens, Georgia.	2215901
Data Management	2.1.1	Southeast Coast Network (SECN). 2013. Revision of Southeast Coast Network protocols and Standard Operating Procedures. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP-2.1.1. National Park Service, Athens, Georgia.	2192669

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	2.3.6	Wright, C. J. and E. Thompson. 2013. Southeast Coast Network salt marsh elevation monitoring database user manual. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP-2.3.6. National Park Service, Athens, Georgia.	2215902
	2.3.7	Wright, C. J. and E. Thompson. 2012. Salt marsh elevation and vegetation community monitoring: data management and technical documentation. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP-2.3.7. National Park Service, Athens, Georgia.	2184275
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	3.1.3	Southeast Coast Network (SECN). 2013. Vehicle use and operation. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP-3.1.3. National Park Service, Athens, Georgia.	2192735
	3.1.4	Corbett, S. L. and B. Smrekar. 2013. Motor vehicle accident reporting procedures. Standard Operating Procedure NPS/SECN/SOP-3.1.4. National Park Service, Athens, Georgia.	2192736
	3.1.7	DeVivo, J. C., and S. L. Corbett. 2013. Communicating field operations with SECN Parks. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP-3.1.7. National Park Service, Athens, Georgia.	2192737

Appendix C. Job Hazards and Risk Assessment

This appendix describes application of the Green-Amber-Red (GAR) Risk Assessment Model as outlined in the NPS Operational Leadership Student Manual (Version 2; July 2011). This GAR was written by the SECN Program Manager (Joe DeVivo) on 21 May 2013 and approved by the NPS Southeast Region I&M program manager (Lisa Garrett) in 2014.

The GAR model allows for a general assessment of a task or operation and generates communication concerning the risks of an activity (in this case, conducting the field-based activities of this coastal salt marsh monitoring protocol. The most important part of the process is the team discussions prior to potentially hazardous activities or tasks that will lead to a better understanding of the risks and how they will be managed.

The GAR is a seven step process. Each step is defined and explained in the context of the sampling that will occur as part of this protocol.

Step 1: Define the Mission or Task

The SECN Coastal Salt Marsh Elevation and Vegetation Community Monitoring Protocol includes several field-based monitoring activities: construction, installation, and maintenance of monitoring platforms in coastal salt marshes, collection of data using a variety of equipment, and operation of motorized watercraft to sampling locations (and collection of samples from those locations).

Sampling at individual locations typically takes less than a day to complete, but transit times between study sites (located at different parks) can take as much as ten hours by vehicle. For shore-based monitoring, activities typically occur “solo,” whereas all boat-based sampling occurs in crews of two to three individuals. The activity is conducted regularly in eight coastal parks, with maintenance and monitoring efforts occurring seasonally to annually. Potential safety hazards (along with mitigation measures) have been identified in a protocol Job Hazard Analysis.

Of specific concern is that:

- Crew members will spend many hours (and miles) driving to, between, and from sampling locations to carry out the requisite sampling design.
- Crew members will be regularly working by boat in park areas outside of communications range (either by park radio or by cell phone).
- During installation and maintenance phases of protocol implementation crews will be using power equipment such as jackhammers in remote areas in challenging environments (from platforms).

Injury or loss of life while in transit by vehicle to and from field sites, as well as while in transit to or performance of data collection activities from watercraft are the most significant risks encountered when conducting this activity.

Step 2: Define the Threats

General field work threats and hazards as well as those that are specific for implementing this protocol are described within this JHA (Table C-1). Because of differences in the types, locations, and risks associated with different portions of the protocol, risks for the fixed-station and park-wide 5-year sampling events are assessed separately.

Table C-1. Tasks and mitigations to reduce threats and hazards associated with implementing the SECN Coastal Salt Marsh Elevation and Vegetation Community Monitoring Protocol.

Category	Mitigation Factors
Supervision	(Score 3). The SECN protocol for Monitoring SECN Salt Marsh Elevation and Vegetation Communities clearly identifies personnel, roles and responsibilities, and a chain of command. In cases where multiple people are present, the field crew lead has many tasks to accomplish in the implementation of the protocol, so is not always focusing solely on supervision. During implementation of this portion of the protocol, a qualified supervisor aware of all portions of the protocol is always present on site. While working on a boat, all personnel are under direct supervision of a trained boat operator. In some cases personnel are accompanied by staff member(s) from the park at which sampling occurs, or with other SECN staff, depending on the actions being implemented on site (sampling and/or maintenance). During field operations, the SECN Coastal Ecologist is the designated field crew lead responsible for all tasks related to protocol implementation including communications with park staff, logistics getting to and from the site, and implementation of data collection procedures. A portion of this work is performed by partner staff from parks or other agencies without the direct oversight and supervision of SECN staff. In such cases the SECN Coastal Ecologist is available for remote support, and partner staff are trained in the operation of equipment required to implement the protocol.
Planning	(Score 3–4). The SECN Coastal Salt Marsh Elevation and Vegetation Community Monitoring Protocol includes numerous SOPs that explain hiring, training, personal safety, emergency communication (equipment and contacts), and appropriate field activities (See Appendix B). Crew members are required to review these materials during training, and crew members are required to have first aid and CPR training. Due to this advanced planning, written documentation and training procedures lower scores were assigned. Although much time goes into planning for this type of work, the complexity of operations requires some last-minute changes and adjustments to schedules.
Communication	(Score 5). Routine and emergency communication equipment and procedures are explained in the relevant SOPs. This includes coordination with park natural resource managers, rangers, and dispatch as preferred by each park. It also includes procedures for daily crew check-out/check-in with the SECN Program Manager and Water Branch lead to ensure that a responsible party knows if someone has not returned from the field activity in a timely manner. Communication can be an issue especially at larger parks where larger distances may have to be covered between sites or boat ramps. Cell phone coverage is highly variable among parks where sampling occurs (and areas therein) and in some cases might not work or be reliable.
Contingency Resources	(Score 4–5). Contingency resources include communication equipment and procedures that explicitly involve park rangers, park dispatch, and 9-1-1. Crew members always have at least one mode of communication as outlined in SOP 3.1.7 (park

Table C-1. Continued.

Category	Mitigation Factors
	communications), though at some parks radios are not monitored and cell phone coverage is often unreliable. Notification of emergency services should happen within minutes of an incident, but there may be delays depending on where incidents occur. The scores for this protocol are higher than what is given to SECN terrestrial-based protocols because much of the work to be done for the coastal assessments is conducted on or near open water. Delays can be substantial in some areas at some parks especially if cell phone service is not available.
Team Selection	(Score 3–5). The monitoring protocol clearly identifies the essential skills and abilities required to execute this protocol in a competent manner. Prior experience is required for most team members. All team members should have basic first aid and CPR skills as well as an ability to swim. Although some of these skills can be worked on during crew training, there is no substitute for experience. The availability of park or SECN staff with local knowledge of water bodies is variable from park to park (and among sampling events); presence of a dedicated boat captain with local expertise greatly reduces risks related to boating.
Team Fitness	(Score 2–4) Team selection should ensure an overall high level of initial team fitness. Crew members are in the field for approximately eight hours per day (not including transit times to and from sites). Sampling always occurs during daylight hours. A score of 2–4 was assigned because the work is not overly strenuous, but can be variable depending on the tasks being conducted on site. Crew members must be diligent about adequate rest and nourishment to ensure that fatigue does not become a safety factor.
Environment	(Score 6–8). Protocol implementation includes inherent environmental dangers associated with field work and transit to field sites. Activities occur during spring and summer months, which exposes crews to a variety of weather conditions, including extreme heat and strong localized storm cells, including exposure to lightning strikes. Additionally, transit times to, from, and between sites can be up to an hour, which (in addition to data collection) can result in work days exceeding 10 hours and return trips by vehicle at the end of long days in the field. A portion of this work is conducted in open water by boat, where limited cover is available if crews are not aware of dynamic weather conditions. Working on open water is an inherently riskier environment.
Event Complexity	(Score 5). Daily field conditions change due to unpredictable weather. Individual crew members must use judgment and experience to respond appropriately. Work requires operation of multiple vehicles, trailers, and boats including towing, backing, launching, and docking, as well as specialized equipment including RSET measurement devices and a liquid nitrogen soil accretion sampling device.

Step 3: Assess Risk and Assign a Numerical Value

Initial risk-level scores were assigned to all protocol elements following the process as described in the NPS Operational Leadership Student Manual (Table C-1, C-2). Scores were initially assigned by Joe DeVivo, the SECN Program Manager with input from SECN and park staff. Final numbers are presented below with concurrence from Brian Gregory, Protocol Lead (Table C-3). It should be noted that at the time final numerical values were assigned (May 22, 2013) the protocol had been in development for several years and considerable time and effort had already gone into evaluating and mitigating risks. Additionally, because of the variability in sites among parks, many element scores are presented as ranges. To compute the total level of risk for the activity, assign a risk code of 0 (For No Risk) through 10 (For Maximum Risk) to each of the eight elements below and then total the risk codes. This is the Total Risk Score and is your personal estimate of the risk. Total Risk Score (Green, Amber, or Red) is based on the GAR Evaluation Scale (Table C-4).

Table C-2. Activity elements and descriptions of major tasks associated with the implementation of SECN Coastal Salt Marsh Elevation and Vegetation Community Monitoring Protocol.

Activity Element	Element Description
Supervision	Supervisory Control considers if supervision is present, how qualified the supervisor is, and whether effective supervision is taking place. Even if a person is qualified to perform a task, supervision acts as a control to minimize risk. This may simply be someone checking what is being done to ensure it is being done correctly. The higher the risk, the more the supervisor needs to be focused on observing and checking. A supervisor who is actively involved in a task (doing something) is easily distracted and should not be considered an effective safety observer in moderate to high-risk conditions.
Planning	Planning and preparation should consider how much information you have, how clear it is, and how much time you have to plan the evolution or evaluate the situation, and the presence of Standard Operating Procedures or pre-plans.
Communication	Communication should include physical (dispatch present, effective repeaters) communication and an assessment of personal communication among team members (assertiveness, climate that values input, high degree of accountability) and the presence of briefs and debriefs.
Contingency Resources	Contingency resources refer to readily available trained assets, and whether there is an established agreement and SOP with the cooperating agency (i.e., local law enforcement agencies, fire departments, ambulance, military units, etc.).
Team Selection	Team selection should consider the qualifications and experience level of the individuals used for the specific event/evolution/incident. Individuals may need to be replaced during the incident. The same concerns apply to the reliefs.
Team Fitness	Team fitness should consider the physical and mental state of the team. This is a function of the amount and quality of rest a team member has had. Quality of rest should consider potential sleep length and any interruptions. Fatigue normally becomes a factor after 18 hours without rest; however, lack of quality sleep builds a deficit and worsens the effects of fatigue.
Environment	Environment should consider factors affecting personnel performance and factors affecting equipment. This includes, but is not limited to, time of day, temperature, humidity, precipitation, wind, terrain, and elevation.
Event or Evolution Complexity	Event/Evolution complexity should consider both the required time and the situation. Generally, the longer one is exposed to a hazard, the greater are the risks. However, each circumstance is unique. For example, more iterations of an evolution can increase the opportunity for a loss to occur, but may have the positive effect of improving the proficiency of the team, thus possibly decreasing the chance of error. This would depend upon the experience level of the team. The situation includes considering how long the environmental conditions will remain stable and the complexity of the work.

Table C-3. Assigned risk codes of for each of the eight elements of the SECN Coastal Salt Marsh Elevation and Vegetation Community Monitoring Protocol. Zero indicates no known risk and 10 indicates maximum level of risk, or a highly dangerous task.

Category	Risk Code Score
Supervision	3
Planning	3–4
Communication	5
Contingency Resources	4–5
Team Selection	3–5
Team Fitness	2–4
Environment	6–8
Event/Evolution Complexity	5
Total Risk Score	31–39

Table C-4. GAR Evaluation Scale for color coding the level of risk. The activity risk can be visualized using the colors of a traffic light. If the total risk value falls in the GREEN ZONE (1–35), risk is rated as low. If the total risk value falls in the AMBER ZONE (36–60), risk is moderate and you should consider adopting procedures to minimize the risk. If the total value falls in the RED ZONE (61–80), you should implement measures to reduce the risk prior to starting the event or evolution.

1–35	36–60	61–80
GREEN (Low Risk)	AMBER (Caution)	RED (High Risk)

Step 4: Identify Risk Control Options

A protocol JHA was performed by the SECN Collateral Duty Safety Officer (Sarah Corbett) and abatement actions and requisite training needs were identified to mitigate hazards associated with implementation of this protocol (Tables C-4, C-5).

Table C-5. Job Hazard Analysis (JHA) for safe implementation of the SECN Coastal Salt Marsh Elevation and Vegetation Community Monitoring Protocol, including potential hazards and recommended abatement actions.

TASK/PROCEDURES	HAZARDS	ABATEMENT ACTION
FIELD WORK	General Field Safety/ Training.	• Complete an annual (American Red Cross) or biannual (American Heart Association) First Aid and CPR training course. • Always carry standard PPE, which includes a first aid kit, compass, safety whistle, hydration bladder/water bottles.
	Tick Bites (Lyme Disease, Rocky Mountain Spotted Fever)	• Spray clothing with insect repellent such as Permethrin, as a barrier. • Wear light colored clothing that fits tightly at the wrists, ankles, and waist. • Each outer garment should overlap the one above it. • Cover trouser legs with high socks, boots, or nylon gaiters OR duct tape pant legs to shoes. • Tuck in shirt tails. • Search the body on a regular basis, especially hair and clothing; ticks generally do not attach for a couple of hours. Run your fingers across your skull feeling for any atypical bumps. • If a tick becomes attached, use tweezers to grasp the tick as close as possible to the point of attachment and pull straight out with gentle pressure. If tweezers are not available, use fingernails or pliers. Wash skin with soap and water then cleanse with rubbing alcohol. Place the tick in an empty container for later identification, if the victim should have a reaction. Record dates of exposure and removal. • Do not try to remove the tick by burning with a match or covering it with chemical agents. • If you cannot remove the tick, or the head detaches, seek prompt medical help. • If you are bitten by a tick, first document it on a calendar or injury log, then watch for warning signs of illness: a large red spot on the bite area; fever, chills, headache, joint and muscle ache, significant fatigue, and facial paralysis are reactions that may appear within two weeks of the bite. Symptoms specific to Lyme disease include: confusion, short-term memory loss, and disorientation. • Review the CDC documents relating to tick-borne diseases at http://www.cdc.gov/ticks/diseases.
	Tetanus	• Insure tetanus booster is up-to-date. • Wear all-leather-upper protective footwear.
	Allergic reactions, insect stings	• If a bite/sting victim develops hives, asthmatic breathing, tissue swelling, or a drop in blood pressure, seek medical help immediately. • Be alert to insect hives in brush or in hollow logs. Watch for insects traveling in and out of one location. • If you or anyone you are working with is known to have allergic reactions to bee, wasp, hornet, yellow jacket, or other insect stings, tell the rest of the crew and your supervisor. Make sure you carry emergency medication (Epipen, etc.) with you at all times, AND know how to administer that medication.

Table C-5. Continued.

TASK/PROCEDURES	HAZARDS	ABATEMENT ACTION
FIELD WORK (cont.)		• Wear long sleeve shirts and trousers; tuck in shirt. Bright colors and metal objects may attract bees. • If you are stung, cold compresses may bring relief. Also, it is advisable to take Benadryl immediately if multiple stings are received. • If a stinger is left behind, scrape it off the skin. Do not use tweezers as this squeezes the venom sack, worsening the injury. • Minimize exposure to plants that cause contact dermatitis (poison ivy, Brazilian peppertree, poison sumac, etc.), EVEN if you do not typically react to them (immunity breaks down with continued exposure). If you are known to have severe reactions, wear ivy block before exposure, and use neutralizing soaps (Technu, etc.) if exposure occurs. Wear long sleeves, long pants, and gloves if working in dense areas with dermatitis-inducing plant species.
	Mosquito Bites - Skin irritation, encephalitis.	• Wear long sleeves and trousers. • Avoid heavy scents, such as strong soap, lotion, or perfume. • Use insect repellents. If using Permethrin, do not apply directly to skin, apply to clothing only. • Carry after-bite medication to reduce skin irritation.
	Dehydration	• Drink at least 1/2 qt. of water every hour. • Limit caffeine intake, as caffeine dehydrates you. • Carry sufficient amounts of water. • Avoid long exposure to sun. • Wear hat with wide brim for shade. • Use electrolyte supplements or drink sports drinks (e.g., Gatorade).
	Uneven terrain Tripping over rocks	• Wear all leather-upper, lace up, 6" minimum high boots with nonskid rubber soles. • Test and use secure footing. Walk, never run, down slopes. • Maintain a safe walking distance between people. • In heavy undergrowth, lift knees high to clear obstacles. Know how to fall. Try to land in the least obstructed spot. Protect your head and back. Roll with the fall. Do not stick out your arms to break a fall. • Use the entire sole of your boots to increase traction and also reduce the fatigue associated with walking on the toes.
	Solar Ultraviolet Radiation.	• Keep exposed skin covered by wearing a hat, a bandanna, and a long sleeved shirt. • Use protective sunscreen lotion.
	Venomous Snakes	• Wear high top boots and snake gaiters or chaps. When going through thick underbrush, be alert. Walk slowly and give snakes ample time to move out of the way. Walk on clear paths as much as possible. Be careful where placing feet and hands at all times.

Table C-5. Continued.

TASK/PROCEDURES	HAZARDS	ABATEMENT ACTION
FIELD WORK (cont.)	Working in Isolated Areas	• Use the buddy system and carry a cellular phone or NPS park radio. Always be alert. Never work alone or leave partner alone. Exceptions may apply to the coastal ecology program when an individual may be required to work alone, but will always have access to communications (VHF radio, park radio, etc.) However, when possible, it is strongly advised to work in pairs.
	Hunting Season	• Wear bright colored clothing, hat or orange vests during hunting season. Observe the area for possible hunters.
	Heat Stress	• Take appropriate breaks. • Maintain proper hydration and electrolyte consumption. • Slow pace or reduce field hours if heat index is high (over 95 degrees Fahrenheit).
	Cold Stress/Hypothermia	• Wear layered clothing, gloves, hard hat with winter liner, etc. • During cold weather - layer clothing and wear wind impervious outerwear; during warm months – wear a long sleeve cotton shirt.
	Fatigue	• Know the limits of your own body (e.g., tolerance to heat, cold, allergies, strength, endurance, etc.), pursue physical conditioning prior to the field season if necessary, and do not over-exert yourself. • Use proper mechanics when bending over or lifting objects (i.e., lift with your knees, bend knees when bending over). Tighten stomach muscles when standing for long periods of time to support the lower back. • When hiking up / down hills, avoid walking on your toes as this cause muscle fatigue rapidly. Using the entire sole of your foot uses the large muscles of your legs thus avoiding leg-muscle fatigue.
	Weather	• Know the weather forecast prior to going into the field. • Enable weather alerts on GPS units or portable radio. • If a tornado approaches and you are caught in the field, take shelter in low area, lie flat on belly and cover head. • There is no safe place outdoors in a lightning storm, but if lightning approaches and you are caught in the field, avoid: standing water if possible, isolated trees, picnic tables, pavilions, flagpoles, metal objects, and fences. Seek shelter under a large grove of trees (preferably shorter than those around it), squat close to ground, keep feet together, tuck head down, close eyes and cover ears, stay 50 feet apart from other people, and remove metal objects from your person. • When conducting boat operations, refer also to the SECN Boat Operation SOP.
	Flash Floods	• DO NOT TRY TO WALK, DRIVE, OR OTHERWISE CROSS FLOODWATERS. Keep in mind that floodwaters are swift moving, even if they do not appear to be on the surface. It is possible to drown in just a few inches of water if swept away by floodwaters. • Especially important when working in stream and river areas, workers should be aware of the possibility of flash floods. When working in stream and river environments, at least one team member should watch nightly weather reports, or monitor weather band radio, to assess if

Table C-5. Continued.

TASK/PROCEDURES	HAZARDS	ABATEMENT ACTION
FIELD WORK (cont.)		weather conditions for flash floods may exist. • If caught in a flash flood while in a boat, point the boat downstream and continue with the flow until it is safe to pull to the bank. • If caught in a flash flood while in an automobile, abandon the vehicle immediately and move to higher ground. If the vehicle is submerged, do not panic, allow the vehicle to fill with water, and open the doors when the vehicle is full (doors will not open until the water pressure is equal outside and in). Opening windows will expedite the process. Hold your breath, and swim for the surface and toward the bank if possible. • If caught in a flash flood while on foot, immediately move to higher ground.
	Overwater work sites (docks).	• Use elevated caution level when working on docks. • Keep workspace neat/organized to reduce possible trip hazards. • Wear a personal floatation device when task requires leaning over or reaching over guardrail.
	Usage of Liquid Nitrogen for Salt Marsh Monitoring	• Liquid Nitrogen is -320oF; so, it can easily freeze skin causing severe damage. This means that care should be taken to not allow contact with the skin. Eye protection, gloves, and long sleeves and pants should be worn when handling the substance. • Liquid Nitrogen expands by a factor of 700 when it warms and becomes gas. As such, all storage containers must be vented properly. • Never block or plug the release valves. This will cause a buildup of pressure in the container, which can cause explosions. • When transporting containers, they should be stored upright and only in containers designed to hold liquid Nitrogen.
	Usage of Powered Equipment for Salt Marsh Monitoring (Jackhammer, Generator, Power tools, etc.)	• Care will be taken when using power tools in the marsh. Use of power tools must be in accordance with all safety recommendations of the manufacturer. When appropriate, the safety guidelines for tool usage from the user manual will be reviewed prior to tool use. • Gloves, safety glasses, and over the ear hearing protection shall be used at all times. • When operating heavy equipment, such as the jackhammer, at least two people must be present. • Before operating a tool on the platforms, ensure that each operator has a secure, stable footing, and has the ability to lift 60 pounds over their head. • Fueling of the generator shall occur in a well ventilated area, and not such that overflow will flow into water or wetlands. • Electricity and water are a dangerous combination. Use extreme caution when operating power equipment around water.

Table C-5. Continued.

TASK/PROCEDURES	HAZARDS	ABATEMENT ACTION
SHOP/WAREHOUSE ACTIVITIES	Power Tool Usage	• Care will be taken when using power tools in the shop/warehouse area. Use of power tools must be in accordance with all safety recommendations of the manufacturer. When appropriate, the safety guidelines for tool usage from the user manual will be reviewed prior to tool use. • Appropriate protective equipment will be worn at all times, including safety glasses or goggles, air filtration masks (when dealing with materials that produce sawdust or fine particulate matter), ear protection (when dealing with loud tools), work gloves, and closed-toe shoes. • Long sleeves and long pants will be worn if any tool emits flames or sparks.
	Hand Tool Use	• Always take care to use hand tools for the purpose for which they are intended (use the "right tool for the job"). • Wear protective eyewear and clothing while using hand tools if there is any chance of flying debris.
VEHICLE OPERATION	Type of Vehicle, Training	• Select appropriate vehicle for work needs and location. • Familiarize yourself with the vehicle and know where the controls are located. • Make the "circle of safety" check of vehicle condition. • Review maps and plan route prior to beginning your trip. • Report any accident (gov, leased or pov), regardless of extent. Complete forms SF-91 and SF-94 immediately if involved in an accident. Copies of these forms should ALWAYS be present in the vehicle. If you are using a POV for government travel, obtain copies of the forms before departure. • Obey speed limit, drive defensively. • Obtain general safety training from a qualified operator before hauling trailers behind any vehicle. • Be conscientious of other drivers (e.g., the left lane is the passing lane and not a cruising lane, pass then get over; do not park too closely to other vehicles). • Always keep your eyes on the road, do not eat and drive, and do not talk on phone and drive. • When possible, take a defensive driving course.
	Vehicle Fires	• All vehicles must be equipped with a working fire extinguisher (the extinguisher should be appropriate for the use, class type, in date and fully charged.). • Never park a warm engine vehicle in tall grass. Avoid engine fuel spills. • Be alert of fire conditions. Do not enter uncontrolled burning areas with a vehicle. Minimize flammables in and near vehicle and work area. • If a vehicle is on fire and the fire cannot be suppressed with an extinguisher, MOVE AWAY FROM THE VEHICLE. Under no circumstances should you re-enter the vehicle to remove belongings or equipment when a vehicle is burning.
	Vehicle Security/Visibility	• Always lock vehicle, do not leave valuables in vehicle, and cover or otherwise keep from view any equipment left in vehicle. • Conduct a full walk-around of vehicle and place orange

Table C-5. Continued.

TASK/PROCEDURES	HAZARDS	ABATEMENT ACTION
VEHICLE OPERATION (cont.)		marker cones behind and/or in front of the vehicle to increase visibility if leaving the vehicle in a generally unsecure area (on a roadside or narrow road shoulder, in a road median, or in an otherwise high-traffic area).
	Vehicle Maintenance	• Check oil and all fluids during every refueling. Document. • Perform vehicle inspection for obvious items such as tire inflation, windshield wipers, and sufficient fuel to get to destination. • Observe federal guidelines for use of a federal vehicle: make certain procedures regarding accidents, injuries, vehicular break downs or roadside emergencies are available in vehicle (Forms SF-91 and SF-94). • Replace windshield wipers annually, and replace tires when they exceed wear.
	Weather Conditions	• Changes in climatic conditions require adjusting to different weather situations. • When using windshield wipers during rain, turn on headlights. • Do not drive in adverse weather conditions if the trip can be delayed. • Avoid being rushed; you will need more time to prepare the vehicle and get to your destination. • Remove all frost and snow prior to starting your trip. Make sure vents are clear of snow to provide adequate airflow for defrosting.
	Off Highway Driving/Driving in Mud and Soft Sand	• Check with local unit as necessary prior to driving on back roads, for items such as construction, washouts, blowdowns and closures. • Obey all posted travel signs. • Proceed slowly around corners and drive on the right side. • Use four wheel drive in appropriate situations. • Always put vehicle in 4WD long before you think you might need it; if you begin to get stuck it is too late for the 4WD to engage. • Do not cause extensive damage to unpaved roads by driving on them when too saturated. • Avoid driving in ruts because the vehicle is susceptible to bottoming out. • Get out of the vehicle to investigate all puddles to determine depth and if the bottom of the puddle is hard enough to support a vehicle. Walk through the puddle if necessary. • Drive SLOWLY through puddles, as driving fast can flood the engine, and/or cause the vehicle to slide laterally. It may also cause more erosion and damage in the road. • Turn around in areas only where enough space on solid ground is available, have passengers get out to help direct, take your time.
	Towing	• Do not exceed recommended towing weight of tow or tow vehicle. • Be aware that states may have speed limits when towing that are not published on speed limit signage. • Insure tow vehicle has proper mirrors installed to view

Table C-5. Continued.

TASK/PROCEDURES	HAZARDS	ABATEMENT ACTION
VEHICLE OPERATION (cont.)		trailer appropriately. • Load trailer per manufacturer's guidance. • Use a hitch lock or safety pin at all times when towing. • Organize load logically so trailer can be hitched and unhitched easily (i.e., not too much weight in the front of the trailer). • Insure all trailer lights and brakes are operational before driving. • Insure safety chains are installed correctly, crossed under the trailer and connected to the tow vehicle. • Check tire pressure, spare tire, and jack. • Maintain bearing grease, checking regularly. • Practice driving vehicle with trailer attached in a safe area until a comfort level is obtained. • Be careful when towing in strong cross winds. • All SECN Employees who will tow a boat or cargo trailer must read and understand the brochure "Towing a Trailer: Being Equipped for Safety" available from the U.S. Department of Transportation website at: www.nhtsa.gov/cars/problems/equipment/towing/index.htm
WATERCRAFT OPERATION	Watercraft Safety and Training	• All SECN employees operating or riding in a watercraft MUST read and understand the SECN Boat Operation Standard Operating Procedure (SOP). This document provides more comprehensive guidance than that provided here. • All SECN employees who operate a motorized vessel must complete the USDI Motorboat Operators Certification Course. Complete an 8 hour refresher course every 5 years. • All DOI employees must wear approved life vests while underway. • Carry cell phone and vhf radio. • File a float plan and work in pairs when possible. • Do not exceed the rated capacity of the vessel (includes personnel and cargo). • It is advisable that all personnel know how to swim OR know what to do if thrown overboard. Life vests MUST be worn. • All new employees will complete a safety orientation with the boat operator or the SECN safety officer prior to getting underway.
	Vessel Maintenance	• Perform vessel inspection for obvious items such seaworthiness of craft, assure oil levels are good, and assure motor is in working order. Maintain vessel and proper safety equipment. Look for any damage to the hull. • For non-motorized vessels, ensure craft is in good condition. Before the start of the field season, fill the craft with water while on land and watch for leaks. Repair leaks immediately.
	Onboard Safety Equipment	• All motorized vessels shall carry U.S. Coast Guard (USCG) and state required safety equipment, including USCG approved life jackets, throwable device, fire extinguisher, working marine radio, sufficient chain/rope and proper anchor, oar/paddle, flares and signaling device, approved navigation lights, and tool kit.

Table C-5. Continued.

TASK/PROCEDURES	HAZARDS	ABATEMENT ACTION
WATERCRAFT OPERATION (cont.)	Weather Conditions	• Changes in climatic conditions require adjusting to different weather situations. • Do not operate vessels in adverse weather conditions if the trip can be delayed. • Avoid traveling in high winds or rough water. • Avoid being rushed; you will need more time to prepare the vehicle and get to your destination.
	Overturned/Capsized Vessels	• To avoid the likelihood of capsizing, keep a lookout facing the direction of movement of the vessel (motorized vessels), and take extreme care when navigating in areas with shallowly submerged objects or sandbars by moving slowly and avoiding sudden port or starboard movements (motorized and non-motorized vessels). • In the event that a motorized or non-motorized vessel overturns or capsized, first account for the location of all passengers and ensure that they are wearing life vests. If not wearing a vest, get one to them as soon as possible. • If a vessel does capsize, assess whether or not you can safely upright it. If so, upright the craft and bail all water out of it before reentering the craft. • If a vessel is unable to be righted, for non-motorized vessels including rowboats, canoes, and kayaks, drag the vessel to the shore if you can and upright it there. This is not advisable with motorized craft, generally due to their size and weight and the additional danger and effort of recovering a beached craft. For motorized vessels, it is advised to remain with the vessel and signal for help (flare, whistle, cell phone, radio if operable).
OFFICE WORK	Computer Use Fatigue	• Take appropriate breaks. • Perform other job duties. • Trade appropriate and assigned duties with coworker. • Apply work/rest ratio guidelines.
	Computer Use Eye Strain	• Take appropriate breaks. • Perform other job duties for a time. • Use a non-glare screen or an anti-glare device on screens. • Trade appropriate and assigned duties with coworker. • Individuals requiring prescription eye wear should ensure proper focal distance is achieved without having to tilt the head. • Adjust screen refresh rate as needed to eliminate screen flicker.
	Carpal Tunnel Syndrome	• Take appropriate breaks. • Use wrist exercises. • Stretch hands. • Ensure proper keyboard position. • Adjust chair height so that forearms are parallel to the work surface.
	Physical Stress	• Take appropriate breaks. • Ensure proper keyboard, chair, and computer monitor positions.

Table C-5. Continued.

TASK/PROCEDURES	HAZARDS	ABATEMENT ACTION
OFFICE WORK (cont.)	Electrical Cords and Electrical Hazards	• Do not overload outlets. • Use surge protection for computer equipment. • Keep cords organized and out of walkways. • Never use personal space heaters in government buildings unless approved by facility maintenance supervisor.
	Indoor Supplies and Activities	• Keep area clean and organized. • Use step ladder for out-of-reach supplies. NEVER use a chair as a step ladder. • Use proper containers and storage for supplies. • Follow MSDS rules and recommendations if applicable. If using volatile chemicals (including paints), supply appropriate ventilation or conduct activities outdoors. For all stored chemicals, keep a Materials Data Safety Sheet nearby (includes volatile glues, insect repellants, and cleaners). • Walk in the office, do not run. • Watch out for tripping hazards. Follow good housekeeping practices, including closing drawers, properly disposing of waste, and properly storage of materials and equipment not in use. • Report maintenance issues that pose a fall/trip hazard to maintenance staff immediately (ex. Wet floor from leaky toilet, torn carpet, etc.).
	Inadequate Lighting and Poor Air Circulation	• Take appropriate breaks. • Alternate indoor and outdoor activities. • Adjust thermostat and open windows as needed. • Turn lights on or off.
	Lacerations and Punctures	• Do not use paper cutters if the guard is removed or blade is dull. • Keep fingers and hands away from point of operation. •
Qualified Personnel	Untrained/Unqualified Personnel	• Personnel will have the correct qualifications for the job assigned. • Trainees will work under the supervision of an appropriately qualified individual. • Trainees will be trained locally or attend appropriate safety courses. • Non-DOI or other government agency personnel (interns and contractors working for SECN or a park are considered government agency personnel) will never accompany SECN staff during work operations UNLESS specifically approved by the SECN Coordinator or a Park Superintendent.
Contact with visitors, adjacent landowners, and concessioners	Aggressive or Inappropriate Behavior	• Act professionally (do not yell or antagonize) but ALWAYS protect yourself. • Do not confront an angry landowner/visitor when alone. • Leave quickly if the situation is unsafe. • Call 911 if situation is or becomes dangerous. • If the opportunity exists, listen to grievances, use a calm voice. • Immediately report incident to supervisor.
General Worker Safety and	Emergency and Hazard	• Know where fire or emergency alarm pull stations are

Table C-5. Continued.

TASK/PROCEDURES	HAZARDS	ABATEMENT ACTION
Reporting	Reporting	located in the building. Know the emergency evacuation routes for the building and the rally point once outside. Perform periodic work place assessments for potential hazards. • Know your building Maintenance Supervisor and report hazards to them for correction. • Know procedures for reporting work related injuries. All SECN employees are required to read and understand the document "On-Duty Injury and Illnesses Standard Operating Procedure." • Keep a copy of the SECN Emergency Status Reporting Card with you at all times. Follow instructions on back of card in the event of natural or other disaster situations.

Table C-6. Training and proficiencies required or recommended for the safe implementation of the SECN Coastal Salt Marsh Elevation and Vegetation Community Monitoring Protocol.

Required Training and Proficiencies

First Aid and CPR training for field workers (terrestrial ecology, coastal ecology, and water quality positions; renewed annually [American Red Cross training] or biannually [American Heart Association training]).

USDI Motorboat Operators Safety Training for positions that require operation of a motorized vessel.

Read and understand the “SECN Boat Operation SOP” for positions that require operation or riding in a motorized vessel and complete a short written exam.

All employees riding or operating a motorized or non-motorized vessel will undergo a safety briefing by a certified operator or the SECN Safety Officer.

Read and understand the document “Towing a Trailer: Being Equipped for Safety” for all positions requiring towing of a trailer and complete a short written exam.

All field staff must read and understand the document “On-Duty Injury and Illnesses SOP” and complete a short written exam.

All SECN staff who will be implementing coastal water quality Vital Signs Monitoring protocols must complete a defensive driving course.

All employees required to operate a government vehicle must read and understand the document “Government Motor Vehicle Accident SOP” and complete a short written exam.

Optional / Recommended Training and Proficiencies (DOI LEARN Online Courses)

Cool Ideas on a Hot Topic

Authorities, Roles, and Responsibilities

Blood borne Pathogens

Fall Protection

Fire Protection

Office Safety

Flammable and Combustible Liquids

Hand and Portable Powered Tools

Walking and Working Surfaces

Resources, References, and Standards

Personal Safety Through Awareness

Laboratory Safety

Hazard Communication

First Responder Awareness Level

NSC Defensive Driving II

Personal Protective Equipment

Stress Management

Step 5: Evaluate Risk vs. Gain

The SECN Program Manager has determined that the activity has an acceptable level of risk, if carried out in accordance with all SOPs and risk abatement measures as outlined in Step 4.

Step 6: Execute Decision

The decision made by the SECN Program Manager is to conduct the activity in accordance with the SOPs and risk abatement measures for the SECN Coastal Salt Marsh Elevation and Vegetation Community Monitoring Protocol as outlined in Step 4.

Step 7: Supervise – Watch for Change

The SECN Program Manager and Protocol Lead will continually solicit feedback from the NPS and cooperator staff on safe execution of this protocol including risk control options not considered thus far.

Appendix D. Notes on Site and Boat Access to Sampling Locations

Cape Hatteras National Seashore

Oregon Inlet Marina

Sites 11, 7, 8. The ramp is located at the Oregon Inlet Fishing Center off Hwy 12 behind the fishing center. Parking is available for approximately 75 vehicles and trailers. The ramp is free.

Avon Boat Ramp

Site 29. From Hwy 12 heading south, turn right on Harbor Road in Avon, NC. The ramp goes through shallow water, so it is important to know the waters or be careful. The ramp may have a launch fee.

Teach's Lair

Sites 63, 1, 3, 10, 19. These sites can be reached by ferry or by driving via Hwy 12. Hatteras Village is 56 miles south of the mainland (1 1/2 hours) on Hwy 12 from Nags Head, NC. The ramp has a launch fee. Some of these sites are easier reached from the Ocracoke Boat ramp, but that would require taking a ferry across Hatteras Inlet with the boat on a trailer and launching in Ocracoke.

Cape Lookout National Seashore

This park has one site that will be reached from the mainland. To get to the sampling location take the ferry from 1000 Morris Marina Rd., Atlantic, NC 28511 to Long Point. From Long point, drive north approximately 12.4 kilometers. There will be a small dirt road that takes you closer to the coordinates (Lat: 34.9794, Lon: -76.1631)

Fort Pulaski National Monument

Lazaretto Creek Boat Ramp

Site 2 and 3. Take Exit 99 east on I-16 for 7.8 miles to Exit 35(165). Take 37th St. Connector Exit for 0.6 miles to 37th Street. Turn left (west) on GA HWY 204 for 0.8 miles to Abercorn Street. Turn right and continue west HWY 204 for 0.3 miles to U.S. HWY 80. Turn left (east) 13.6 miles to the Lazaretto Creek Boat Ramp. (One double-lane ramp). This ramp is free.

Fort Frederica National Memorial

Mackay River Boat Ramp

Site 16. Take Exit 38 south on Spur 25 (North Golden Isles Expressway) 4.3 miles to U.S. HWY 17. Turn right 1.7 miles to the Torras Causeway leading to St. Simons Island. Turn left (east) 3.7 miles and drive across the MacKay River Bridge. Boat ramp entrance located approximately 0.3 miles past the MacKay River Bridge on right side of Causeway. Turn right (U-turn) onto side road and drive back toward bridge. (One double-lane ramp). Ramp is free.

Cumberland Island National Seashore

Saint Marys Boat Ramp

Sites 4, 49. Take Exit 3 east on GA HWY 40 for 9.3 miles to St. Marys Street. Turn right 0.1 miles to boat ramp located on left. (Two single-lane ramps). Ramp is free.

Crooked River Park Ramp

Sites 25, 27, 9. Take Exit 3 east on GA HWY 40 for 3.6 miles to King's Bay Road. Turn left 2.1 miles to GA Spur 40. Turn left 4.2 miles to boat ramp located at end of GA Spur 40. (One two-lane ramp w/service dock). Ramp is free.

Timucuan Ecological and Historic Preserve

Sisters Creek Park

Site 78. ICW at 8203 Heckscher Dr. (Bridge); recently improved double-wide ramp; adequate parking and new floating concrete docks; restrooms, paved parking lot, cannot be used much of July because of use of site by Greater Jacksonville Kingfish Tournament. Ramp is free.

Joe Carlucci Boat Ramp

Alternate Ramp for Sites 78. ICW, McKenna Dr. off Heckscher Dr. on north bank of St. Johns River at juncture with ICW; new, double-wide, rippled-surface ramp; picnic area, restrooms. Also unavailable for much of July due to the Greater Jacksonville Kingfish Tournament. Ramp is free.

Palms Fish Camp Public Boat Ramp

Sites 27, 02. 6359 Heckscher Drive, Jacksonville, FL 32226 (at Clapboard Creek). Boat ramp, decent amount of parking, easy St Johns River access via Clapboard Creek, Port-O-Let. Ramp is free.

Goffinsville-Nassau River State Park

Site 54. 95001 Goffinsville Road, Fernandina Beach, FL 32034. 30 parking spots for vehicles with trailers. The park includes now includes the boat ramp, a hand launch area for small boats, a fishing pier, another 118' dock, a nice playground, 6 covered picnic pavilions, each with one table, 3 of the small pavilions have grills also, and a handicap accessible trail (about 3/4 of a mile long). Currents at this ramp can get extreme at certain tide changes, care should be taken when launching during these times. Ramp is free.

Wilson Neck Ramp

Sites 20, 65. 85006 Faye Rd., Yulee, FL 32097 Wilson Neck / Whiskey Creek offers a boat ramp, loading and unloading dock, shoreline fishing, and 15 boat trailer parking spots. There are no restrooms at this location. Ramp is free.

Fort Matanzas National Monument/Guana Tolomato Matanzas NERR

Palm Valley Boat Ramp

Site 40. 383 S Roscoe Blvd., St. Augustine, FL 32082. Roscoe Road under the Palm Valley Bridge. Boat Ramp Single Access, Dock with Floating Dock, Portable Restrooms, Parking Lot

Usina Boat Ramp

Site. 00. 603 Euclid Ave., St. Augustine, FL 32084 (Vilano/North Beach). Boat Ramp Double Access, Dock with Floating Dock, Fishing Pier, Observation Platform, Restrooms, Parking Lot.

Frank Butler West Boat Ramp

Sites 06, 22. 400 Riverside Blvd, St. Augustine, FL 32080. 1 Boat Ramp, Double Access, Dock with Floating Dock, Picnic Shelters, Tables, Parking Lot, Barbeque Pit, Barbeque Grills, Clam Bake Pit, Trail network, Observation Area, Restrooms. At extreme low tides, the ramp is too shallow to use for most boats. The ramp is free.

Pellicer Creek at Faver-Dykes

Site 46. [Faver-Dykes State Park](#) is located off U.S. 1 near the St. Johns and Flagler county line. The boat ramp gives boaters and kayakers access to the creek and the tidal marshes that extend east to the Matanzas River. You will also find camping and picnic areas here. Access is limited to Faver-Dykes Park hours; the park is gated. The ramp has restroom facilities and is free.

Bings Landing Boat Ramp

Site 01. 5862 N. Oceanshore Blvd. Palm Coast, FL. The eight-acre park is located on A1A. The park houses a state-of-the-art boat launch on the Intracoastal Waterway, fishing pier, picnic and playground facilities, and an archaeological dig of the Mala Compra Plantation. The ramp is free.

Canaveral National Seashore***Canaveral National Seashore Boat Ramp***

Site 2. New Smyrna, FL on Atlantic Avenue. Once you go through the northern gates the boat ramp is less than 2/10ths of a mile down on the right. There are two docks with a paved ramp. Small to medium length boats work best. Restroom Facilities available. Parks hours are from 6 AM to 8 PM, but the ramp is outside the gate that is locked after hours.

Appendix E. Site Suitability Assessment Reports

Southeast Coast Network staff, in consultation with NPS, NOAA, and USFWS staff evaluated potential salt marsh community sites within each park study area (Table E-1). Sites were evaluated for their ability to support a salt marsh community monitoring site as well as whether they met site-selection criteria as per the sampling design.

An initial draw of 70 spatially-balanced randomly-selected sampling locations were chosen for each site following site-selection methods described in SOP 1.1.7 (Byrne and Blankley 2013). Two levels of selection criteria were applied to all sampling locations: 1) those applied in a GIS where relevant data layers were available, accurate, and reliable, and 2) those applied in the field. Field evaluation is necessary because the resolution in available GIS data is too imprecise for a determination of the sample-ability or applicability of any given sampling location.

Characteristics Evaluated in a GIS

Sampling locations are excluded from the sampling draw if:

- The site is greater than 20,000 yards (10 nautical miles) from a boat launching facility; however, this distance may be reduced or increased based on boat used, normal water conditions and accessibility.
- The site is not accessible by open water.
- The sampling location occurs on private in-holdings where access is not permitted.

Characteristics Evaluated in the Field

Sampling locations are also excluded in the field if upon inspection:

- Sites are not regularly inundated by tidal water, defined as at least one inundation event during any 24-hour period.
- Sites are visible from normal public view within park lands.
- Sites are not vegetated with typical salt marsh species (e.g., *Juncus roemerianus*, *Spartina alterniflora*).
- Sites are not accessible by boat at low tide. The boat should be able to bow into shore, and contact a 30-foot platform established as part of site preparation. Low tide is defined as two hours either side of mean low water.
- The sampling location is potentially unsafe.
- The GIS used as part of the initial evaluation were of inappropriate resolution or incorrect.

Field crews visited designated sites by boat and, at the accessible sites, did a baseline survey. This included taking a vegetation vertical photo point, a panorama photo, and collecting GPS data with a Trimble GeoXH (better than 1m accuracy). Crews installed labeled PVC pipes at the suitable sites. All sites deemed inappropriate (i.e., do not meet the aforementioned criteria) were recorded as such and this information, and the corresponding location, will be maintained for inclusion as existing points into potential future iterations of the spatially-balanced sample generation process if additional sampling locations are necessary.

Appendix E summarizes the findings from site suitability assessment trips conducted in 2010 and 2011 prior to installation of permanent sampling locations. Full trip reports with photodocumentation are on file with the Southeast Coast Network.

Table E-1. Site suitability assessments conducted at each park to select permanent sampling locations for SECN Coastal Wetland Elevation and Condition monitoring.

Park	SECN Staff	Park / Partner Staff	Dates	# Sites Evaluated	# Suitable sites	Installed by 9/30/2013	Planned FY 2014
CAHA	Jennifer Asper	Sara Strickland Laura Pickens Damien Hardgrove	March–April 2011	470	17	1	0
CALO	Jennifer Asper	Michael Rikard	March–April 2011				
FOPU	Jennifer Asper		March 2011	70	2	1	0
FOFR	Jennifer Asper	Paula Messing	January 2011	70	2	1	0
CUIS	Jennifer Asper	Multiple	October–November 2010	70	10	1	
TIMU	Jennifer Asper		November 2010 – January 2011	170	11	6	0
FOMA	Jennifer Asper Tony Curtis	NPS Kurt Foote, GTMNERR Matt Kimball Katie Petrinc, Scott Eastmann Jamie Pawele Matt Welsh Wendy Eash	March–April 2011	70	8	6	0
CANA	Jennifer Asper	NPS John Stiner, Cameron Welch, Kate Hargrove USFWS Phil Amoroso	September 2011	70	29*	1	0

*water levels at the time of the assessment were exceptionally high, and may have allowed access to sites that are not normally reachable.

Cape Hatteras National Seashore

The tide gauges used for trip planning were Oregon Inlet Marina, Rodanthe, Cape Hatteras, and Ocracoke. The sites were visited between two hours before and two hours after low tide. The locations of the all the sites can be seen in Figure E-1. All sites are within 10NM as the crow flies of a boat ramp, but further via waterways.



Figure E-1. Map of sites assessed at Cape Hatteras National Seashore considered on the April assessment trip (August points not pictured due to density in their watershed)

On 10 April 2011 Sara Strickland and Jenny Asper launched from Oregon Inlet Marina. On the way out the channel, they turned too soon and found themselves in the middle of a large sand bar unable to move. After eventually freeing themselves, they tried to visit sites CAHA45, CAHA 54, CAHA37, CAHA56, and CAHA64. All of these sites, however, were too shallow to access.

On 13 April 2011, Jenny Asper and Laura Pickens set out from the Oregon Inlet Marina and after a few frustrating wrong turns, found their way to CAHA24. This site was a suitable salt marsh community site, though it was impossible to drive the PVC into the marsh. The site was located just south of Oregon Inlet. They also tried to visit CAHA31, CAHA55, CAHA38, and CAHA60, but all of them were too shallow to access. Wind started picking up by the end of the day, but despite the building seas, the pair arrived safely back at the marina.

On 14 April 2011, Jenny Asper and Sara Strickland launched at Teach's Lair Marina in Hatteras, NC. The first site they visited was CAHA63. The site was accessible and suitable for a salt marsh community site, but the wind that day was about 15 mph from the north, which meant that water was being pushed into the area more than normal and water levels might be lower with different winds. This site also did not allow for the installation of PVC. Next they went to site CAHA28, but the site was only a sand beach, no salt marsh. CAHA32 was next and was a suitable salt marsh community site. The site had *Spartina alterniflora*, which indicates regular flooding, but it had other species that were less tolerant of flooding. The PVC at this site was not driven in as deeply as desired and was exposed for 2.06 meters above the ground. The last site for the day was site CAHA 27, which was suitable with *Spartina alterniflora* and other less flood tolerant species such as *Borrchia frutescens*. The PVC at this site sticks out 2.42 meters above the surface.

On 15 April 2011, Sara Strickland and Jenny Asper again launched at Teach's Lair Marina in Hatteras. They first went to Site CAHA53, which was inside the pony enclosure and also inaccessible due to shallow water. Next they visited site CALO25, which was also too shallow to access. Site CAHA44 was accessible and suitable for a salt marsh community site. The site had very little *Spartina alterniflora* and even had *Distichlis spicata*, which indicates that the majority of the area was not regularly flooded. The site was not able to accommodate a PVC marker. The last site of the day was CAHA20, which was also a suitable salt marsh community site. It did not have any *Spartina alterniflora*, which may indicate that it is not regularly flooded, but the soil seemed to regularly flood. The site had no PVC installed due to the density of the ground.

On the 17th of April 2011, Sara Strickland and Jenny Asper launched at Oregon Inlet Marina. The first sites they endeavored to visit were CAHA23 and CAHA21. The sites, however, were too shallow to access. CAHA57 was the next site of the day. The site was regularly flooded, but had plants that do not tolerate flooding well, such as *Borrchia frutescens*. They were not able to drive the PVC to depth, so it remained 2.23 meters above the surface. Last, they went to CAHA29, which was a suitable site that is regularly flooded. They were not able to install PVC and the pictures were not perfect due to a building wind that made even holding the boat against the shore difficult. They ruled out CAHA43 after looking at the imagery and seeing no viable shoreline within the buffer.

On 18 April 2011, Jenny Asper and Damien Hardgrove launched from Teach's Lair Marina in Hatteras. They traveled a good distance southwest to the area around Ocracoke. First they went to site CAHA62, which was inaccessible due to shallow water. Next were sites CAHA 40, CAHA18, and CAHA 66, which were also too shallow to access.

In August, Jenny Asper returned to Cape Hatteras to find suitable sites in the remaining watershed and to revisit the sites that were assessed by Tony and Jenny the year before in a smaller boat. It was decided, however, in the interest of time, only a site assessment would be conducted and not a baseline survey.

On August 21, 2011 Jenny Asper and Sara Strickland launched at Oregon Inlet. They traveled north to CAHA 11, which was previously assessed by Tony Curtis and Jenny. They then traveled north to CAHA 36 and CAHA 10, both already assessed. The sites were all accessible and suitable.

On August 22 Jenny and Sara launched again at Oregon Inlet. They visited sites CAHA07, CAHA13, and CAHA08. All of the sites had been previously assessed by Jenny and Tony. This visit confirmed that they were accessible and suitable. On the way back, the engine had cooling problems and could not run for more than 30 seconds at a time without the overheat buzzer warning. The two decided to be safe rather than crossing the dangerous Oregon Inlet without a reliable motor. The coast guard towed them back to the Oregon Inlet Marina and the next day was spent on boat repairs. The problem was with the thermostats getting clogged with sea grass. When cleaned out periodically, the motor operated properly after this incident.

August 24 was the last day that Jenny could go out due to the approach of Hurricane Irene. She and Darren Bouldin went only to the lowest numbered site in the remaining watersheds and were fortunate enough to find them suitable. CAHA2_19 (the "2" is necessary because this was a separate site selection), CAHA2_01, and CAHA2_10 were all suitable and were the only sites visited by the pair. Jenny evacuated the Outer Banks the next day.

The protocol calls for sites in each of the HUC12 zones in Cape Hatteras National Seashore. The sites that were chosen took into account their location in relation to the HUC zones. Each of the suitable sites will be described in the following section in numerical order. The lowest numbered sites in each of the areas of interest were chosen as the final sites. The sites that proved suitable for use are shown in Figure E-2.

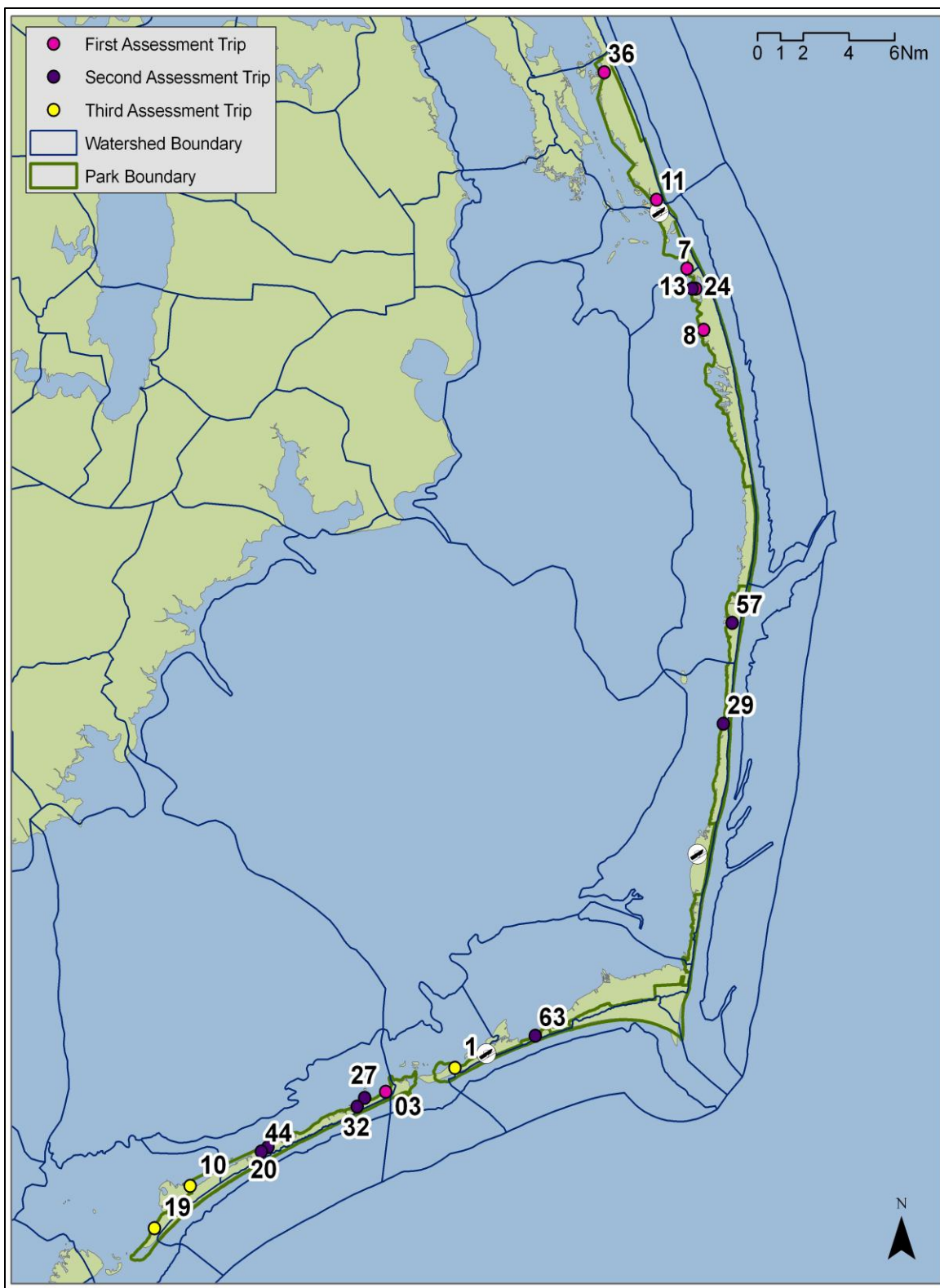


Figure E-2. Map of suitable sites at Cape Hatteras National Seashore. The sites indicated by a pink dot were evaluated on the first trip in a different boat and were re-evaluated before use as a final site on the third trip, which has new points indicated by yellow dots. The purple dots were from the second trip.

The protocol states that the chosen site must be the lowest numbered site. Based on this criterion, the HUC12 zones around Cape Hatteras National Seashore, the sites that should be used are sites 29 and 63 from the first trip, sites 03, 07, 08, and 11 from the second trip and sites 1, 10, and 19 from the third trip. The coordinates for all of the chosen sites from the assessments, can be seen in Table E-2. The sites assessed on a previous trip can be seen in Table E-3. The sites from the third trip are seen in Table E-4.

Table E-2. Coordinates for sites selected for sampling at Cape Hatteras National Seashore.

Site	Northing	Easting
29	3922042.647	455589.987
63	3897989.525	440314.107

Table E-3. Coordinates for additional sites found suitable in the first trip to Cape Hatteras National Seashore.

Site	Northing	Easting
03	3893661.269	428176.088
07	3957159.458	452641.983
08	3952421.842	453985.486
11	3962462.759	450167.109

Table E-4. Coordinates for additional sites found on the third trip to Cape Hatteras National Seashore.

Site	Northing	Easting
1	3895520	433800
10	3886390	412304
19	3883140	409405

Cape Lookout National Seashore

On 26 April 2011 Jenny Asper and Michael Rikard launched at the Fish and Wildlife boat ramp on Lola Road. They tried to visit CALO66, CALO50, CALO68, CALO53, CALO46, and CALO69, but all of the sites were significantly too shallow to access. They were not able to get the boat closer than an estimated quarter mile. Before the tide period was over, the weather deteriorated into a dangerous lightning storm right as the pair made it back to the dock. Based on experience and aerial imagery CALO37 and CALO32 were ruled out that evening.

On 29 April 2011 Jenny Asper and Michael Rikard launched from the Salters Creek boat ramp on NC Route 70. They attempted to access CALO45, CALO28, CALO64, and CALO31, and got closer to the sites, but still not close enough. The sites were all too shallow to access. They were en route to assess other sites when they began to have motor problems and had to start back toward the ramp. Eventually they requested assistance from another NPS boat and were towed back in.

The trip was cut short so that boat repairs could be completed. The water pump impeller on the motor's lower unit had been chewed up by sand intake. Jenny Asper brought it back to Athens to have this repaired and have Beavertail float pods installed to assist with floatation and hopefully allow shallower water access.

Fort Pulaski National Monument

The tide gauge used for trip planning was Savannah River entrance, Georgia. The sites were visited within a time period between two hours before and two hours after low tide. The locations of the all the sites can be seen in Figure E-3. All of the sites are within 10 NM as the crow flies of a boat ramp, though they are further via waterways.

On March 2, 2011, Jenny Asper and Rachel McManamay launched from the boat ramp located on Route 80 on Lazaretto Creek. They started with the site 3, located on the Intracoastal Waterway. Other than the fact that it is visible to all of the boats that traverse the Intracoastal Waterway, the site was a suitable site. They then went east and made their way to site 2. This site was also accessible and suitable for a site. The next two sites, 4 and 0, were inaccessible due to the shallowness of the creeks leading up to them. Site 6 was inaccessible due to a shallow sloping mud flat. Site 10 was also inaccessible because of the shallowness of creeks.

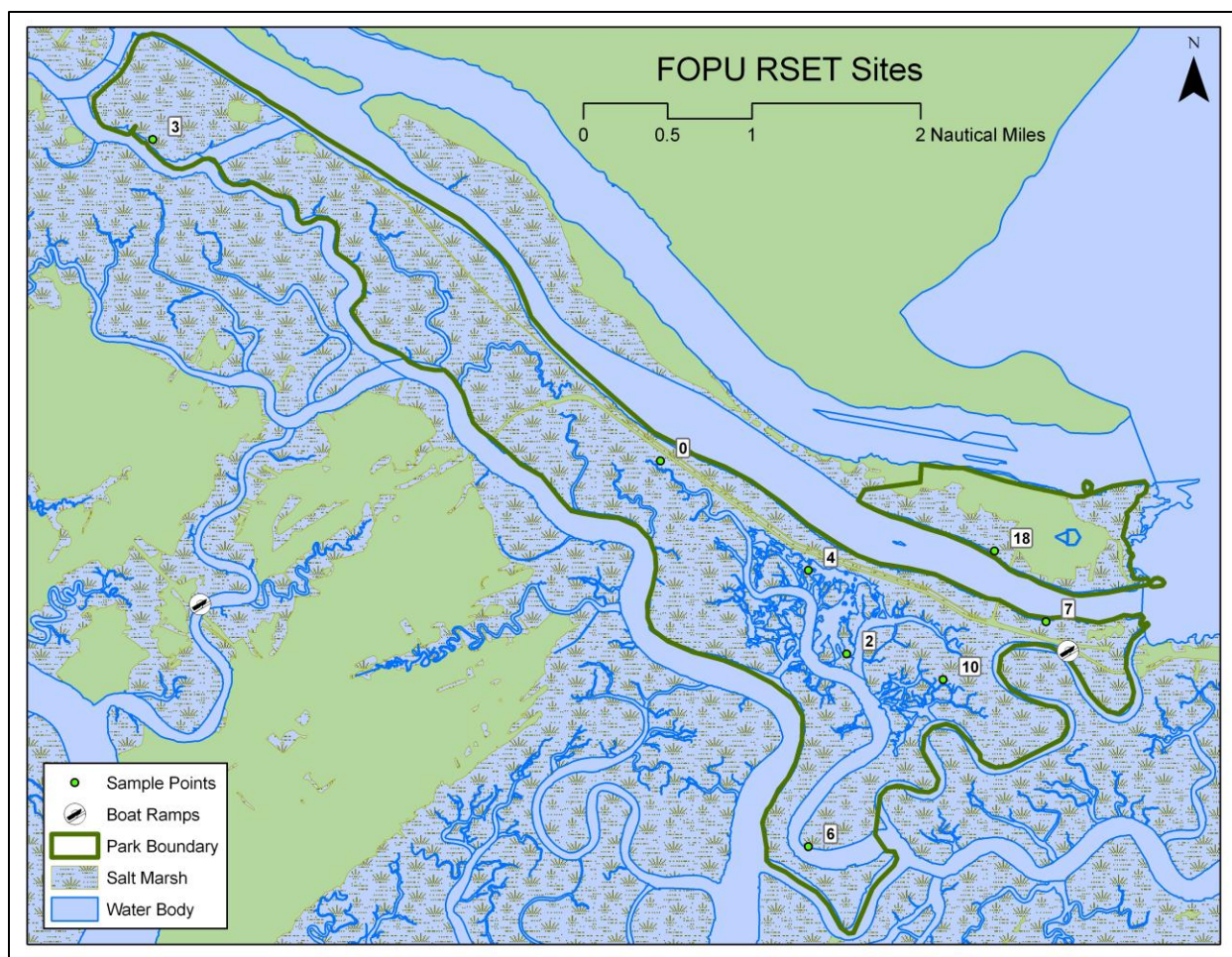


Figure E-3. Map of sites assessed at Fort Pulaski National Monument.

The protocol states that the chosen sites must be the lowest numbered suitable sites. The sites were chosen based on this criterion and based on the two HUC12 zones around the park. Since only two sites were accessible, both were in different HUC12 zones, both sites will be utilized. Therefore, the final sites for FOPU are sites 02 and 03, which can be seen on the map in Figure E-4.

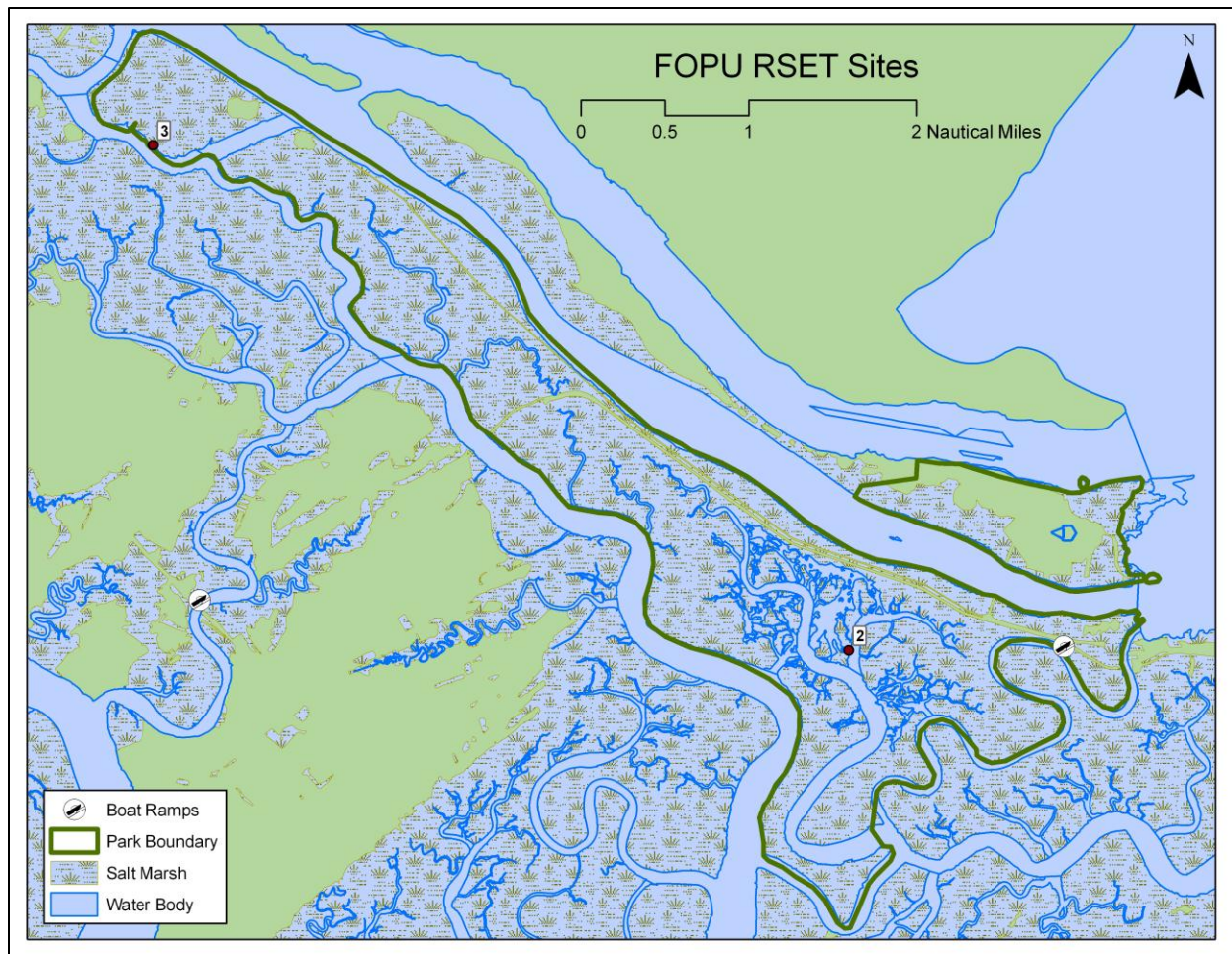


Figure E-4. Map of suitable sites at Fort Pulaski National Monument.

Fort Frederica National Monument

The tide gauge used for trip planning was Dillard Creek, Turtle River, GA. The sites were visited within a time period between two hours before and two hours after low tide. The locations of the all the sites can be seen in Figure E-5. All sites are within 10 NM as the crow flies, though they are further as the boat drives.

On January 4, 2011, Jenny Asper and CUIS SCA intern Paula Messing launched from Lanier Island, GA ramp on the Frederica River. They went north and started with site 16, the site farthest north. This site was suitable for an installation, as was Site FOFR01, the next site they visited. While remaining in the Frederica River, the team visited and ruled out sites 10, 19, 5, and 13. All were inaccessible due to mud flats. On a nearby tributary of Jove Creek, the team attempted to visit sites 17, 9, 18, and 8, but the channels were too narrow or too shallow to go through. Interestingly, the channels were very deep, even though they were quite narrow. Also, two raccoons and countless raccoon tracks were observed, indicating the presence of high marsh nearby.

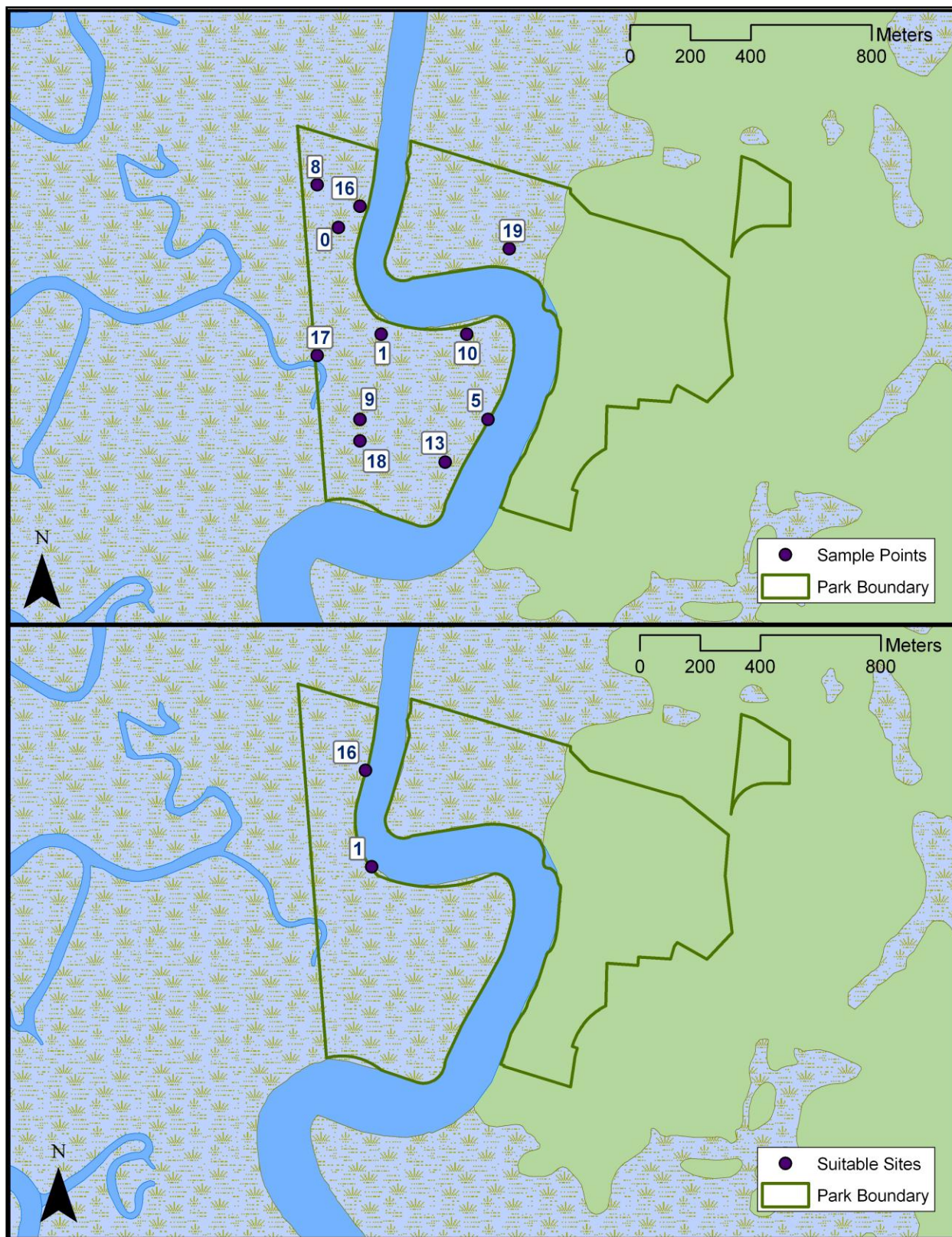


Figure E-5. Map of sites assessed (top) and suitable sites (bottom) at Fort Frederica National Monument.

Sites were chosen based on this criterion and the fact that there is only one HUC12 zone around the park. Because only two sites were accessible and one was within view of the park, site16 will be used for the salt marsh community site installation. The coordinates for all of the suitable sites, including the chosen sites, can be seen in Table E-5.

Table E-5. Coordinates of suitable sites at Fort Frederica National Monument.

Site	Northing	Easting
16	3454781.55059	461941.66444
1	3454461.58438	461961.40003

Cumberland Island National Seashore

The tide gauge used for trip planning was Saint Marys River Entrance. The sites were visited within a time period between two hours before and two hours after low tide. The locations of the all the sites can be seen in Figure E-6. All sites are within 10 NM as the crow flies, though they are further via waterways.

On October 14, Jenny Asper and Marylou Moore (Wildlife SCA Intern) launched at the Saint Marys Ramp and visited the sites at the south end of the island. Sites 12 and 65 were in Beach Creek. Both sites were deemed inaccessible due to mud flats or to marsh mud elevation being significantly higher than the boat. Site 4, also in Beach Creek, was accessible and met all of the requirements, but it might be difficult to fit three platforms within the buffer. Site 49, located on a channel off of the Cumberland River, was accessible and would make a good site and could adequately support three platforms. Site 61 was a usable site on Old House Creek, however, a dock was located within view of the site. Jenny later discovered that the dock belongs to the National Park Service and therefore would cause no problems. The last site of the day was site 10, which could not be viewed because of the shallowness of the channels to the site.

On October 18, Jenny and Marylou launched at Crooked River. Site 47, located on a tributary of Brickhill River, was too shallow to access; so much so that shrimp were jumping into the boat. Site 20, also off of Brickhill River, was also too shallow to access. Site 25 and 52 were both off of Brickhill River, but were accessible and usable as salt marsh community sites, though, site 52 might prove challenging at extreme low tides.

October 20, yielded only one feasible site. SCA Wildlife intern Casey Harris and Jenny launched from Crooked River and found that sites 54 and 2 on Brickhill River and sites 6 and 35 on Mumford Creek and its tributary were all inaccessible due to mud flats, sandbars, and oyster beds. Site 64, however, was accessible, though it may be a bit more difficult at extreme lows. The site was also capable of supporting three platforms.

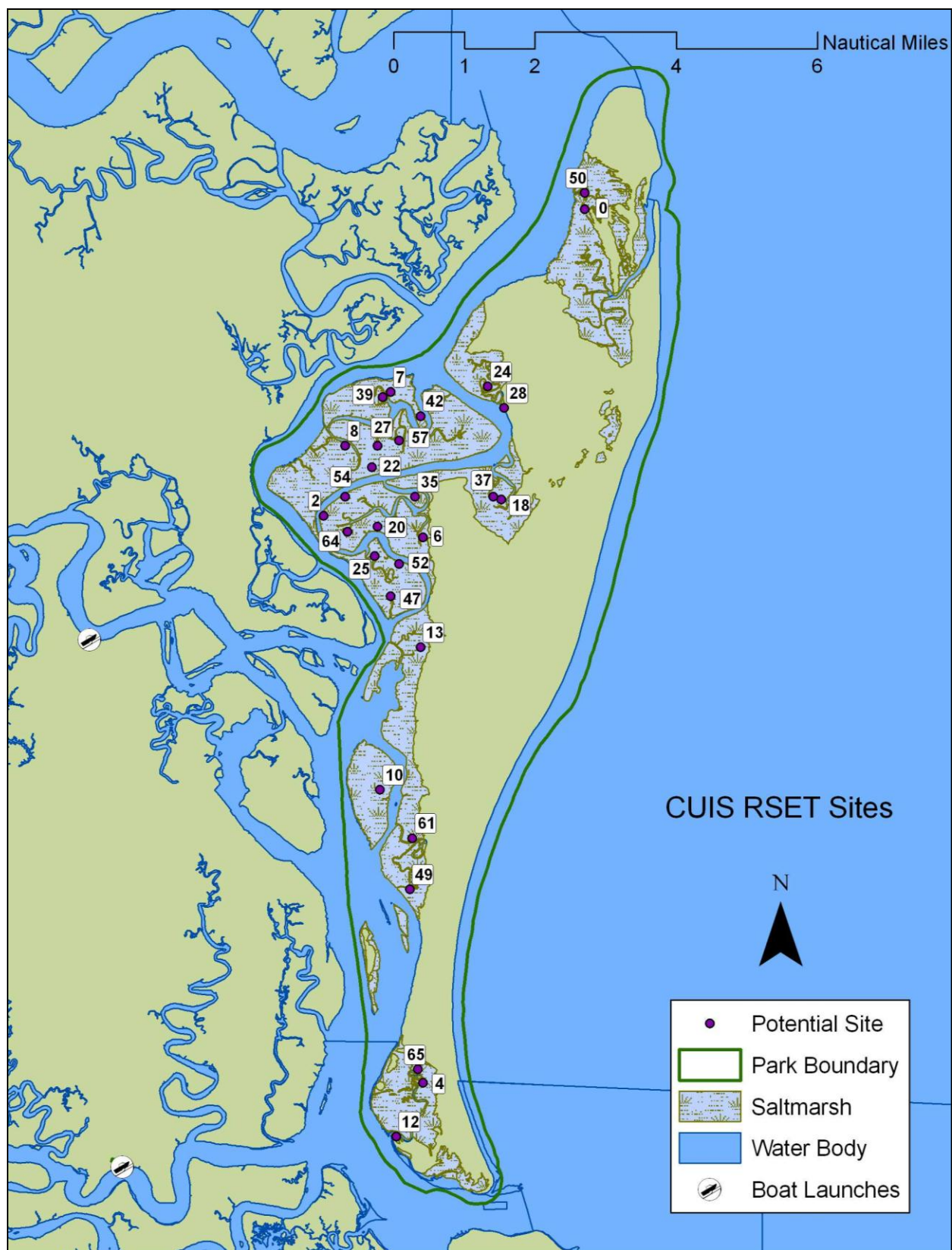


Figure E-6. Map of sites assessed in Cumberland Island National Seashore.

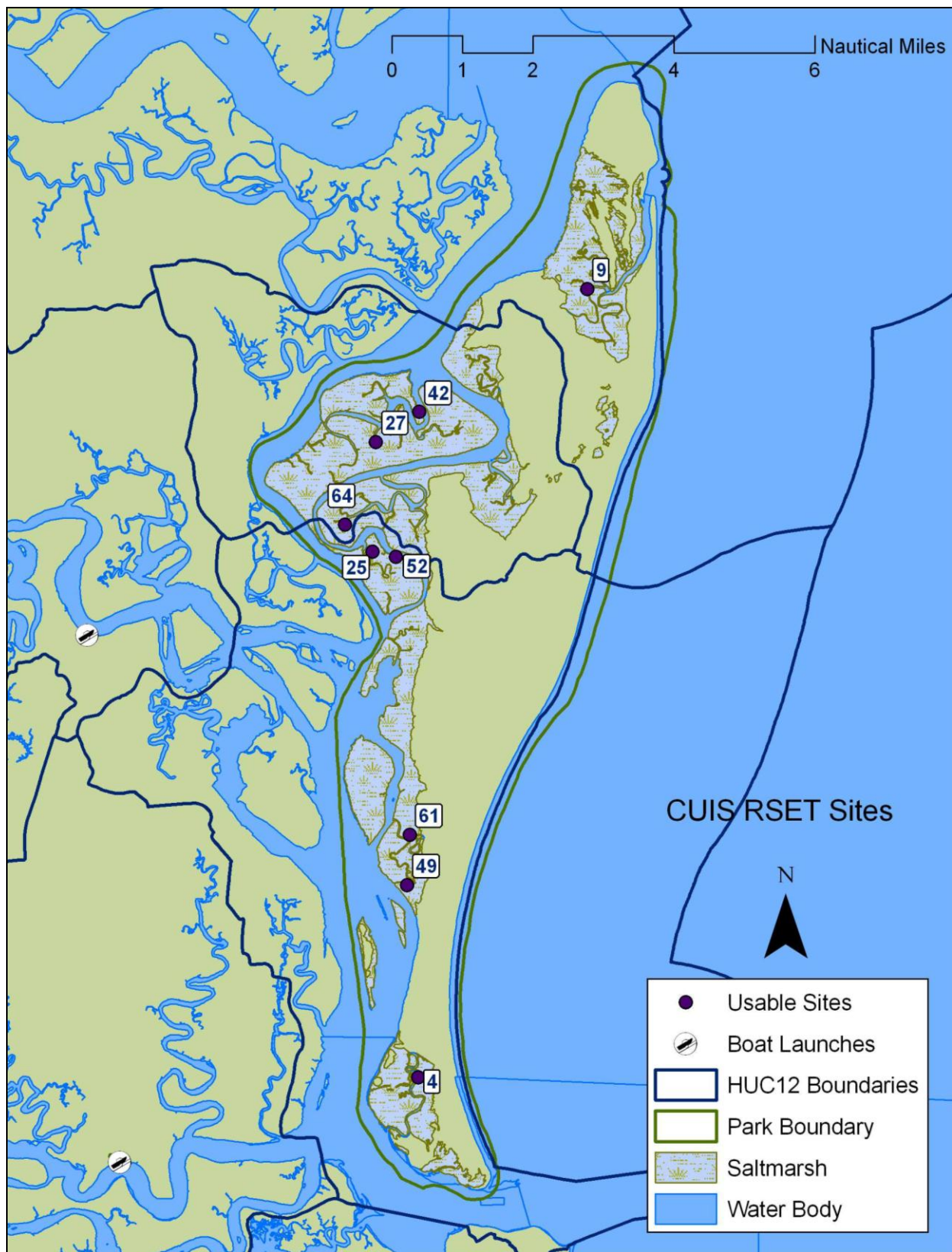


Figure E-7. Map of suitable sites at Cumberland Island National Seashore. HUC12 boundaries indicate areas taken into consideration when choosing the final sites.

October 21 had two suitable sites. Casey and Jenny launched again at Crooked River and visited sites in Mud Creek. Sites 57, 7, 8, and 39 were all in areas that were too shallow to access. Site 42 was along Mud Creek, which is a larger creek in CUIS and might be a bit public, but it was accessible and able to support the three platforms. Site 27 was accessible and able to support the platforms. Both sides of the stream were within the buffer, giving plenty of options for platform locations.

November 1 was the last day of site assessments for CUIS. Marylou and Jenny went to Brickhill River and its tributaries. Sites 18 and 37, off Malkintooh Creek were both too shallow to access. Site 22 off Brickhill Creek and site 24 on Hawkins Creek were in areas which were too shallow. Site 28, right at the entrance to Hawkins Creek was right on the edge of a large mud flat and was high marsh. Site 50 was inaccessible on one side of the creek due to shallow water and mud flats and high marsh on the other side. Since the waters were calm, Marylou and Jenny attempted entrance into Christmas Creek. The conditions that day allowed for safe access to the Creek, but safety would be a concern in any worse conditions. Site 9, however, was evaluated and was determined to be a suitable site, capable of supporting the three platforms. The site was located just off Brockington Creek, one of the tributaries of Christmas Creek.

The protocol states that the chosen site must be the lowest numbered site. Based on this criterion, the HUC12 zones around Cumberland Island, the rivers affecting the island, and the Kings Bay Navy Base, the sites that should be used are sites 4, 49, 25, 27, and, if possible 9 (Figure E-7). If a method for access cannot be found for site 9, another site must be found for that HUC12 zone, as no other sites in this round of site assessments were usable that were not also in Christmas Creek. The coordinates for all of the suitable sites, including the chosen sites, can be seen in Table E-6.

Table E-6. Coordinates of suitable sites at Cumberland Island National Seashore.

Site	Northing	Easting
27	3417641.53023	454035.49949
42	3418437.28194	455171.70762
9	3421669.64373	459584.43262
64	3415467.27534	453216.25767
25	3414754.81954	453941.93306
52	3414624.94151	454555.35795
4	3400940.08794	455145.11871
4	3400939.77831	455145.90871
49	3405997.39786	454848.14359
61	3407315.94130	454926.39582

Timucuan Ecological and Historic Preserve

Tide gauges used for trip planning included Nassau River entrance, Clapboard Creek, and Edward Creek. The sites were visited within a time period between two hours before and two hours after low tide. The locations of the all the sites can be seen in Figure E-8. All sites are within 10NM as the crow flies of a boat ramp, though they may be a bit further via waterways.

Jenny Asper and Wildlife SCA Intern Casey Harris set out from Wilson Neck Ramp on November 2, 2010. They visited sites in the far northwest section of the park. All three sites that they visited, sites 20, 52, and 65 were suitable for installation. The sites met all the salt marsh community site requirements and a vegetation plot was installed. Sites 20 and 52 were both located right on the Nassau River, while site 65 was located in Seaton Creek.

On November 3, 2010, Jenny and Cumberland Island SCA Intern Victoria Jumper visited sites in the northern section of the park. They launched from Holly Point Park, though it was later discovered that Goffinsville-Nassau River Park is a better ramp. They visited site 61, on Pumpkin Hill Creek, but it was too shallow to access, even at 2 hours before low. Next they installed a vegetation plot at site 66, which initially appeared to meet all of the criteria and was also on the edge of Pumpkin Hill Creek. The GPS was mistakenly set to collect line data rather than point data, so it was necessary to revisit the site later. Upon revisit, the site proved to be too shallow and, therefore, inaccessible at absolute low. Site 54 was the last site visited, on a tributary of Pumpkin Hill Creek. This site met all of the requirements for a salt marsh community site and a vegetation plot was installed.

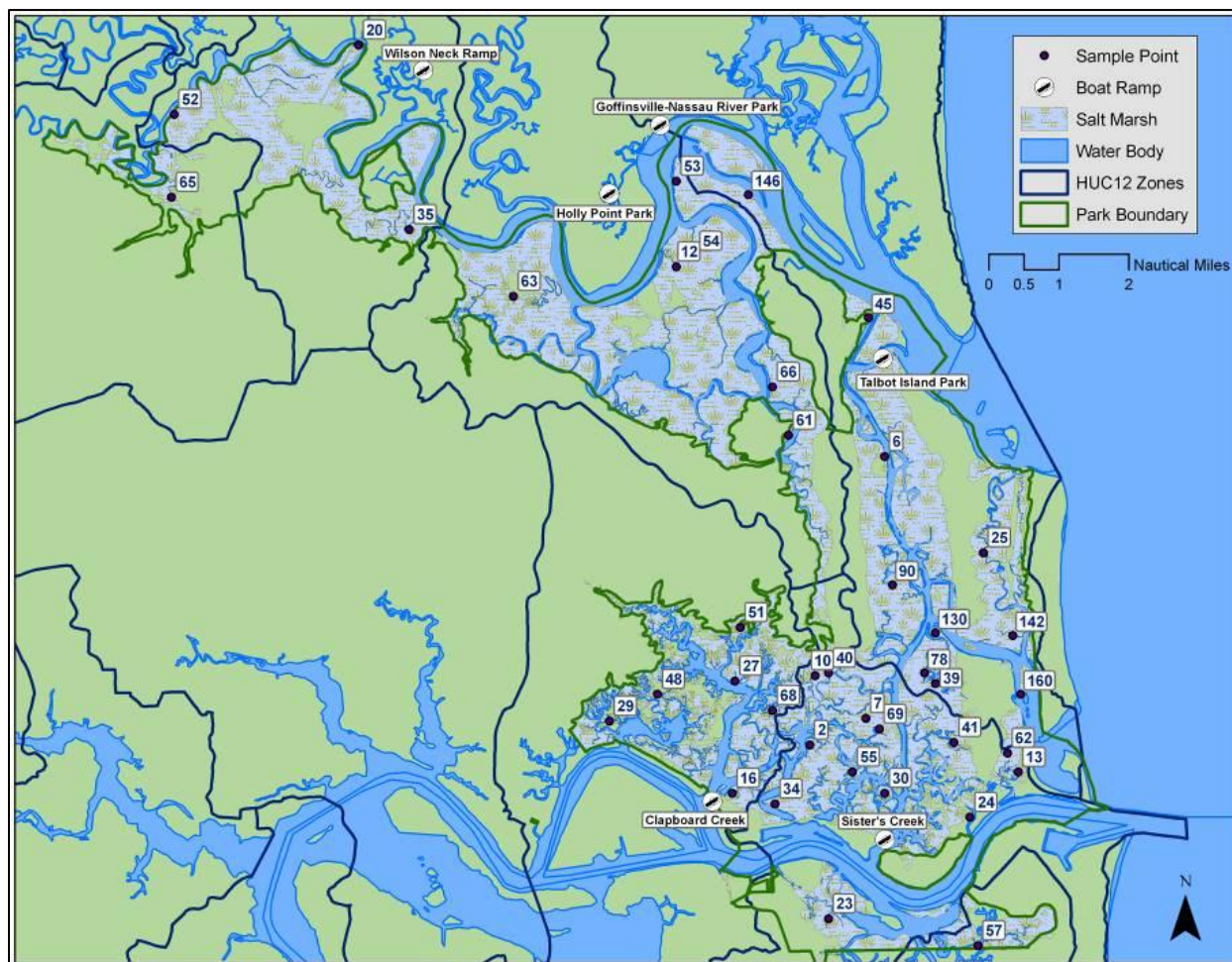


Figure E-8. Map of sites in Timucuan Ecological and Historical Preserve to which assessment visits were attempted.

November 15 brought Jenny and Wildlife SCA Intern Marylou Moore to the southwest portion of the park, where they launched at Clapboard Creek Ramp. Sites 29 and 48 both proved too shallow and had too many oyster beds for accessibility. Site 68 is on Clapboard Creek and was suitable for a vegetation plot, though it got a bit shallow at extreme low. Site 27 was also a suitable site on Clapboard Creek, which met all of the criteria, and a vegetation plot was installed.

The only site that met the criteria for salt marsh community sites on November 29, 2010 was site 35. Jenny and Marylou launched from Wilson Neck Ramp to visit sites in the north of the park. The buffer, in this case, extended to both sides of Deese Creek, which is off of the Nassau River in the northwest section of the park. Sites 12, 53, and 63 were all too shallow to access.

On November 30, Jenny and Casey launched from Big Talbot Island State Park ramp. Sites 39, 25, and 10 were too shallow to access. Site 40 was located on a wide tributary off the Intracoastal Waterway. It was suitable for a site installation, though the wind that day made it necessary to use notable throttle to stay perpendicular to the shore.

December 2 yielded no suitable sites for salt marsh community sites or vegetation plots. Jenny and Marylou Moore launched from the Sister's Creek Ramp and traveled up the Intracoastal Waterway and adjacent tributaries. Sites that were attempted included 69, 7, 51, 55, 30, 34 and 41. All six sites were too shallow. Many were never even viewed from a distance.

December 16th was no more successful than the 2nd. Jenny and Rachel McManamay, the Remote Sensing Specialist for SECN, launched from Sisters Creek and visited sites off of the St. Johns River. Sites 62 and 13 were not accessible because a pier extended entirely across the stream that was thought to be the access point. Site 24 was very public with multiple houses in clear view of the site. The site was also predominately high marsh species such as *Borrchia frutescens* and *Salicornia/Sarcocornia spp.* Site 57 was located near the Navy Base and was predominately upland species such as *Quercus virginiana* and *Sabal palmetto*. Site 23 was just too shallow to access.

January 18, 2011 was the first day of the second set of points for HUC 030702050304. Jenny Asper and Casey Harris set out from Big Talbot Island Boat Ramp and first visited sites 146 and 45. Site 146 was not accessible due to mud flats extending out from the shore, even at 2 hours before low tide. Site 45 had mud flats which made it unreachable, but also was located in a very public location on the Intracoastal Waterway with houses in sight. Heading south, the pair attempted to access site 90, but met with shallow waters and oyster beds. Site 130 not only got the two stuck for a little while, but also would not allow them to install a PVC pipe. The PVC would go in about 4 feet and then hit a rock-solid layer of what was presumed to be oysters. As the water rose, they floated off the mud and the pair went to site 78, which was suitable; so, they installed a vegetation plot. Site 142 was too shallow to access at an hour and a half past low. Site 160 was accessible, but very public. The crew had difficulty driving the PVC due to soil density.

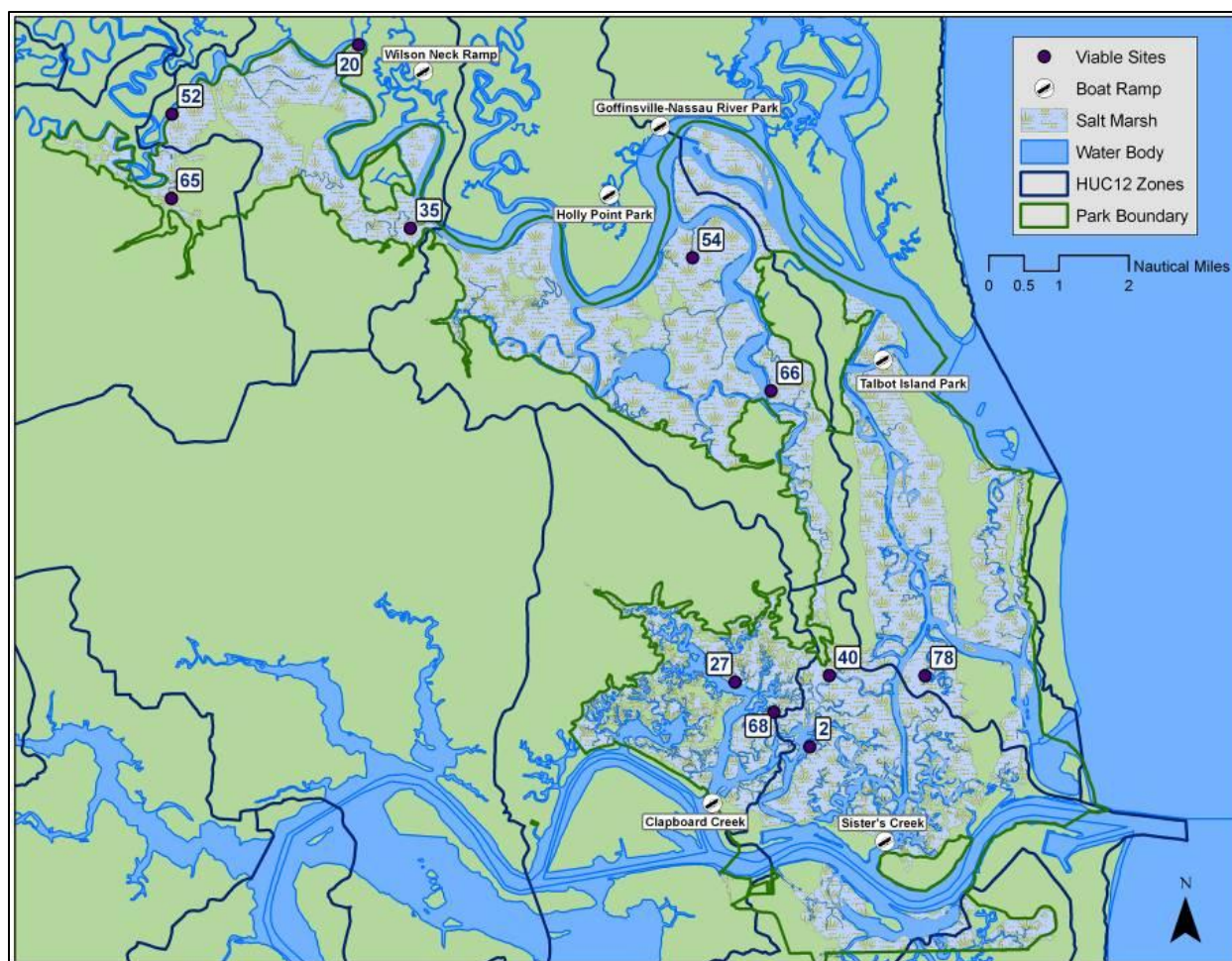


Figure E-9. Map of sites deemed viable in Timucuan Ecological and Historical Preserve. HUC12 boundaries indicate areas taken into consideration when choosing the final sites.

Based on the selection process, each of the above sites must be considered in numeric order based on sound reasoning before advancing to the next site. Based on this criterion, and the HUC12 zones, the preferred sites are sites 65, 20, 54, 2 (already installed), 27, and 78 (Figure E-9). The coordinates for all of the suitable sites, including the chosen sites, can be seen in Table E-7.

Table E-7. Coordinates of suitable sites at Timucuan Ecological and Historic Preserve.

Site	Northing	Easting
40	3367102.93993	454404.34417
35	3378927.72358	443315.99851
66	3374625.83872	452863.80991
68	3366134.88893	452939.86942
27	3366930.74404	451915.63300
54	3378149.63391	450784.00451
65	3379714.43637	436983.62014
52	3381943.44100	437001.61848
20	3383777.19514	441941.61360
2	3365216.15011	453888.00563
78	3367094.40073	456937.93106

Fort Matanzas National Monument and Guana Tolomato Matanzas National Estuarine Research Reserve

The tide gauges used for trip planning were St. Augustine City Dock, Bings Landing, Vilano Beach-ICWW, and Palm Valley-ICWW. The sites were visited within a time period between two hours before and two hours after low tide. The locations of the all the sites can be seen in Figure E-10. All sites are within 10 NM as the crow flies of a boat ramp, though they are further via waterways.

On 11 March 28, Jenny Asper, Coastal Technician, and Tony Curtis, Coastal Ecologist for the Southeast Coast Network launched at the Frank Butler West boat ramp and headed north. The first site was site FOMA22, which was accessible low marsh. There were a few individual *Avicennia germinans* plants in the buffer, which means the site can be used for a transitional mangrove site. It met all of the requirements of a salt marsh community site. The next site visited was site FOMA06, which was difficult to navigate to, given the shallow areas leading to the Moses Creek entrance. Once into the creek, however, the site met the criteria. There was also a dock located on the Moses Creek, owned by the St. John River Water Management District, which could be used for staging materials during platform installation. The next site visited was site FOMA62, also located on Moses Creek. The site was near Murat Point public use area, also owned by Saint Johns River Water Management District. The site was high marsh, which both made driving PVC difficult and also made the site not ideal for a salt marsh community site. The last site visited that day was completely unsuitable for a salt marsh community site, because it was located in between two private docks and on the Intracoastal Waterway.

On 29 March 2011, after meeting with staff of the GTMNERR to discuss the project, two boats were launched at Bings Landing. In the two boats were Jenny Asper and Tony Curtis, from the Southeast Coast Network, and Mat Kimball, Katie Petrinec, and Scott Eastman from GTMNERR. Due to winds

that day, the tides were significantly different than predicted, which may affect accessibility on future dates. . The first site visited was site FOMA65 with Matt Kimball and Jenny Asper in the boat. The site was vegetated by mangroves surrounded by high marsh. It was, however, located on a deep stream off the Intracoastal Waterway, which makes it easily accessible. Next, Katie Petrinec switched spots with Matt Kimball and accompanied Jenny Asper to site FOMA01. The site was high marsh and had mangroves located nearby, but not within the buffer. The site also, however, had *Spartina alterniflora*, which indicates regular flooding. Site 42 was the next site visited by Katie and Jenny, but the shoreline was lined with shallow oyster beds, which prevented access to the site. After that, Scott Eastman replaced Katie Petrinec in the boat and he and Jenny proceeded to site FOMA 63. The site was similar to FOMA01 in that it seemed like high marsh, but still had *Spartina alterniflora*, which indicates regular flooding. The site is nicely hidden away from the Intracoastal Waterway, but caution must be taken on access to avoid numerous oyster beds. Scott and Jenny then continued to FOMA50, which was an interesting mix of high and low marsh vegetation, and had *Avicennia germinans* within the buffer. The site was otherwise completely acceptable for a salt marsh community site. Sites FOMA20 and FOMA56 were not accessed, but were determined to be in areas too shallow to access using experience and knowledge of the NERR staff.

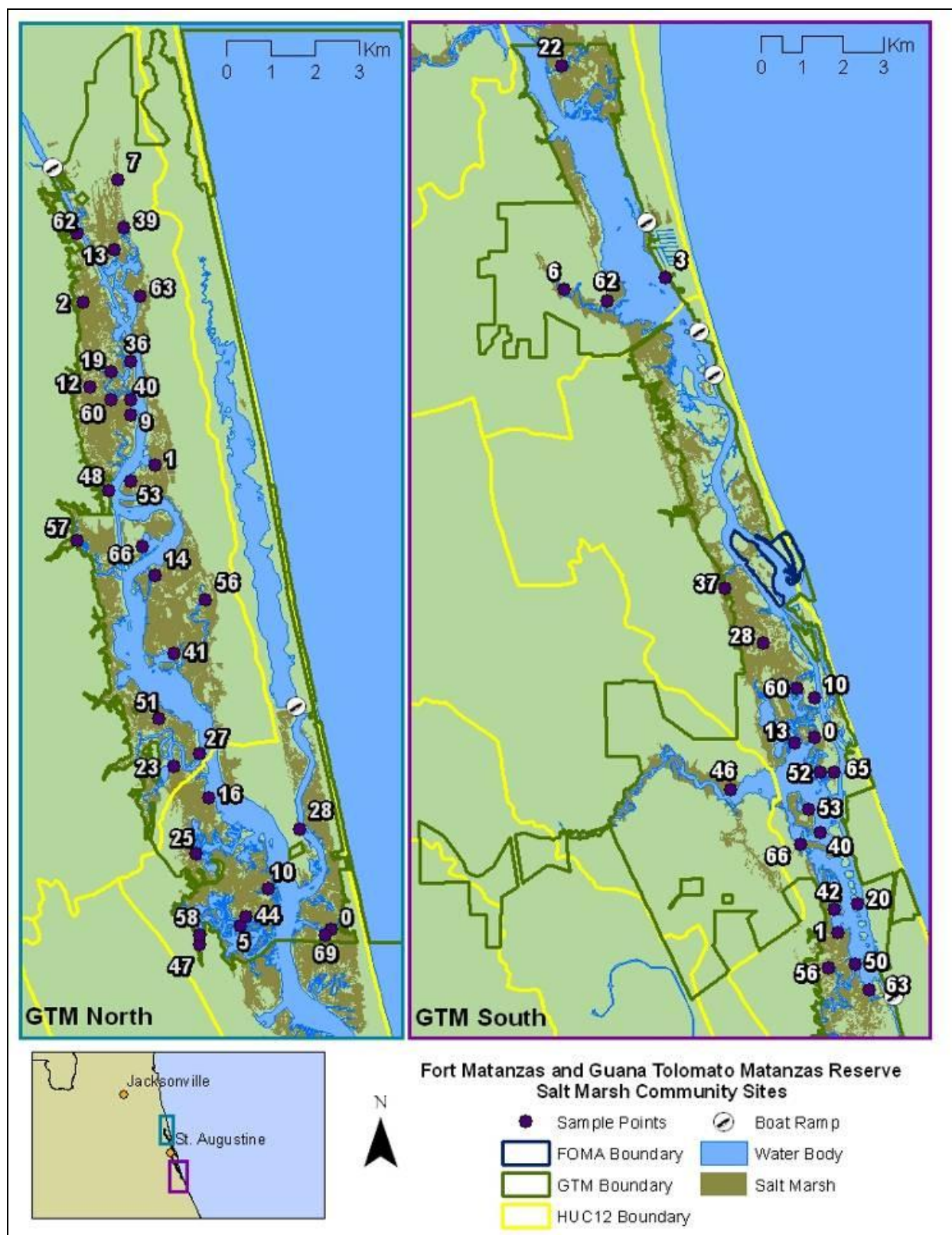


Figure E-10. Map of potential sites in the north and south sections of GTMNERR.

On 30 March 2011, Jenny Asper and Tony Curtis from the Southeast Coast Network, Kurt Foote from Fort Matanzas National Monument, and Matt Welsh and Jamie Pawelek from GTMNERR launched two boats from Faver-Dykes State Park boat ramp, located on Pellicer Creek. With the threat of severe thunderstorms in the afternoon, the crew kept a close eye on the weather as they proceeded to FOMA46. Both boats were able to access this site two hours before low, but it showed evidence of getting much shallower once water levels dropped. The site was suitable for a salt marsh community site. Next, after getting both boats temporarily stuck, sites FOMA66, FOMA40, FOMA53, FOMA00, FOMA13, and FOMA52 were determined to be too shallow to access. The mouth of the Pellicer Creek expands into a mud flat that, according to local knowledge, is exposed mud at certain tides.

The first of April 2011 brought the site assessments to the north section of GTMNERR. Jenny Asper and Tony Curtis, along with Jamie Pawelek and Matt Welsh from GTMNERR, launched from the Palm Valley boat ramp. The first site, FOMA62, was attempted by Jamie and Jenny, but was too shallow to access. Next was FOMA40, which was a suitable site vegetated primarily by *Spartina alterniflora* and located on a small creek off of the Intracoastal Waterway. Aerial imagery should be consulted to see the best route for access. Jamie and Jenny then determined that FOMA23 was also not accessible. Further south, they went to site FOMA00, which was both accessible and suitable for a salt marsh community site. They were at the site over two hours after low tide, which might mean that the site will be more difficult to access at a lower tide. After that, Jenny and Matt Welsh visited site FOMA69, which was a suitable site, easily accessible at almost 3 hours after low tide. The site met all of the criteria for a salt marsh community site. One mangrove was located nearby outside the buffer, which is one of the furthest north observed of *Avicennia germinans*. The last site to be visited was FOMA28, which was along the Guana River. It could be suitable for a site to observe the transition from upland to water, since it was a very narrow strip of marsh between the river and the upland area of GTMNERR. The site, however, was not suitable for normal salt marsh community sites because of oyster beds lining the bank and the inability to support 30 foot long platforms. Site FOMA48, FOMA36, and FOMA09 were not visited because they were determined to be too shallow by experience and knowledge of the NERR staff.

A few sites were eliminated before going out in the field. These were ruled out because of NERR staff knowledge and experience with the waterways. The sites that were ruled out are FOMA10, FOMA60, FOMA37, and FOMA 28.

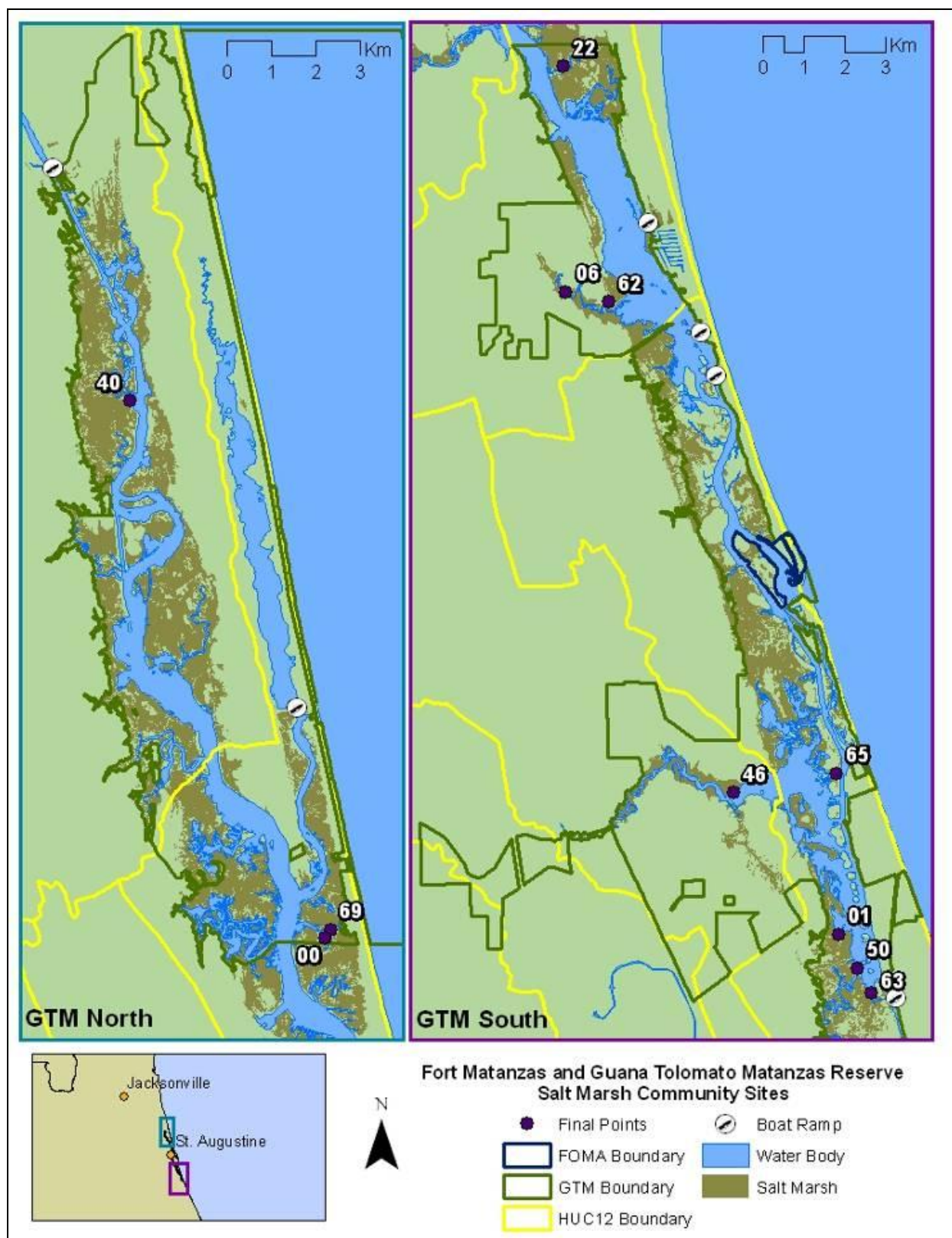


Figure E-11. Map of suitable sites in the north and south sections of GTMNERR.

The protocol states that the chosen site must be the lowest numbered site. Based on this criterion, the HUC12 zones around Guana Tolomato Matanzas NERR, the sites that should be used are sites FOMA00, and FOMA40, in the north section. In the south section, sites FOMA 06, FOMA46, and FOMA01 represent each of the watersheds, while FOMA22 represents a mangrove site (Figure E-11). The coordinates for all of the suitable sites, including the chosen sites, can be seen in Table E-8.

Table E-8. Coordinates for suitable sites at Fort Matanzas National Monument/GTMNERR.

Site	Northing	Easting
46	3281190	476275
65	3281660	478801
01	3277710	478864
63	3276270	479654
50	3276870	479322
22	3299040	472097
06	3293490	472166
62	3293240	473207

Canaveral National Seashore

The tide range in the Mosquito Lagoon is negligible, especially in comparison to the seasonal water-level changes, so tides were not taken into consideration in the site assessments. The sites were visited in September, however, which is the high water-level season, which means in other times of year access will be more difficult. The locations of the all the sites can be seen in Figure E-12. All sites are within 10NM as the crow flies of a boat ramp, but further via waterways.

After a series of warnings about the difficulties of navigation in the Lagoon, Jenny Asper took advantage of the park law enforcement's offer to show her the way around the lagoon on September 20, 2011. This especially proved helpful for learning the deeper running channels and the location of the incorrectly marked gate into the Pole and Troll Zone.

This park is unique in that it is jointly managed by the National Park Service and Fish and Wildlife Service. Because of this, Jenny spent the second day meeting with Fish and Wildlife and National Park Service resource management people about the project and how the different organizations can work together smoothly.

On September 21, 2011 Jenny Asper and John Stiner, Resource Manager for CANA, launched from the NPS ramp and visited sites starting with site 6 and 21 right across from the park boat house then started with the most northern sites and worked south. They visited sites 32, 50, 61, 29, 46, 40, and 13. All of the sites are vegetated with high marsh and mangrove species. The only site that was highly visible to park land was site 6, which was on a main channel across from the NPS boat house and Turtle Mound.

On September 22, Phil Amoroso, law enforcement for Fish and Wildlife Service, showed Jenny the best way to access the Pole and Troll Zone. They launched at the Beacon 42 boat ramp and visited

sites 48, 58, 53, 05 and 08. The sites were all accessible and vegetated with primarily *Batis maritime* and *Avicennia germinans*.

On September 24, Cameron Welch, SCA intern for Cape Canaveral, and Jenny Asper launched from the National Park Service ramp and finished all of the sites in the north. They visited sites 12, 60, 19, 14, 55, 34, 52, 43, 02, 67, 10, 65, 39, and 25. All of the sites were accessible and met the salt marsh community site criteria.

The last launch was on September 25 from the Beacon 42 boat ramp. Kate Hargrove met up with Jenny Asper that morning. They went to sites 44, 09, 03, and 35. None of these sites were suitable. Sites 44 and 09 were predominantly upland and 03 and 35 were inside impoundments and were not accessible.

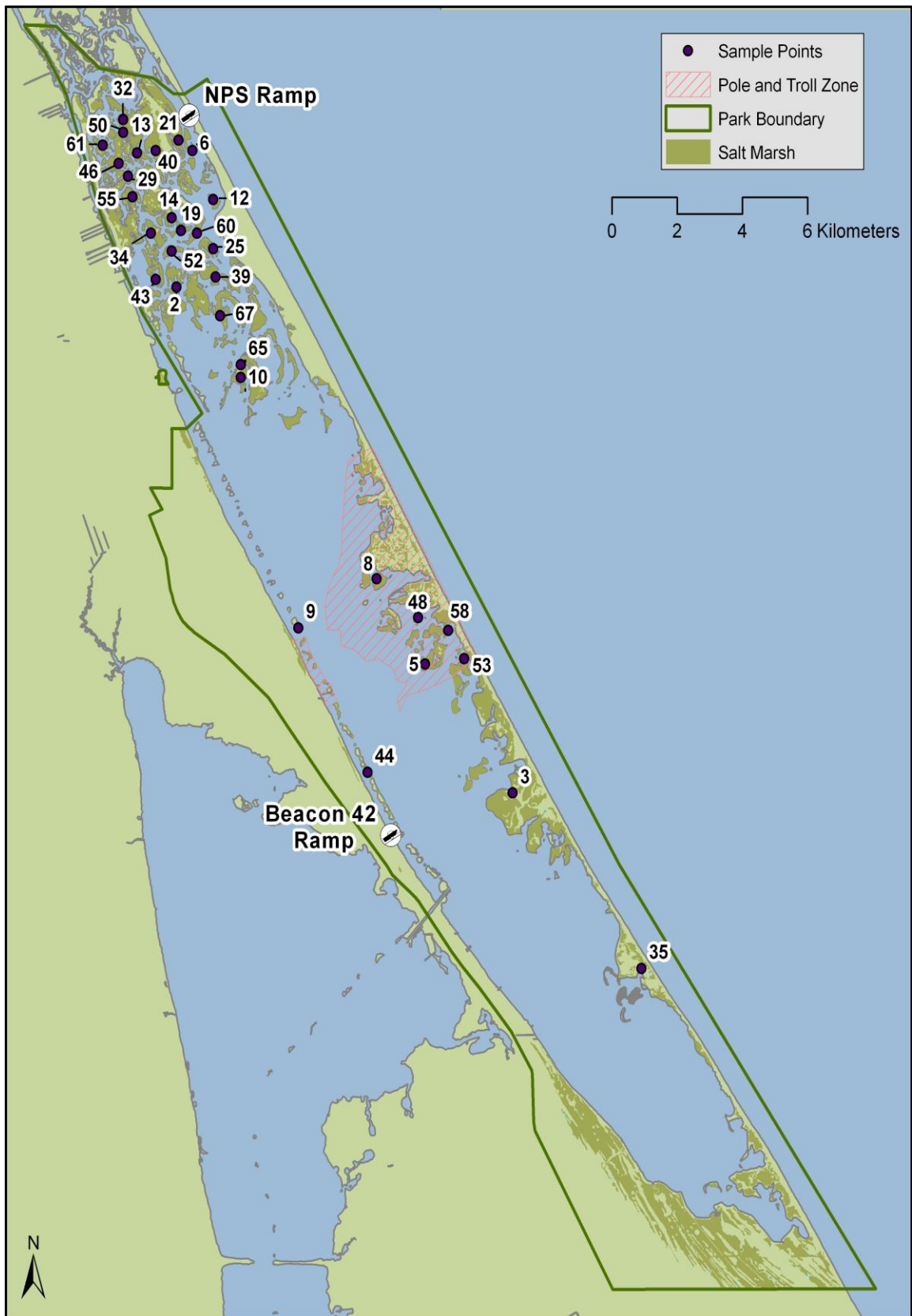


Figure E-12. Map of possible sites at Canaveral National Seashore considered on the assessment trip.

The protocol calls for sites in each of the HUC12 zones in Cape Canaveral National Seashore. Since there is only one HUC zone in the Mosquito Lagoon, the three districts (i.e. North, Central, and South) were considered. The lowest numbered sites in each of the areas of interest were chosen as the final sites. The coordinates for all of the suitable sites are in Table E-9.

The protocol requires that the chosen site must be the lowest numbered site. The three zones in Canaveral are also important to take into consideration. In this case, however, the southern district has no suitable, accessible salt marsh; sampling locations will have to be limited to the Central and Northern areas of the park. The Fish and Wildlife Service, however, has RSETs installed in the Merritt Island Wildlife Refuge, which surrounds and includes the southern area of the park. Cooperation with FWS can potentially provide RSET data for that area of the park.

Table E-9. Coordinates for suitable sites at Canaveral National Seashore.

Site	Northing	Easting
02	3196020	516245
05	3185690	523881
06	3199760	516740
08	3188030	522396
10	3193540	518225
12	3198420	517376
13	3199690	515043
14	3197920	516103
19	3197570	516386
21	3200050	516315
22	3197920	514760
25	3197080	517376
29	3199060	514760
32	3200610	514618
34	3197500	515467
39	3196300	517447
40	3199760	515608
43	3196230	515608
46	3199410	514477
48	3186960	523669
50	3200260	514618
52	3197010	516103
53	3185830	525083
55	3198490	514901
58	3186610	524589
60	3197500	516881
61	3199900	513982
65	3193890	518225
67	3195240	517588

Appendix F. Power Analyses

All power analyses were conducted using PASS software with the following notes on the types of tests performed and parameters included in the analyses.

Report Definitions

- Power is the probability of rejecting a false null hypothesis.
- N is the number of pairs drawn from the population.
- Alpha is the probability of rejecting a true null hypothesis.
- Beta is the probability of accepting a false null hypothesis.
- Mean of paired differences is the mean difference at which the power and sample size are determined.
- S is the standard deviation of the paired differences for the population. It is assumed to be unknown.
- Effect Size, $|\text{Mean of paired differences}|/\text{Sigma}$, is the relative magnitude of the effect under the alternative.

Elevation Measurements from RSET Devices

Power to detect differences between two sampling events is assessed using paired *t*-tests of means. For all analyses, we assume a normal distribution in the differences for matched pairs. Standard deviation is estimated at 0.6 for all analyses (calculated as the range/5 where the range is estimated at 3 mm/year).

Numeric Results for Paired t-test

Null Hypothesis: Mean of Paired Differences = 0, Alternative Hypothesis: Mean of Paired Differences $\neq$ 0; Unknown standard deviation.

Table F-1. Test results for elevation.

Power	N	Alpha	Beta	Mean of paired differences	S	Effect size
0.95	4	0.05	0.05	1.7	0.6	2.827
0.95	36	0.05	0.05	0.4	0.6	0.618
0.90	3	0.05	0.10	2.4	0.6	3.923
0.90	4	0.05	0.10	1.5	0.6	2.507
0.90	36	0.05	0.10	0.3	0.6	0.556
0.80	3	0.05	0.20	2.0	0.6	3.264
0.80	4	0.05	0.20	1.3	0.6	2.128
0.80	36	0.05	0.20	0.3	0.6	0.480

Summary Statements

A sample size of 3 (used when comparing sampling locations over time) is expected to achieve 80% power to detect a mean of paired differences of 2.0 mm with an estimated standard deviation of differences of 0.6 and with a significance level (alpha) of 0.05 using a two-sided paired *t*-test.

At any given station, the method is expected to achieve 80% power to detect a mean of paired differences of 1.3 mm (using four averages of measurements taken in the cardinal directions as replicates) or 0.3 mm (if 36 individual pin measurements are used as replicate measures) with an estimated standard deviation of differences of 0.6 and with a significance level (alpha) of 0.05 using a two-sided paired *t*-test (Figure F-1).

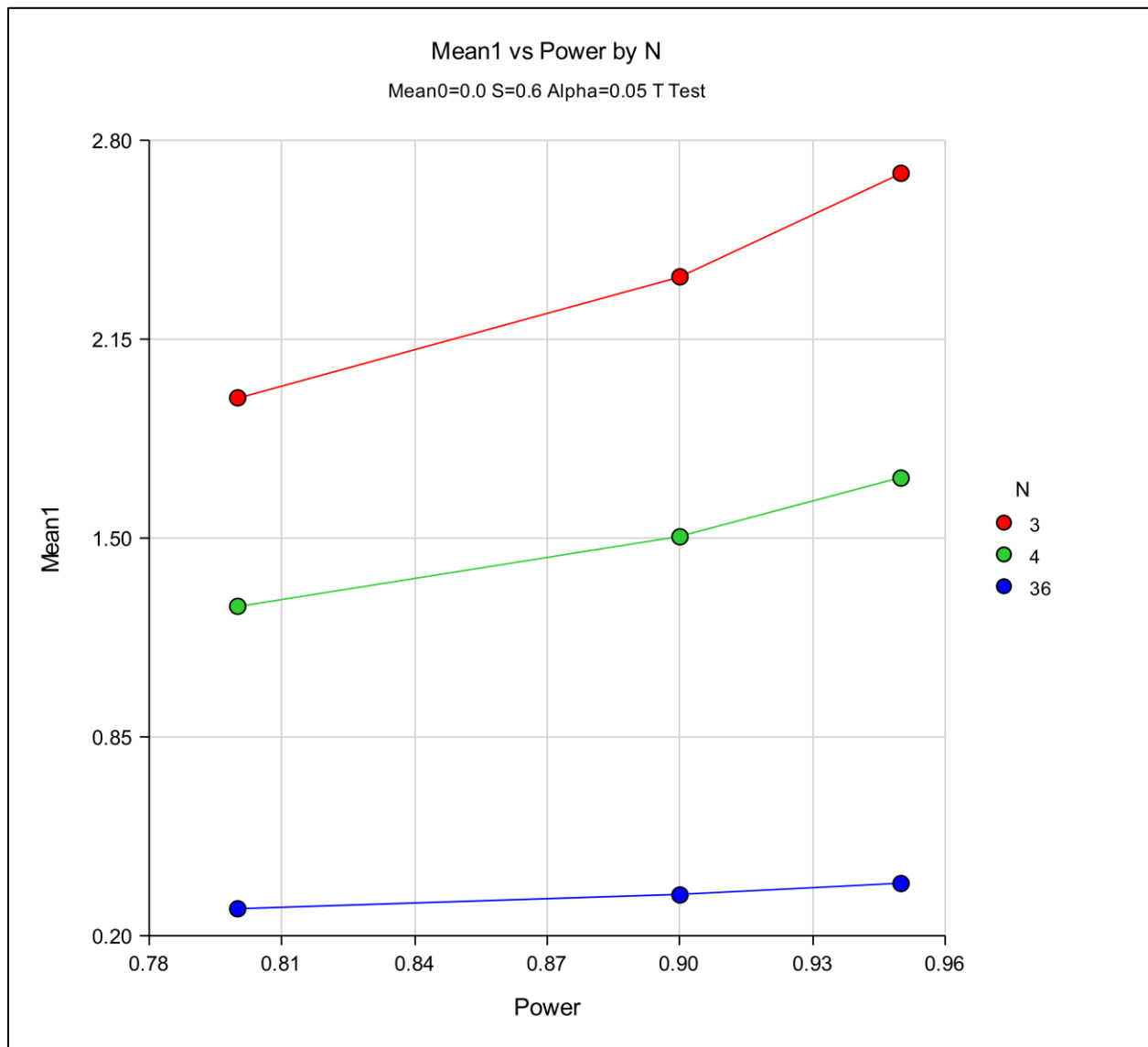


Figure F-1. Power analysis curves for comparing means of changes in surface elevation between sampling events.

Accretion Measurements

Power to detect differences between two sampling events is assessed using paired *t*-tests of means. For all analyses, we assume a normal distribution in the differences for matched pairs. Standard deviation is estimated at 6 mm for all analyses (calculated as the range/5 where the range is estimated at 3 cm/year).

Numeric Results for Paired *t*-test

Null Hypothesis: Mean of Paired Differences = 0, Alternative Hypothesis: Mean of Paired Differences $\neq$ 0; Unknown standard deviation.

Table F-2. Test results for accretion.

Power	N	Alpha	Beta	Mean of paired differences	S	Effect size
0.95	3	0.05	0.05	26.9	6.0	4.487
0.95	9	0.05	0.05	8.3	6.0	1.379
0.90	3	0.05	0.10	23.5	6.0	3.923
0.90	9	0.05	0.10	7.4	6.0	1.237
0.80	3	0.05	0.20	19.6	6.0	3.264
0.80	9	0.05	0.20	6.4	6.0	1.067

Summary Statements

A sample size of 3 (used when comparing rates at individual stations between two sampling events) achieves 80% power to detect a mean of paired differences of 19.6 mm with an estimated standard deviation of differences of 6.0 and with a significance level (alpha) of 0.05 using a two-sided paired *t*-test. A sample size of 9 (used when comparing rates at sampling locations between two sampling events) achieves 80% power to detect a mean of paired differences of 6.4 mm with an estimated standard deviation of differences of 6.0 and with a significance level (alpha) of 0.05 using a two-sided paired *t*-test (Figure F-2).

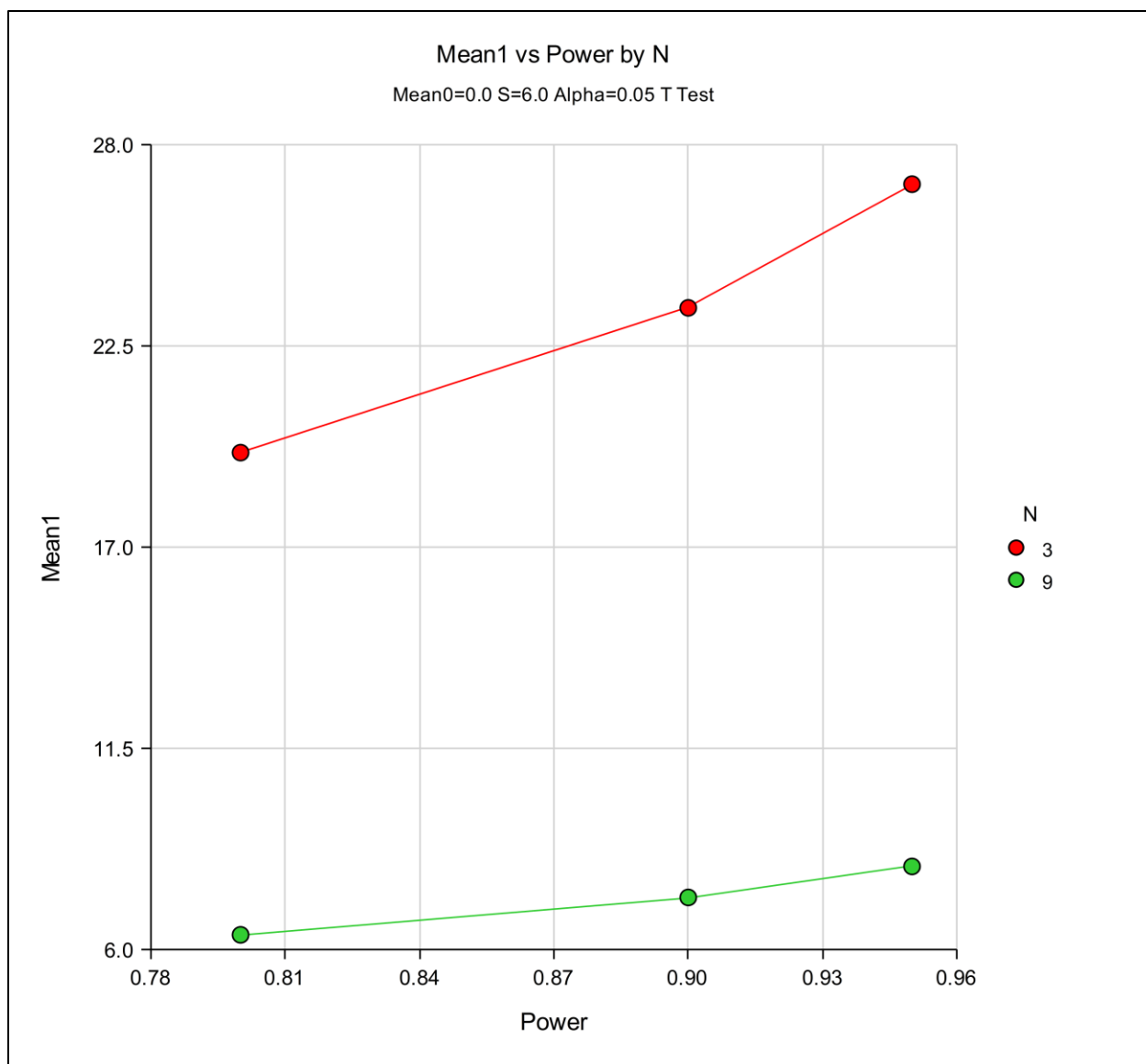


Figure F-2. Power analysis curves for comparing means of accretion rates between sampling events.

Soil Porewater Measurements

Power to detect differences between two sampling events is assessed using paired *t*-tests of means. For all analyses, we assume a normal distribution in the differences for matched pairs. Standard deviation is estimated at 3 for all analyses (calculated as the range/5 where the range is estimated at 15 ppt).

Numeric Results for Paired *t*-test

Null Hypothesis: Mean of Paired Differences = 0, Alternative Hypothesis: Mean of Paired Differences $\neq$ 0; Unknown standard deviation.

Table F-3. Test results for soil porewater.

Power	N	Alpha	Beta	Mean of paired differences	S	Effect size
0.95	3	0.05	0.05	13.5	3.0	4.487
0.95	9	0.05	0.05	4.1	3.0	1.379
0.90	3	0.05	0.10	11.8	3.0	3.923
0.90	9	0.05	0.10	3.7	3.0	1.237
0.80	3	0.05	0.20	9.8	3.0	3.264
0.80	9	0.05	0.20	3.2	3.0	1.067

Summary Statements

A sample size of 3 (used when comparing rates at individual stations between two sampling events) achieves 80% power to detect a mean of paired differences of 9.8 ppt with an estimated standard deviation of differences of 3.0 and with a significance level (alpha) of 0.05 using a two-sided paired *t*-test. A sample size of 9 (used when comparing rates at sampling locations between two sampling events) achieves 80% power to detect a mean of paired differences of 3.2 ppt with an estimated standard deviation of differences of 6.0 and with a significance level (alpha) of 0.05 using a two-sided paired *t*-test (Figure F-3).

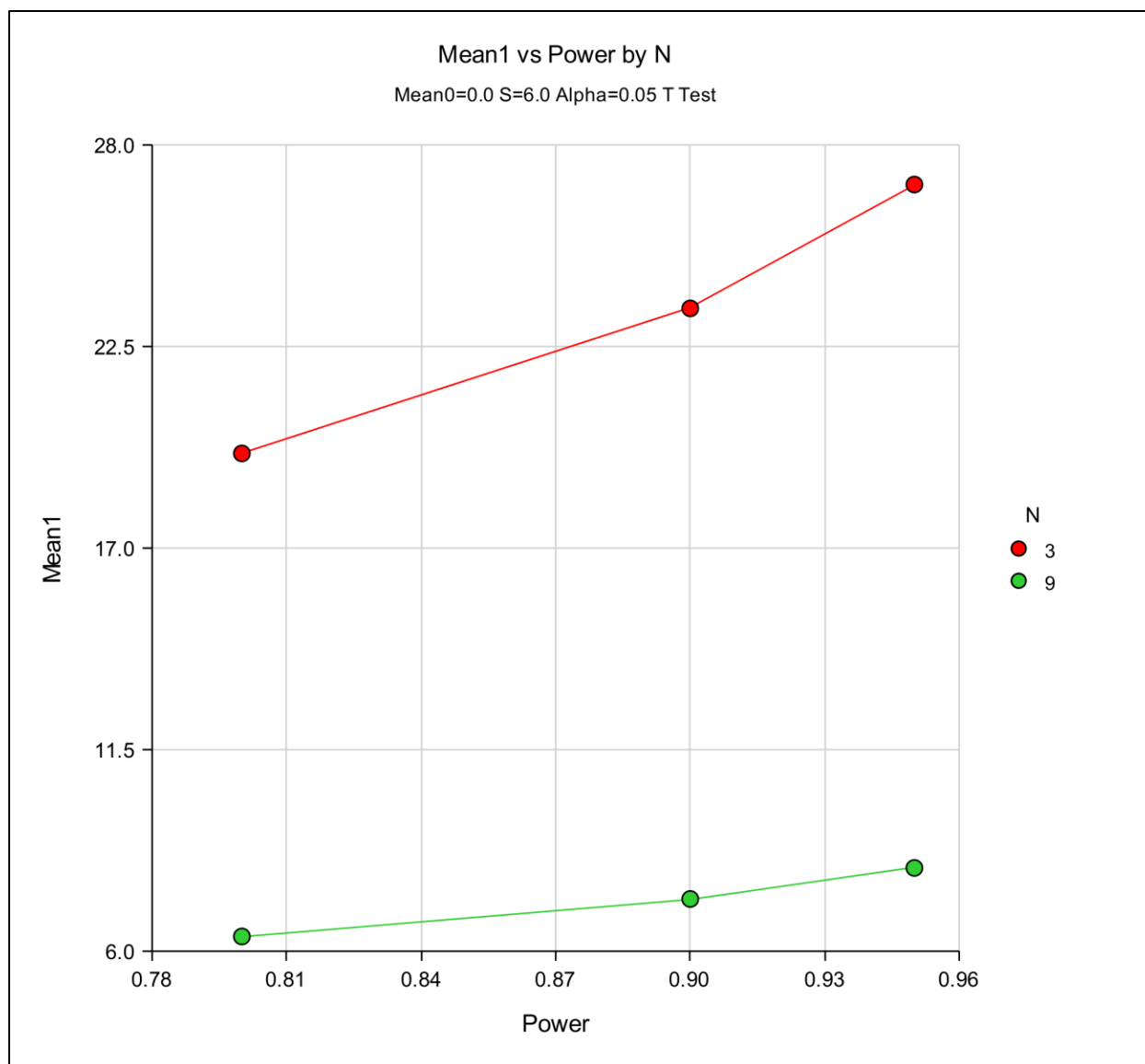


Figure F-3. Power analysis curves for comparing means of soil porewater salinity between sampling events.

SamplePoint Analyses of Vegetation and Non-vegetation Cover Types

Power to detect differences between two sampling events is assessed using a paired *t*-test of means. For all analyses, we assume a normal distribution in the differences for matched pairs. Standard deviation is estimated at 0.2 for all analyses (calculated as the range/5 where the range = 1).

Numeric Results for Paired t-test

Null Hypothesis: Mean of Paired Differences = 0, Alternative Hypothesis: Mean of Paired Differences $\neq$ 0, unknown standard deviation.

Table F-4. Test results for vegetation cover.

Power	N	Alpha	Beta	Mean of paired differences	S	Effect size
0.95	5	0.05	0.05	0.4	0.2	2.204
0.95	10	0.05	0.05	0.3	0.2	1.286
0.95	15	0.05	0.05	0.2	0.2	1.002
0.95	20	0.05	0.05	0.2	0.2	0.850
0.90	5	0.05	0.10	0.4	0.2	1.966
0.90	10	0.05	0.10	0.2	0.2	1.155
0.90	15	0.05	0.10	0.2	0.2	0.901
0.90	20	0.05	0.10	0.2	0.2	0.764
0.80	5	0.05	0.20	0.3	0.2	1.682
0.80	10	0.05	0.20	0.2	0.2	0.996
0.80	15	0.05	0.20	0.2	0.2	0.778
0.80	20	0.05	0.20	0.1	0.2	0.660

Summary Statements

A sample size of five achieves 95% power to detect a mean of paired differences of 0.4 with an estimated standard deviation of differences of 0.2 and with a significance level (alpha) of 0.05000 using a two-sided paired *t*-test (Figure F-4).

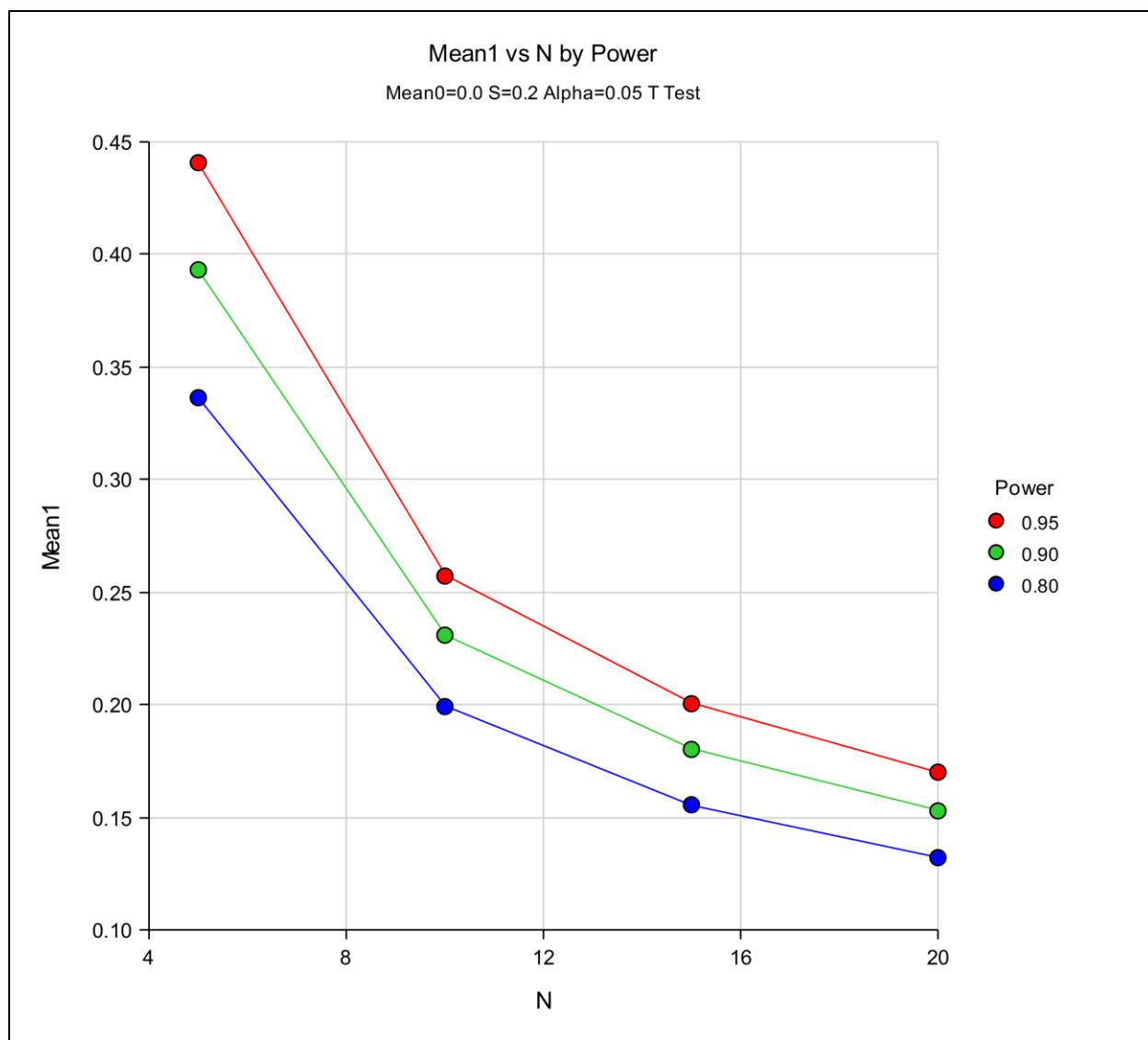


Figure F-4. Power analysis curves for comparing means of vegetation cover between sampling events.

References for power analysis

- Machin, D., M. Campbell, P. Fayers, and A. Pinol. 1997. Sample size tables for clinical studies, 2nd Edition. Blackwell Science, Malden, Massachusetts.
- Zar, J. H. 1984. Biostatistical analysis, 2nd edition. Prentice-Hall. Englewood Cliffs, New Jersey.

Appendix G. Permits



MARK WILLIAMS
COMMISSIONER

A.G. 'SPUD' WOODWARD
DIRECTOR

COASTAL MARSHLANDS PROTECTION ACT STAFF'S FINDINGS & RECOMMENDATIONS

February 10, 2012

TO: Coastal Marshlands Protection Committee:
Commissioner Mark Williams, Chairman
Ms. Leslie Mattingly
Mr. Henry Williams, Jr.
Mr. Sonny Timmerman
Mr. Rick Gardner

FROM: Department Staff to the Committee

APPLICANT: Southeast Coast Network, National Park Service
101 Wheeler Street
Saint Marys, GA 31558

AGENT: Tony Curtis, PWS
Southeast Coast Network, National Park Service
101 Wheeler Street
Saint Marys, GA 31558

LOCATION: Multiple Locations throughout Coastal Georgia.

PROJECT: The proposed project is for the installation of scientific monitoring equipment stations at multiple sites throughout coastal Georgia. The project is less than 1/10 of an acre and is considered a minor alteration of coastal marshlands under O.C.G.A. 12-5-280 *et seq.*

ARMY CORPS NUMBER: 2011-00418, NWP 5

APPLICABLE LAW: O.C.G.A. §12-5-280 *et seq.*, as amended, Coastal Marshlands Protection Act of 1970.

SUMMARY OF PUBLIC COMMENTS: The public notice of the Coastal Marshlands Protection Committee (CMPC) ran from January 6, 2012 to February 6, 2012. One comment was received supporting the project.

FINDINGS: Department Staff to the CMPC make the following findings regarding this application:

Project Scope and Justification: O.C.G.A. § 12-5-286(b); O.C.G.A. § 12-5-286 (b) (8) requires a discussion of why the permit should be granted.

1. The applicant proposes to install eight (8) monitoring stations in various locations in coastal Georgia.
2. Five (5) stations will be located at Cumberland Island National Seashore in Camden County. One (1) station will be located at Fort Frederica National Monument in Glynn County, and two (2) stations will be located at Fort Pulaski National Monument in Chatham County.
3. The purpose of the project is to allow for measurements of both salt marsh accretion, and subsidence and sea level rise.
4. The rod-surface elevation table (RSET) method will be used to provide a non-destructive process to precisely measure sediment elevation over a long period of time. Construction of permanent stations will enable the installation of the deep rods for the RSET and other data collection stations to be performed from the platform without disturbing the surface of the marsh.
5. Each station will consist of two platforms, one approximately 29.5' x 2' (59 sq. ft.) and one approximately 9.8' x 2' (19.6 sq. ft.). Each platform will be constructed of two 2" x 8" x 10' boards arranged parallel to each other and spaced approximately 10 cm (4") apart to allow for sunlight to penetrate down to marsh vegetation.
6. The platforms will be elevated a minimum of 45 cm (18") in height by support structures constructed of 2" x 4" lumber. All lumber used to construct the platforms will be pressure treated.
7. Each station represents approximately 78.6 sq. ft. square feet of shading impact to vegetated marsh for a total of 628.8 sq. ft. (0.014 acre) for all eight stations.

O.C.G.A. § 12-5-286 (b) (8) requires a discussion of why the permit should be granted.

8. The installation of raised monitoring stations is essential to the success of the research project because it allows the monitoring activities to be conducted with minimal human impact to the surface of the marsh.

Application Form, Applicant Name and Address, Project Plans, Plat, Deed or other instrument, Written permission to carry out project by owner of land, O.C.G.A. § 12-5-286(b)(1-4):

9. Applicant has submitted the application form, name and address, project plans, plats, and deed.

Adjoining Landowners, Non-refundable application fee, O.C.G.A. § 12-5-286 (b)(5,7):

10. Applicant has submitted names and addresses of adjoining property owners as well as the non-refundable application fee.

Local Government Zoning, O.C.G.A. § 12-5-286(b)(6):

11. Letters have been received from the local government zoning offices of Camden County, Glynn County and Chatham County stating that the proposed activity is not prohibited under current zoning. The letters are not conditioned.

Alternative Sites Description and Feasibility 12-5-286 (b)(8):

12. The only alternative would be to not conduct this particular scientific research study in Coastal Georgia.

Landfill, Hazardous Waste Inquiry, O.C.G.A. § 12-5-286(b)(9):

13. Applicant has reviewed the Hazardous Site Index maintained by Georgia Environmental Protection Division. There are no landfills or hazardous waste sites near the proposed project locations.

Water Quality Certification, O.C.G.A. § 12-5-286(b)(10):

14. The 401 Water Quality Certification is not required for this project.

Adherence to Erosion and Sediment Control Responsibilities, O.C.G.A. § 12-5-286 (b)(11):

15. Applicant has stated the intention to adhere to soil and erosion control responsibilities.

Notification of Proposed Project, O.C.G.A. § 12-5-286(d)(e):

16. Adjacent property owners and interested parties who have requested to be placed on the mailing list were notified in writing of the proposed project. The public notice of the Coastal Marshlands Protection Committee (CMPC) ran from January 6, 2012 to February 6, 2012. One comment was received supporting the project.

Public Interest Considerations, O.C.G.A. § 12-5-286(g):

17. In passing upon application for a permit, the CMPC shall consider the public interest.
- a. The design of the project is such that no unreasonably harmful obstruction to or alteration of the natural flow of navigational water within the affected area will arise as a result of the proposal.** The proposed project locations are not located in navigable waters. The monitoring stations are elevated off the marsh surface allowing free flow of water across the marsh surface at times of higher tide levels. No unreasonably harmful obstruction to or alteration of the natural flow of navigational water within the affected area is expected as a result of the project.
 - b. The design of the project is such that no unreasonably harmful or increased erosion, shoaling of the channels, or stagnant areas of water will be created.** The monitoring stations are elevated off the marsh surface allowing free flow of water across the marsh surface at times of higher tide levels. Therefore, the proposed project is not expected to result in increased erosion, shoaling of channels or stagnant areas of water.
 - c. The proposal will not unreasonably interfere with the conservation of fish, shrimp, oysters, crabs, and clams or any marine life or wildlife or other natural resources including but not limited to water and oxygen supply.** The monitoring stations are designed to allow for some light penetration to the marsh surface below. They are also narrow in design and elevated up off of the marsh surface. The amount of shading impact that will occur from the presence of these structures will not be unreasonable. Therefore, the proposed project is not expected to unreasonably interfere with the conservation of fish, shrimp, oysters, crabs, and clams or any marine life or wildlife or other natural resources including but not limited to water and oxygen supply.

Restriction on granting of permits; size restriction; activities and structures considered contrary to the public interest, O.C.G.A. § 12-5-288 (a) and (b):

18. The proposed project is water-related and water dependent.

Leasing of state owned marshland or water bottoms, O.C.G.A. § 12-5-287:

19. A waterbottoms lease is not required.

Determining Project Boundaries, Rule 391-2-3-.02(3):

20. The marsh component of the project are the eight monitoring stations each consisting of two platforms, one approximately 29.5' x 2' (59 sq. ft.) and one approximately 9.8' x 2' (19.6 sq. ft.). Each platform will be constructed of two 2" x 8" x 10' boards arranged parallel to each other and spaced approximately 10 cm (4") apart of two elements.
21. There are no upland areas meeting the definition of "upland component" as defined in Rule 391-2-3-.02 "Regulation of Upland Component of a Project. Amended" at any of the eight locations.

RECOMMENDATION: Should the Committee determine that the proposed project is in the public interest, Department staff recommends the following STANDARD and SPECIAL conditions:

COASTAL MARSHLANDS PROTECTION ACT STANDARD CONDITIONS

1. The project must comply, as applicable, for areas permitted herein, with all other federal, state, and local statutes, ordinances, and regulations and the applicant must obtain all licenses and permits prior to commencement of construction.
2. This permit does not resolve actual or potential disputes regarding ownership of, rights in or over the property upon which the subject project is proposed, and shall not be construed as recognizing or denying any such rights or interests.
3. All plans, documents and materials contained in this permit application, required by Coastal Marshlands Protection Act of 1970, as amended O.C.G.A. § 12-5-280 et seq. are a part of this permit and conformance to such plans, documents, and materials are a condition of this permit. No change or deviation from these plans, documents, and materials shall be permitted without prior notification and approval by the Department or CMPC.
4. No further encroachment or construction shall take place within state jurisdiction, except as permitted by the CMPC. Any modification of the plans or structure in the jurisdictional area must be reviewed and approved by the Department or the CMPC, as necessary, prior to construction.
5. No construction or alteration of a project may commence until the expiration of 30 days following the date on which the application is approved; provided however that if a timely appeal is filed, no construction or alteration may commence until all administrative and judicial proceedings are terminated.
6. The permit must be posted onsite within twenty-four (24) hours of beginning construction.
7. A copy of these and all permit conditions must be supplied to the person in charge of construction. All contractors and subcontractors are responsible for strict adherence to all permit conditions.
8. All Best Management Practices (BMPs) should be used to prevent any erosion and sedimentation at the site. No equipment, materials, or debris may be placed in, disposed of,

or stored in jurisdictional areas. Any visible alterations in the marsh topography will be restored immediately using low-impact hand tools. Any damage to the marsh vegetation that has not recovered naturally during the next growing season will be repaired by a method acceptable to the Department.

9. If the permitted improvements are damaged, fall into disrepair, become dilapidated, or are not meeting their expected usefulness and are not maintained at a serviceable level, it is the responsibility of the owner to remove the improvements. A new permit will be required to retain and repair the structure, improvement, or asset if it loses its structural integrity and is no longer serviceable.
10. The CMPC is not bound in the future to protect any improvement or asset authorized by the permit.

SPECIAL CONDITIONS:

1. All equipment must be operated from the upland. No construction materials or machinery shall be stored or operated in the jurisdictional marshlands.
2. Should unreasonable damage to the marsh surface occur, preexisting surface elevations shall be restored using hand tools. Such restoration must be coordinated with the Department prior to conducting.
3. There shall be no disposal of excavated sediments in coastal marshlands.
4. Siltation screens shall be placed where disposal of material will occur to hold placed material and to prevent fill of coastal marshlands.
5. Maintenance work can be performed during the 5-year life of this permit with 48 hour advanced notice provided to the Department. Notice shall include estimates of length of time the maintenance activity will occur and the anticipated quantity of sediment to be removed.
6. Construction activities shall be performed using best management practices (BMPs) to comply with the Georgia Erosion & Sedimentation Act, O.C.G.A. §12-7-1 *et seq.*
7. Permittee may be required to provide a post-construction survey to the Georgia Department of Natural Resources, Coastal Resources Division upon completion of the permitted activity. Such survey shall comply with the Georgia Plat Act O.C.G.A. 15-6-67 *et seq.*

02 MAY 2013



North Carolina Department of Environment and Natural Resources

Division of Coastal Management

Pat McCrory
Governor

Braxton C. Davis
Director

John E. Skvarla, III
Secretary

May 1, 2013

Patrick Kenney
Superintendent
Cape Lookout National Seashore
131 Charles Street
Harkers Island, NC 28531

SUBJECT: CD13-028 – Consistency Concurrence for the Installation of Two Monitoring Stations, Cape Lookout National Seashore and Cape Hatteras National Seashore, Carteret and Dare Counties, North Carolina (DCM#20130031)

Dear Mr. Kenney:

We received your consistency submission on March 25, 2013 concerning the establishment of two salt marsh elevation monitoring stations. One monitoring station will be located at the Cape Lookout National Seashore and the other at the Cape Hatteras National Seashore. The purpose of these stations is to measure the elevation of salt marsh as related to changes in sea level rise.

North Carolina's coastal zone management program consists of, but is not limited to, the Coastal Area Management Act, the State's Dredge and Fill Law, Chapter 7 of Title 15A of the North Carolina Administrative Code, and the land use plan of the County and/or local municipality in which the proposed project is located. It is the objective of the Division of Coastal Management (DCM) to manage the State's coastal resources to ensure that proposed Federal activities would be compatible with safeguarding and perpetuating the biological, social, economic, and aesthetic values of the State's coastal waters.

To solicit public comments, DCM circulated a description of the proposed action to State agencies that would have a regulatory interest. No comments asserting that the proposed activity would be inconsistent with the State's coastal management program were received.

DCM has reviewed the submitted information pursuant to the management objectives and enforceable policies of Subchapters 7H and 7M of Chapter 7 in Title 15A of the North Carolina

400 Commerce Ave., Morehead City, NC 28557-3421
Phone: 252-808-2808 \ FAX: 252-247-3330 Internet: www.nccoastalmanagement.net

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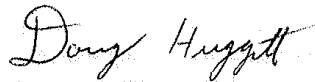
Administrative Code and concurs, as conditioned below, that the proposed Federal activity by the National Park Service (Applicant) is consistent, to the maximum extent practicable, with North Carolina's certified coastal management program.

- Each monitoring station, at the time of decommissioning, shall be removed by the Applicant, provided that the removal can be done in a manner that minimizes additional impacts to the marsh.

This letter of concurrence is contingent on the Federal agency agreeing with the condition stated above. In the event that the Federal agency does not agree with the condition of concurrence, this letter effectively becomes a letter of State "*Objection*". Should the Federal agency not agree with the condition stated above, a letter of non-agreement should be sent to DCM. The procedures of 15 CFR 930.43 would then need to be followed.

Should the proposed action be modified, a revised consistency determination could be necessary. This might take the form of either a supplemental consistency determination pursuant to 15 CFR 930.46, or a new consistency determination pursuant to 15 CFR 930.36. Likewise, if further project assessments reveal environmental effects not previously considered by the proposed development, a supplemental consistency certification may be required. If you have any questions, please contact Stephen Rynas at 252-808-2808 x209. Thank you for your consideration of the North Carolina Coastal Management Program.

Sincerely,



Doug Huggett
Manager, Major Permits and Consistency Unit

Cc: Roy Brownlow, Division of Coastal Management
Frank Jennings, Division of Coastal Management
Michael Rikard, National Park Service

From: Tony_Curtis@nps.gov [mailto:Tony_Curtis@nps.gov]
Sent: Friday, June 03, 2011 11:20 AM
To: Sarchet, Aaron
Subject: RE: Request to Modify Permit Numbers SAJ-2009-354 (NW-NBF) and 16-293758-001-EE

Tony Curtis, PWS
Coastal Ecologist
Southeast Coast Network
National Park Service
101 Wheeler Street
Saint Marys, GA 31558

<http://science.nature.nps.gov/im/units/secn> or follow us on
Twitter - <http://twitter.com/SECoastNetwNPS>

[illegible]



DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT CORPS OF ENGINEERS
POST OFFICE BOX 4970
JACKSONVILLE, FLORIDA 32232-0019

REPLY TO
ATTENTION OF

June 7, 2011

Regulatory Division
North Permits Branch
Jacksonville Permits Section
SAJ-2009-00354 (NW-JKM)

Mr. Tony Curtis
National Park Service - Timucuan Preserve
13165 Mount Pleasant Road
Jacksonville, FL 32225

Dear Mr. Curtis:

Your application for a Department of the Army permit received on June 1, 2011, has been assigned number SAJ-2009-00354. A review of the information and drawings provided shows the proposed work is to install five salt marsh community monitoring sites. The project sites are located as follows: site 20 on the Nassau River in the northwest section of the park, site 27 just off Clapboard Creek, in the southeast area of the park, site 54 on a tributary off Pumpkin Hill Creek, site 65 on Seaton Creek, in the very northwest corner of the park, and site 78 on a tributary of Garden Creek, in the Timucuan Ecological and Historic Preserve, Duval County, Florida.

Your project, as depicted on the enclosed drawings, is authorized by Nationwide Permit (NWP) Number 5. In addition, project specific conditions have been enclosed. This verification is valid until the NWP is modified, reissued, or revoked prior to March 18, 2012. It is incumbent upon you to remain informed of changes to the NWPs. We will issue a public notice when the NWPs are issued. Furthermore, if you commence or are under contract to commence this activity before the date that the relevant nationwide permit is modified or revoked, you will have 12 months from the date of the modification or revocation of the NWP to complete the activity under the present terms and conditions of this nationwide permit. Please access the U.S. Army Corps of Engineers' (Corps) Jacksonville District's Regulatory webpage to access web links to view the Final Nationwide Permits, Federal Register Vol. 72, dated March 12, 2007, the Corrections to the Final Nationwide Permits, Federal Register 72, May 8, 2007, and the List of Regional Conditions. The website address is as follows:

<http://www.saj.usace.army.mil/Divisions/Regulatory/sourcebook.htm>.

Please be aware this web address is case sensitive and should be entered as it appears above. Once there you will need to click on "Nationwide Permits." These files contain the description of the Nationwide Permit authorization, the Nationwide Permit general conditions, and the regional conditions, which apply specifically to this verification for NWP 5. Additionally, enclosed is a list of the six General Conditions, which apply to all Department of the Army authorizations. You must comply with all of the special and general conditions and any project specific condition of this authorization or you may be subject to enforcement action. In the event you have not completed construction of your project within the specified time limit, a separate application or re-verification may be required.

The following special conditions are included with this verification:

1. Within 60 days of completion of the work authorized, the attached "Self-Certification Statement of Compliance" must be completed and submitted to the U.S. Army Corps of Engineers. Mail the completed form to the Regulatory Division, Special Projects and Enforcement Branch, Post Office Box 4970, Jacksonville, Florida 32232-0019.

2. The Permittee understands and agrees that, if future operations by the United States require the removal, relocation, or other alteration, of the structures or work herein authorized, or if, in the opinion of the Secretary of the Army or his authorized representative, said structure or work shall cause unreasonable obstruction to the free navigation of the navigable waters, the Permittee will be required, upon due notice from the U.S. Army Corps of Engineers, to remove, relocate, or alter the structural work or obstructions caused thereby, without expense to the United States. No claim shall be made against the United States on account of any such removal or alteration.

3. No structure or work shall adversely affect or disturb properties listed in the National Register of Historic Places or those eligible for inclusion in the National Register. Prior to the start of work, the Permittee or other party on the Permittee's behalf, shall conduct a search in the National Register Information System (NRIS). Information can be found at; <http://www.cr.nps.gov/nr/research>. Information on properties

eligible for inclusion in the National Register can be identified by contacting the Florida Master File Office by email at fmsfile@dos.state.fl.us or by telephone at 850-245-6440.

If unexpected cultural resources are encountered at any time within the project area that was not the subject of a previous cultural resource assessment survey, work should cease in the immediate vicinity of such discoveries. The permittee, or other party, should notify the SHPO immediately, as well as the appropriate Army Corps of Engineers office. After such notifications, project activities should not resume without verbal and/or written authorization from the SHPO.

If unmarked human remains are encountered, all work shall stop immediately, and the proper authorities notified in accordance with Section 872.05, Florida Statutes, unless on Federal lands. After such notifications, project activities on non-Federal lands shall not resume without verbal and/or written authorization from the Florida State Archaeologist for finds under his or her jurisdiction.

This letter of authorization does not obviate the necessity to obtain any other Federal, State, or local permits, which may be required. In Florida, projects qualifying for this NWP must be authorized under Part IV of Chapter 373 by the Department of Environmental Protection, a water management district under §. 373.069, F.S., or a local government with delegated authority under §. 373.441, F.S., and receive Water Quality Certification (WQC) and Coastal Zone Consistency Concurrence (CZCC) (or a waiver), as well as any authorizations required by the State for the use of sovereign submerged lands. You should check State-permitting requirements with the Florida Department of Environmental Protection or the appropriate water management district.

This letter does not give absolute Federal authority to perform the work as specified on your application. The proposed work may be subject to local building restrictions mandated by the National Flood Insurance Program. You should contact your local office that issues building permits to determine if your site is located in a flood-prone area, and if you must comply with the local building requirements mandated by the National Flood Insurance Program.

-4-

If you are unable to access the internet or require a hardcopy of any of the conditions, limitations, or expiration date for the above referenced NWP, please contact me by telephone at 904-232-3358.

Thank you for your cooperation with our permit program. The Corps Jacksonville District Regulatory Division is committed to improving service to our customers. We strive to perform our duty in a friendly and timely manner while working to preserve our environment. We invite you to take a few minutes to visit the following link and complete our automated Customer Service Survey: <http://per2.nwp.usace.army.mil/survey.html>. Your input is appreciated - favorable or otherwise. Again, please be aware this web address is case sensitive and should be entered as it appears above.

Sincerely,



John Mask
Project Manager

Enclosures

Copy Furnished:

CESAJ-RD-PE

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 910/128957, June 2015

National Park Service
U.S. Department of the Interior



Natural Resource Stewardship and Science

1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525

www.nature.nps.gov