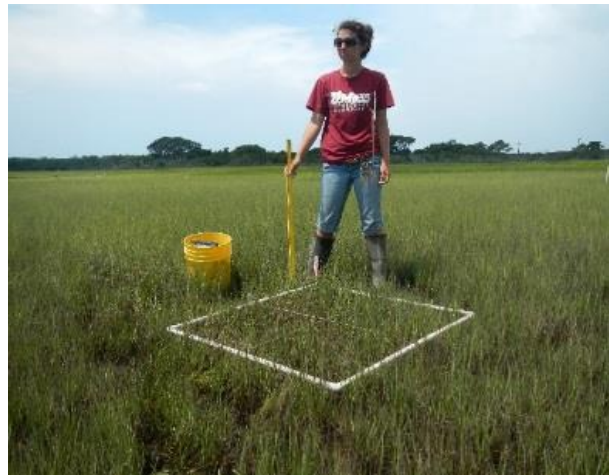


Coastal Wetlands Monitoring in the Southeast U.S.



This project was funded by EPA Region 4 Wetland Program Development Grant. This report was prepared for the GSAA by Kim Matthews, RTI International in partnership with the GSAA's Clean Coastal and Ocean Waters Technical Team.

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ACRONYMS

ACE	Ashepoo-Combahee-Edisto
APNEP	Albemarle-Pamlico National Estuary Partnership
CCFHR	Center for Coastal Fisheries and Habitat Research
CCHA	Critical Coastal Habitat Assessment
CCOW	Clean Coastal and Ocean Waters
CHIMMP	Coastal Habitat Integrated Mapping and Monitoring Program
CVS	Carolina Vegetation Survey
CWEM	Coastal Wetland Elevation Monitoring
CWRE	Coastal Wetland Restoration and Evaluation
DCERP	Defense Coastal/Estuarine Research Program
ELI	Environmental Law Institute
EPA	U.S. Environmental Protection Agency
FGDC	Federal Geographic Data Committee
GA AAW	Coastal Georgia Adopt-A-Wetland
GA CRD	Georgia Department of Natural Resources, Coastal Resources Division
GA EPD	Georgia Department of Natural Resources, Environmental Protection Division
GCE-LTER-CLIM	Georgia Coastal Ecosystems Long Term Ecological Research Climate Monitoring
GCE-LTER-STWL	Georgia Coastal Ecosystems Long Term Ecological Research Continuous Salinity, Temperature and Water Level Monitoring
GCE-LTER-WQM	Georgia Coastal Ecosystems Long Term Ecological Research Climate Monitoring Water Quality Monitoring
GIS	geographical information systems
GIW	geographically isolated wetlands
GSAA	Governors' South Atlantic Alliance
GTM	Guana Tolomato Matanzas
GTMNERR-SWMP	Guana Tolomato Matanzas National Estuarine Research Reserve System-Wide Monitoring Program
HGM	hydrogeomorphic
HUC	hydrologic unit code
I&M	Inventory & Monitoring
LDI	Landscape Development Intensity
LIDAR	light detection and ranging
LLWW	landscape position, landform, water flow path, and waterbody type
LoBOS	Long Bay Observation System
LS	Living Shorelines
MAREX	University of Georgia's Marine Extension Service
MD	Marsh Dieback
MEA	Marsh Edge Assessment

NARS	National Aquatic Resource Surveys
NC DEQ	North Carolina Department of Environmental Quality
NC-CREWS	North Carolina Coastal Region Evaluation of Wetland Significance
NCDWR	North Carolina Division of Water Resources
NCNERR	North Carolina National Estuarine Research Reserve
NCNERR-SWMP	North Carolina National Estuarine Research Reserve System-Wide Monitoring Program
NCSU	North Carolina State University
NC WAM	North Carolina Wetland Assessment Method
NERRS	National Estuarine Research Reserve Systems
NOAA	National Oceanic and Atmospheric Administration
NSF-LTREB	National Science Foundation Long Term Research in Environmental Biology at North Inlet, SC
NWCA	National Wetland Condition Assessment
NWI	National Wetlands Inventory
NWRS	National Wildlife Refuge System
ORAM	Ohio Rapid Assessment Method
PCQ	Point-Centered Quarter
SAV	submerged aquatic vegetation
SC DHEC	South Carolina Department of Health and Environmental Control
SCDNR	South Carolina Department of Natural Resources
SECOORA	Southeast Coastal Ocean Observing Regional Association
SEIWA	Southeast Isolated Wetlands Assessment
SET	Surface elevation table
SINERR	Sapelo Island National Estuarine Research Reserve
SINERR-SWMP	Sapelo Island National Estuarine Research Reserve System Wide Monitoring Program
SJRWMD	St. Johns River Water Management District
SWMP	System-Wide Monitoring Program
TB CCHA	Tampa Bay Critical Coastal Habitat Assessment
TBEP	Tampa Bay Estuary Program
TNC	The Nature Conservancy
TOWeR	Timberlake Observatory for Wetland Restoration
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
NC WMN	North Carolina Wetland Monitoring Network
WRAP	Wetland Rapid Assessment Procedure

EXECUTIVE SUMMARY

The Governors' South Atlantic Alliance (GSAA) has a long-term vision of providing regional-scale data, analysis, information, and research that meet the common needs of member states in pursuing their priorities for wetlands protection, restoration, and management with the ultimate goals of improving water quality and coastal resilience. The goals of this project were to improve coordination among coastal wetlands monitoring programs across North Carolina, South Carolina, Georgia, and the Atlantic coast of Florida; identify opportunities to enhance comparability of wetland monitoring programs; build awareness of available data; and improve information sharing. The findings reported here contribute significantly to any future efforts to establish regional coastal wetlands monitoring guidelines.

The first task was to establish a regional workgroup of coastal wetlands monitoring experts representing a cross-section of scientists and managers. The workgroup included 20 to 25 active members that provided input to the program through monthly webinars and three in-person meetings from October 2015 through December 2016.

The second task was to develop and generate a catalog of existing coastal wetlands monitoring programs that included information about where data are collected, what data parameters are sampled, and what methods are employed to collect the data. This Coastal Wetlands Monitoring Metadata Data Catalog provides a centralized location to access information about coastal wetland monitoring programs and station information in North Carolina, South Carolina, Georgia, and Florida (Atlantic Coast). The user-friendly interface allows exploration of the different coastal wetlands monitoring programs, identifying where to find monitoring data of interest. The database contains over 700 monitoring stations from 35 monitoring programs of 19 organizations. While the focus was on coastal wetlands, stations throughout the project area were included in the database, as were non-wetlands stations for monitoring nearby surface waters, atmospheric conditions, and oyster reefs.

The final task was to assess the monitoring methods employed across the region. The compilation of the methods contained within this report serves as the starting point for developing regional monitoring guidelines. Many coastal wetlands monitoring programs are either short term (1 to 2 years) or are just in their infancy. The final section of this report identifies the opportunities and obstacles for the next step in developing regional monitoring guidelines.

1. BACKGROUND

1.1 Introduction

Monitoring the coastal wetlands of North Carolina, South Carolina, Georgia, and Florida is necessary to understand the current extent, condition, and function of these important resources and to begin to predict how these ecosystems will respond to changes in land use, climate, sea level, and water quality. Currently, there is no standardized or widely accepted set of monitoring practices in use across these South Atlantic states. Instead, various federal, state, and local agencies, in addition to universities and nongovernmental organizations, are monitoring one or more aspects of coastal wetlands and their associated waters for sometimes different purposes. However, there is little coordination among these agencies and organizations with only limited sharing of data and information and leveraging of resources.

The Governors' South Atlantic Alliance (GSAA) has a long-term vision of providing regional-scale data, analysis, information, and research that meet the common needs of member states in pursuing their priorities for wetlands protection, restoration, and management with the ultimate goals of improving water quality and coastal resilience. The GSAA developed a framework for the South Atlantic region that brings together critical partners from national, regional, and state levels to produce data and results to address the regional-scale need for coastal wetland monitoring and assessment.

1.2 Purpose and Goals

The GSAA received funding for this project to facilitate communication about coastal wetland science in the South Atlantic and to assess the comparability of state monitoring efforts, through a Wetland Program Development Grant from the U.S. Environmental Protection Agency (EPA) Region 4. The goals of this project were to improve coordination among coastal wetlands monitoring programs across North Carolina, South Carolina, Georgia, and the Atlantic coast of Florida; identify opportunities to enhance comparability of wetland monitoring program methods and data; build awareness of available methods and data; and, improve information sharing. These findings will significantly contribute to any future efforts to establish regional coastal wetlands monitoring guidelines.

1.3 Approach

The GSAA contracted RTI International to develop and implement a plan to achieve these goals. First, a regional workgroup was established that reflected the coastal wetlands monitoring expertise in the region. With input from the workgroup, RTI developed and generated a catalog of existing coastal wetlands monitoring programs that including information on where data are collected, what data parameters are sampled, and what methods are employed to collect the data. Based on the information in the database, RTI

assessed the comparability of the monitoring programs methods and data and identified opportunities for future collaboration among existing programs. The purpose of this report is to summarize the outputs from each of these tasks. Both the report and the data catalog are the final products from this project that can be used to enhance collaboration among coastal wetland monitoring programs across the southeastern United States.

2. COASTAL WETLANDS MONITORING WORKGROUP

2.1 Workgroup Membership

The responsibility of monitoring wetlands often falls to multiple state agencies; therefore, to be successful, the workgroup needed to be inclusive of all state agencies with an interest in coastal waters. The workgroup was also inclusive of practitioners from federal agencies and universities conducting coastal wetlands related monitoring efforts. RTI worked in partnership with the GSAA Clean Coastal and Ocean Waters (CCOW) Technical Team to identify and recruit workgroup members from each state. The goal was to have 3 to 5 members from each state that represented a cross-section of agencies and institutions conducting coastal wetlands related monitoring.

2.2 Participation/Engagement Process

The Coastal Wetlands Monitoring Workgroup was an integral part of this project as they helped to guide the development of the database and provided much of the information included within the database. Workgroup members participated in monthly webinars and three in-person meetings with remote participation possible for members who could not travel. The meetings utilized collaborative features such as online polls and chat functions to ensure equal opportunity to participate among members.

Meeting presentations were posted on the GSAA website to inform workgroup members who may have missed a meeting. In addition, the workgroup re-evaluated decisions made at previous meetings through distribution of meeting minutes and through presentations at the current monthly meeting to ensure agreement among participants. This step was important for ensuring that workgroup members had ownership in the process and thus were more likely to use products from this project in future monitoring efforts.

2.3 Workgroup Members

The Coastal Wetlands Monitoring Workgroup had approximately 30 members. The members are listed in **Table 2-1**. Membership was equally divided among the four states.

Table 2-1. Members of the Coastal Wetlands Monitoring Workgroup and their Affiliation

Name	Affiliation
North Carolina (NC)	
Cyndi Karoly & Kristie Gianopulos	NC Division of Water Resources
Dean Carpenter	Albemarle-Pamlico National Estuary Partnership
Brandon Puckett	NC National Estuarine Research Reserve (NERR)
Tancred Miller	NC DEQ Division of Coastal Management
Christine Pickens	The Nature Conservancy
Georgia (GA)	
Jan Mackinnon & Dominic Guadagnoli, Ben Maher, Sheldon Leiker	GA Department of Natural Resources
Jessica O'Connell	University of Georgia
Nicole Rankin	U.S. Fish and Wildlife Service
Doug Sampson	Sapelo Island NERR
Katy Smith	University of Georgia Marine Extension and Georgia Sea Grant
Florida (FL)	
J. Cho	Bethune-Cookman University
Nikki Dix	Guana Tolomato Matanzas NERR
Laura Geselbracht	The Nature Conservancy
Paul Haydt & Chuck Jacoby	St. Johns River Water Management District
Ryan Moyer & Kara Radabaugh	Florida Fish and Wildlife Research Institute
Kelly Reiss	University of Florida
South Carolina (SC)	
David Chestnut & Rusty Wenerick	SC Dept. of Health & Environmental Control
Denise Sanger	SC Department of Natural Resources
Richard Viso	Coastal Carolina University
EPA	
Rhonda Evans	EPA Region 4
Pete Kalla	EPA Region 4

2.4 Summary of Meetings

The initial workgroup webinar was held in November 2015; monthly meetings (webinars) were held on the third Thursday of each month through November 2016. Three, 2-day in-person meetings were held at locations sponsored by workgroup members for further

discussion of the development of the database and comparability of monitoring program methods and data. These meetings were held on the dates and at the locations listed below:

- February 2016: South Carolina Department of Natural Resources, Marine Resources Division, Marine Resources Research Institute in Charleston, South Carolina
- June 2016: Guana Tolomato Matanzas (GTM) National Estuarine Research Reserve facility in Ponte Vedra, Florida
- December 2-3: Villas by the Sea Conference Center on Jekyll Island, Georgia

Presentations from these meetings are posted on the GSAA website (<http://southatlanticalliance.org/coastal-wetlands-monitoring-workgroup/>).

3. COASTAL WETLANDS MONITORING DATA CATALOG

3.1 Design Requirements

RTI developed a catalog of stations and available monitoring data for coastal wetlands in the South Atlantic states. The design of the data catalog and user interface was developed based on input from the Coastal Wetlands Monitoring Workgroup (Section 2.3).

The Coastal Wetlands Monitoring Data Catalog was designed to be easy to access and query. The data catalog was created using Microsoft Access and is available at the GSAA website (<http://southatlanticalliance.org/>). The data catalog provides a centralized location to access information about coastal wetland monitoring programs and station information including geographic location, wetland type, parameters monitored, and sampling methods used. As available, web links were provided for the user to access the data and additional information about the monitoring program.

The workgroup discussed and decided on the geographic scope and definition of “coastal wetlands” to be used for the development of the data catalog. The data catalog focused on wetlands located within North Carolina, South Carolina, Georgia, and the Atlantic coast of Florida. Coastal wetlands include saltwater and freshwater wetlands located within coastal watersheds—specifically U.S. Geological Survey (USGS) 8-digit hydrologic unit codes (HUCs) of the watersheds that drain to the Atlantic Ocean (EPA 2016). These areas are designated in purple in **Figure 3-1**.

In addition, the workgroup discussed non-wetland data sources. They decided that the data catalog should contain atmospheric station information and nearby surface water station information that is useful for interpreting wetland data. The workgroup also decided that the data catalog should include information from stations associated with oyster beds and submerged aquatic vegetation.

3.2 Database Design

The data catalog was developed as a relational database using Microsoft Access. There are three main components of the data (**Figure 3-2**): the lead organization conducting the monitoring, a description of the monitoring program, and the station information and parameters collected at each station. The database describes the organization and program,



Figure 3-1. Coastal Wetlands Are Located within 8-digit HUCs that Drain to the Atlantic Ocean (EPA 2016)

lists the contact information for each, and provides web links where one can find monitoring program methods and data (if applicable). Appendix A presents the data dictionary for the fields in the database. These definitions are also located within the database in boxes that appear with the user holds their mouse over a question mark.

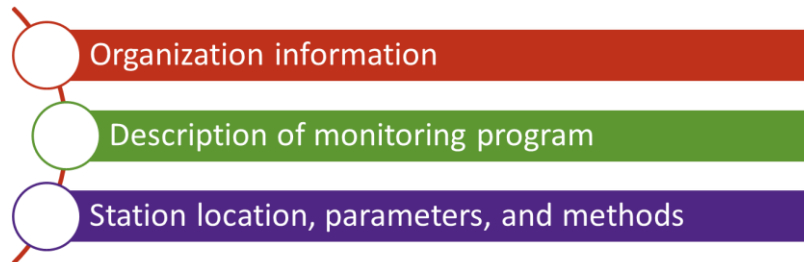


Figure 3-2. Components of the Coastal Wetlands Data Catalog

Coastal wetland monitoring data were solicited from workgroup members and other programs initially as MS Excel spreadsheets that were imported into the database. However, the database was developed so that in the future the user can edit and add new data. This will help extend the life of the database beyond the end of this project. The database is available on the GSAA website, which is archived with the Southeast Coastal Ocean Observing Regional Association (SECOORA).

3.2.1 Query Functions

The data catalog was designed with a user interface for searching for and querying information at three levels: Organization, Monitoring Program, and Station (**Figure 3-3**). The Organization and Monitoring Program are searched in similar manners such that the user can select from a pull down menu for all the options or search for a title containing a specific word. Organizations can also be searched by program type which is defined as government - federal; government - state; government - other; academic institution; organization, non-government; or other. Monitoring programs can be searched by program scale as defined by the location of the stations: national (e.g., EPA National Wetland Condition Assessment), regional (e.g., multi-state), state, local, or other. Once the organization or monitoring program criteria have been selected, the user can view a description and contact information.

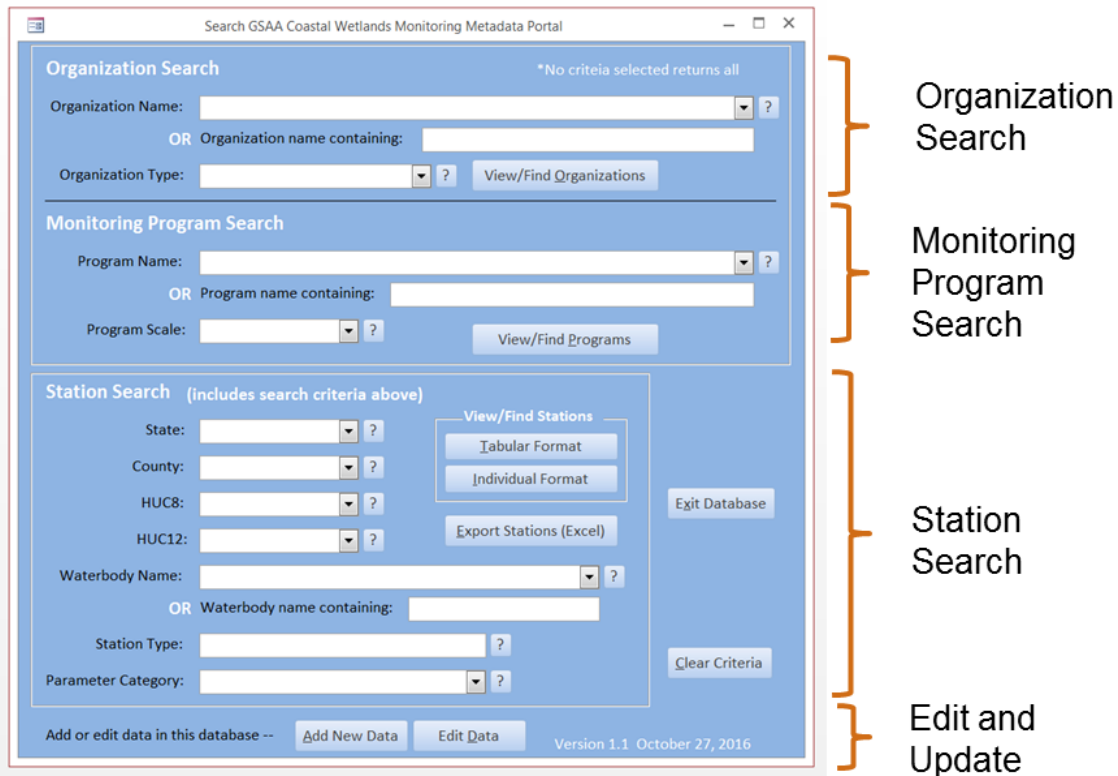


Figure 3-3. Main Query Interface of the Coastal Wetlands Monitoring Data Catalog

The Station search can be combined with the Organization/Monitoring Program search to find stations for a specified program or the Station search can be conducted independently. The Station search criteria are based on geography (i.e., state, county), watershed (i.e., HUC, waterbody name), station type (e.g., wetland type), and parameter category. The geography and watershed information is based on the coordinates of each station. The station type is based on three variables in the database used to classify the type of wetland station: Cowardin Classification System determined from the National Wetlands Inventory (see Section 5.1.1); the hydrogeomorphic wetland classification defined by Brinson (1993) that was user identified; and wetland type based on North Carolina Wetland Assessment Method (NC WAM) classification system. If the monitoring station was not a wetland, then “not applicable” was used to define the wetland type. The user could also enter another wetland type such as mangrove forest that was not defined by any of the three classification systems.

Each station also lists the parameters or variables that were collected at the station. No attempt was made to standardize the parameters that were submitted to the data catalog. Instead, the parameters were categorized in seven parameter categories to aid in querying station data and comparing programs. The individual parameters are maintained in the database and viewable in the results. The parameter categories are atmospheric conditions, biology, hydrology, physical/chemical water properties, porewater, rapid assessment

methods, and soils and elevation. The definitions for these categories are provided in Appendix A.

3.2.2 Edit Information

Existing information in the database can be revised or edited by clicking the “Edit Data” button on the Search Screen (**Figure 3-3**). As shown in **Figure 3-4**, the Organization, Monitoring Program, and Station information can be edited. In addition, the values in the look-up tables (i.e., pull-down lists) can also be edited.

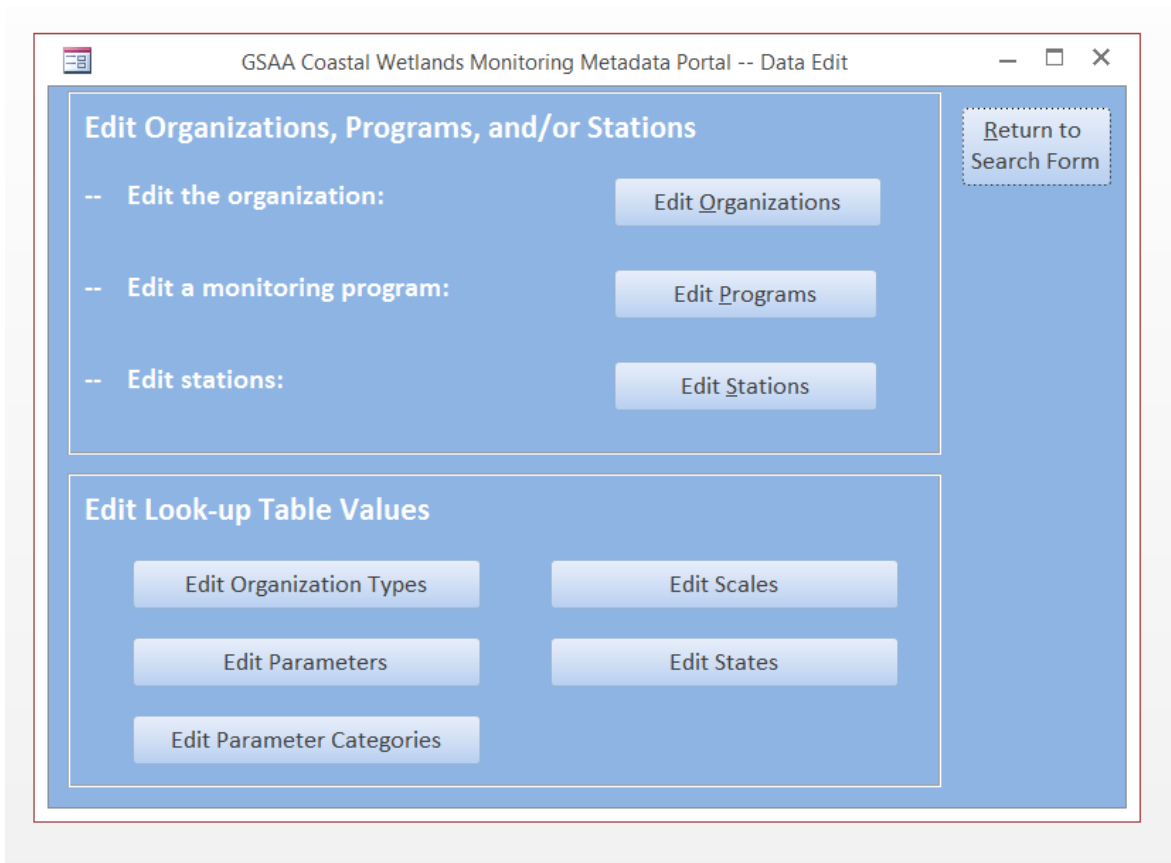


Figure 3-4. User interface to Edit Existing Information in the Data Catalog

3.2.3 Add New Data

Adding new information or data is performed in a similar manner as editing information. Organization, Monitoring Program, and Station information is entered on each form. New values must be added when necessary for the look-up tables including Organization Types, Scales, States, Parameters, and Parameter Categories.

3.3 Summary of Results

3.3.1 Organizations

Nineteen organizations are represented in the data catalog with equitable representation from all sectors: two state government organizations, three federal government organizations, six from other types of government organizations dominated by joint state and federal organizations such as the National Estuarine Research Reserves, two non-government organizations, five academic institutions, and one other organization. The organizations are also geographically distributed with five based in North Carolina, three in South Carolina, four in Georgia, four in Florida, and two national programs. A complete list of organizations is provided in Appendix B.

3.3.2 Monitoring Programs

There are 35 monitoring programs with coastal wetland monitoring stations, geospatial data related to coastal wetlands, or a combination of these that are contained within the database. **Table 3-1** lists these monitoring programs, their organization, and start and end dates of the monitoring program. The North Carolina Division of Water Resources has the highest number of monitoring programs, followed by the Georgia Coastal Resources Division, the Georgia Coastal Ecosystems Long-term Ecological Research Center, and The Nature Conservancy, which each have multiple monitoring programs. These monitoring programs are described in Section 4 and listed in Appendix C.

Table 3-1. Wetland Monitoring Programs in the Coastal Wetlands Monitoring Data Catalog

	Organization Name	Monitoring Program	Start and End Dates
National	Environmental Protection Agency - Office of Wetlands, Oceans, and Watersheds - National Aquatic Resource Surveys	National Wetland Condition Assessment (NWCA)	2011
	U.S. Fish and Wildlife Service, Southeast Region Inventory and Monitoring	Coastal Wetland Elevation Monitoring (CWEM)	2012–ongoing
Florida	Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute	Coastal Habitat Integrated Mapping and Monitoring Program (CHIMMP)	2014–ongoing
	St. Johns River Water Management District	Coastal Wetland Restoration and Evaluation (CWRE)	2001–ongoing
	Tampa Bay Estuary Program	Tampa Bay Critical Coastal Habitat Assessment (TB CCHA)	2015–ongoing
	Guana Tolomato Matanzas National Estuarine Research Reserve	Guana Tolomato Matanzas National Estuarine Research Reserve System-Wide Monitoring Program (GTMNERR-SWMP)	2012–ongoing

	Organization Name	Monitoring Program	Start and End Dates
Georgia	Georgia Coastal Ecosystems Long Term Ecological Research	GCE LTER Climate Monitoring (GCE-LTER-CLIM)	2000–ongoing
		GCE LTER Continuous Salinity, Temperature and Water Level Monitoring (GCE-LTER-STWL)	2000–ongoing
		GCE LTER Water Quality Monitoring (GCE-LTER-WQM)	2001–ongoing
	Georgia Department of Natural Resources, Coastal Resources Division	Living Shorelines (LS)	Ongoing
		Marsh Dieback (MD)	Ongoing
		Marsh Edge Assessment (MEA)	Ongoing
	Sapelo Island National Estuarine Research Reserve	System Wide Monitoring Program (SINERR SWMP)	1999–ongoing
University of Georgia Marine Extension and Georgia Sea Grant	Coastal Georgia Adopt-A-Wetland (GA AAW) Program	2014–ongoing	
North Carolina	National Oceanic and Atmospheric Administration, National Centers for Coastal Ocean Science, Center for Coastal Fisheries and Habitat Research	Defense Coastal/Estuarine Research Program (DCERP)	2008-2016
		Marsh Shoreline (NOAA)	2006-2016
	North Carolina Division of Water Resources	Assessing Geographically Isolated Wetlands in North and South Carolina – the Southeast Isolated Wetlands Assessment (SEIWA)	2008-2011
		Development of a Wetland Monitoring Program in North Carolina (Headwater Wetlands)	2004-2013
		North Carolina Wetland Mitigation Evaluation – Aquatic Biota	2013-2015
		Field Verification of Wetland Functional Assessment Methods within Local Watershed Planning Areas (Field Verification)	2006-2013
		Isolated Wetland Hydrologic Connectivity	2008-2011
		National Wetland Condition Assessment 2011 (NWCA-NC)	2011
		National Wetland Condition Assessment Study of the Alabama, South Carolina and North Carolina Piedmont and Coastal Plain Regions (NWCA Intensification)	2012

	Organization Name	Monitoring Program	Start and End Dates
North Carolina (continued)	North Carolina Division of Water Resources (continued)	North Carolina Wetland Mitigation Evaluation - Pilot Study	2012
	North Carolina National Estuarine Research Reserve	North Carolina National Estuarine Research Reserve System-Wide Monitoring Program (NCNERR SWMP)	2008-ongoing
	North Carolina State University, Biological and Agricultural Engineering	North Carolina Wetland Monitoring Network (NC WMN)	2015-ongoing
	North Carolina State University, Department of Forestry and Environmental Resources	Timberlake Observatory for Wetland Restoration (TOWeR)	2007-ongoing
South Carolina	Ashepoo-Combahee-Edisto (ACE) Basin National Estuarine Research Reserve	System-Wide Monitoring Program (ACE Basin NERR)-ACENERR	2012-ongoing
	Belle W. Baruch Institute for Marine and Coastal Sciences (University of South Carolina)	National Science Foundation Long Term Research in Environmental Biology at North Inlet SC (NSF-LTREB)	1986-ongoing
	Coastal Carolina University	Long Bay Observation System (LoBOS)	-
	The Nature Conservancy - South Carolina Chapter	Oyster Reef Restoration and Enhancement Program (TNC Oyster Restoration)	2009-2015
		Goldbug Living Shoreline Program	-
		Oak Point Living Shoreline Program	-
	South Carolina Department of Health and Environmental Control	Winyah Island Living Shoreline Program	-
Hydrogeomorphic (HGM) Approach to Assessing Headwater Slope Wetlands		1998-2003	

3.3.3 Stations

There are over 700 coastal wetlands monitoring stations in the database representing the 35 monitoring programs, distributed throughout North Carolina, South Carolina, Georgia, and Florida. All stations submitted were included in the database even if they were located outside of the 8-digit HUC that drains to the Atlantic Ocean. The same station may also be listed more than once if it was sampled by different organizations and programs. For example, stations that were monitored during the National Wetland Condition Assessment may be listed twice if another organization collected additional data at the same station as was the case for the North Carolina Division of Water Resources. **Figure 3-5** illustrates the stations in the Coastal Wetlands Monitoring Data Catalog illustrating the geographic

distribution of the stations. A summary of the number of stations and the types of data available from each monitoring program is provided in **Table 3-2**.

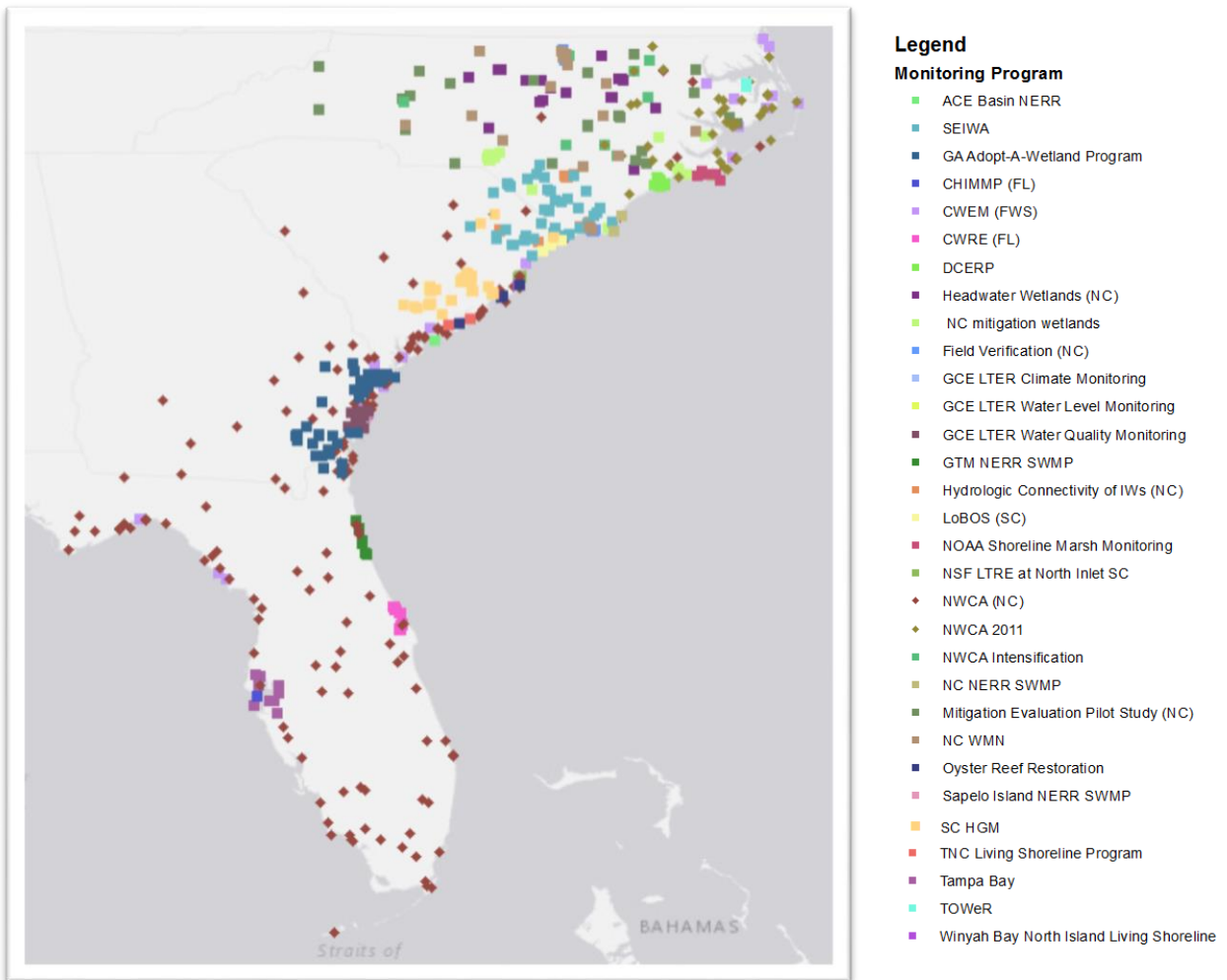


Figure 3-5. Monitoring Stations in the Coastal Wetlands Monitoring Data Catalog

Table 3-2. Number of Stations and Parameter Categories Collected by Monitoring Program Included in the Data Catalog (Note: Monitoring program abbreviations are defined in Table 3-1)

Monitoring Program	Number of Stations	Atmospheric Condition	Biology	Vegetation	Water Quality	Hydrology	Soils	Elevation	Porewater	RAM
NWCA	236	no	yes	yes	yes	yes	yes	no	no	yes
CWEM	20	no	no	yes	no	no	-	yes	yes	no
CHIMMP	6	no	yes	yes	yes	no	yes	no	yes	no
CWRE	48	no	no	no	no	no	no	yes	no	no
CCHA	9	no	yes	yes	no	no	yes	yes	yes	no
SWMP (GTMNERR)	6	no	no	yes	no	no	no	no	yes	no
GCE-LTER-CLIM	3	yes	no	no	no	no	no	no	no	no
GCE-LTER-STWL	9	yes	no	no	yes	no	no	yes	no	no
GCE-LTER-WQM	12	yes	no	no	yes	no	yes	yes	no	no
LS (GA CRD)	4	no	yes	yes	yes	no	no	yes	no	no
MD (GA CRD)	6	no	yes	yes	yes	no	no	no	yes	no
MEA (GA CRD)	42	no	yes	yes	yes	no	no	yes	no	no
SWMP (SINERR)	9	yes	no	no	yes	no	no	no	no	no
GA AAW	47	yes	yes	no	yes	no	no	no	no	no
DCERP	23	yes	yes	yes	yes	yes	no	yes	no	no
Marsh Shoreline (NOAA)	6		yes	yes	no	no	no	yes	no	no
SEIWA	53	no	no	no	no	no	yes	no	no	yes
NCDWR Headwater Wetlands	34	no	yes	yes	yes	yes	yes	no	no	yes
North Carolina Wetland Mitigation Evaluation - Aquatic Biota	16	no	yes	yes	yes	yes	no	no	no	yes

Monitoring Program	Number of Stations	Atmospheric Condition	Biology	Vegetation	Water Quality	Hydrology	Soils	Elevation	Porewater	RAM
NCDWR Field Verification	25	no	yes	yes	yes	yes	yes	no	no	yes
NCDWR Isolated Wetland Connectivity	21	no	yes	yes	yes	no	yes	no	no	yes
NWCA-NC	47	no	no	no	no	no	no	no	no	yes
NWCA Intensification	20	no	yes	yes	yes	yes	yes	no	no	yes
NC Wetland Mitigation Evaluation - Pilot	30	no	yes	yes	yes	yes	yes	no	no	yes
SWMP (NCNERR)	3	no	yes	yes	no	no	no	yes	no	no
NC WMN	16	no	yes	yes	yes	yes	yes	no	no	no
TOWeR	4	no	no	no	yes	no	no	no	no	no
SWMP (ACE Basin NERR)	1	no	yes	yes	no	yes	no	yes	yes	no
NSF-LTREB	10	no	no	yes	no	no	no	yes	yes	no
TNC Oyster Restoration	5	no	yes	yes	no	no	yes	no	no	no
TNC Goldbug Shoreline Program	1	no	yes	yes	no	no	yes	yes	no	no
TNC Oak Point Living Shoreline	1	no	yes	yes	no	no	yes	yes	no	no
TNC Winyah Bay Living Shoreline	2	no	yes	no	yes	no	yes	yes	no	no
LoBOS	3	yes	no	no	yes	no	no	no	no	no
SC HGM	58	no	yes	yes	no	yes	yes	no	no	no

4. DESCRIPTION OF MONITORING PROGRAMS

A combination of state and federal agencies, academic institutions, and non-governmental organizations have monitoring programs to assess the extent, condition, and function of coastal wetlands in the South Atlantic. The purpose of this section is to summarize these monitoring programs with an emphasis on the monitoring programs that submitted information for this project. The number of station and parameter categories collected by each program is summarized in Table 3-2.

4.1 State Agencies

Wetland programs are found in different departments and divisions within state agencies, and may address different aspects of wetland protection and assessment. For example, one agency may address regulatory needs associated with wetlands while another agency within the state may address monitoring needs. In fact, each of the four states in the South Atlantic region are structured differently, but each has a 401 Water Quality certification program to regulate impacts to wetlands and other waters of the United States. Each state has or is in the process of finalizing a Wetland Program Plan to address EPA’s core elements framework (Monitoring and Assessment; Regulatory; Voluntary Restoration and Protection; and Wetland Water Quality Standards [EPA 2009]) (**Table 4-1**). Lastly, each state has participated in at least one EPA NWCA program, which helped to enhance staff knowledge of wetland monitoring methods.

Table 4-1. Comparison of Wetlands Monitoring and Assessment Programs in the South Atlantic Region

Elements	North Carolina	South Carolina	Georgia	Florida
Wetland Program Plan	Yes	Yes	Yes	Yes
Coastal Wetland Monitoring Program	No	No	Yes	No
Mapping of Coastal Wetlands	Yes	Limited	Yes	Yes
2011 NWCA	Yes	Yes	Yes (GA CRD/ GA EPD)	Yes
2016 NWCA	Yes	No	Yes (GA CRD)/ No (GA EPD)	Yes

4.1.1 North Carolina

North Carolina Department of Environmental Quality

The North Carolina Department of Environmental Quality is the lead stewardship agency for the protection of North Carolina's environmental resources. The Division of Water Resources is responsible for regulating and monitoring wetlands throughout the state. For coastal wetlands, the Division of Coastal Management has additional regulatory authority and conducts additional wetland assessments. While North Carolina does not have a formal wetland monitoring program, the Division of Water Resources developed wetland monitoring and assessment methods beginning in 2004, including the development of NC Wetland Assessment Method (i.e., rapid assessment tool), evaluation of wetland mitigation sites, and development of regional coefficients of conservatism for EPA Region 4. The Division of Water Resources participated in both the 2011 and 2016 NWCAs and coordinated the 2011 Intensification Study in partnership with South Carolina, Georgia, and Alabama. In the 1990s, the Division of Coastal Management developed the North Carolina Coastal Region Evaluation of Wetland Significance (NC-CREWS) to provide functional assessment of coastal wetlands.

Development of a Wetland Monitoring Program in North Carolina. This program was the beginning of the North Carolina wetland monitoring program and focused on the monitoring of physical, chemical, and biological parameters of one type of wetland: headwater wetlands. Headwater wetlands were chosen as the initial monitoring target because they are an important natural resource found in the highest reaches of watersheds across the entire state. Eleven coastal plain and twelve piedmont headwater wetlands located along a disturbance gradient were monitored during a 2-year period.

Field Verification of Wetland Functional Assessment Methods within Local Watershed Planning Areas. This program is an expansion of the North Carolina wetland monitoring program and focused on three wetland types: small basin wetlands, bottomland hardwood forests, and riverine swamp forests. Seven riverine swamp forests and six small basin wetlands were located in the coastal plain.

National Wetland Condition Assessment Study of the Alabama, South Carolina, and North Carolina Piedmont and Coastal Plain Regions (2011 Intensification Study). This monitoring program was an extension of EPA's 2011 NWCA, and was conducted in 2012 and 2013. North Carolina, South Carolina, and Alabama participated in this regional wetland assessment. The assessment consisted of surveying 45 wetlands in ecoregion 45 (piedmont) and 45 wetlands in ecoregion 65 (southeastern coastal plains). The wetlands were riverine swamp forest wetlands in ecoregion 65 in order to reduce some of the variance in the biotic measurements. The NWCA methods were used with additional methods for sampling amphibians, macroinvertebrates, water quality, and hydrology.

North Carolina NWCA 2011. The purpose of this monitoring program was to augment EPA's first national survey of wetlands. Additional rapid assessments were added to compliment the EPA's protocol and gather additional information for the state's use through NC WAM and the Ohio Rapid Assessment Method (ORAM).

Assessing Geographically Isolated Wetlands in North and South Carolina – the Southeast Isolated Wetlands Assessment (SEIWA). This project explored the condition and fate of geographically isolated wetlands (GIWs) in an eight-county portion of the coastal plain of North and South Carolina. SEIWA employed a phased approach based on three levels of wetland assessment described by EPA (U.S. EPA 2009): Level 1, which used geographical information systems (GIS) to identify GIWs in the study area; Level 2 to rapidly assess the type and condition of a random sample of the Level 1 sites and to determine the accuracy of Level 1; and Level 3, detailed assessments to measure the hydrologic, water quality, and habitat functions of selected GIW sites.

Hydrologic Connectivity, Water Quality Function, and Biocriteria of Coastal Plain Geographically Isolated Wetlands. Isolated wetlands in eight coastal plain counties of North and South Carolina were evaluated for their hydrological function and pollution absorption capacity and surveyed to develop biocriteria. Eleven “biocriteria” sites (seven in North Carolina and four in South Carolina) and eleven “hydrology and water quality” sites (eight in North Carolina and three in South Carolina) were assessed.

North Carolina Wetland Mitigation Evaluation Pilot Study. The Environmental Law Institute subcontracted both NCDWR and North Carolina State University to collect wetland data on 30 compensatory wetland mitigation sites in North Carolina to evaluate the ecological integrity of wetland compensatory mitigation projects in the state overall and by each of the three types—permittee responsible, mitigation bank, and in-lieu fee. Specific objectives compared the results among floristic indices, ORAM, and NC WAM using correlation and constrained correspondence analysis ordination, and to determine the relationships between various environmental parameters and a land disturbance index with the floristic indices, ORAM, and NC WAM scores.

Evaluation of Success Criteria and Restoration Techniques to Promote Aquatic Biota in NC Mitigation Wetlands. The purpose of this study was to assess success of traditional wetland restoration techniques used for North Carolina compensatory mitigation and non-traditional restoration techniques by comparing amphibian and macroinvertebrate use of the two types of restoration sites to reference sites. Species composition data were gathered, along with data on a myriad of biotic and abiotic environmental factors.

North Carolina Coastal Region Evaluation of Wetland Significance (NC-CREWS). NC-CREWS is a watershed-based wetlands functional assessment model that uses GIS software and data to assess the level of water quality, wildlife habitat, and hydrologic functions of individual wetlands. The primary objective of the NC-CREWS wetland functional assessment

is to provide users with information about the relative ecological importance of wetlands for use in planning and the overall management of wetlands.

4.1.2 South Carolina

South Carolina Department of Health and Environmental Control

The South Carolina Department of Health and Environmental Control (SC DHEC) is the state regulatory agency charged with promoting and protecting the state's public health and its land, air, coastal resources, and water quality as authorized by federal and state law. While South Carolina does not have a formal wetland monitoring program. SC DHEC did participate in the 2011 NWCA and the previously mentioned 2011 Intensification Study. However, they did not participate in the 2016 NWCA. There are two main branches of the SC DHEC that assess wetlands: the Bureau of Water within the Office of Environmental Quality Control, and the Office of Ocean and Coastal Resource Management. These two offices together comprise the environmental side of the agency and are organized under a Director of Environmental Affairs. In addition to the 2011 Intensification Study, the SC DHEC Bureau of Water partnered with the NC Division of Water Resources on their SEIWA project. SCDHEC also contributed in the past to the development of an HGM guidebook, discussed below.

Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing the Functions of Headwater Slope Wetlands on the South Carolina Coastal Plain

This was a wetland monitoring and assessment project undertaken by SC DHEC with funding from an EPA Region 4 wetland protection grant. The purpose of the project was to develop a hydrogeomorphic (HGM) guidebook for assessing the functions of a regional subclass of wetlands important to water quality and under pressure from coastal development, partly due to their small size and adjacency to uplands. Data were collected from 59 wetlands in six counties: Berkeley, Colleton, Charleston, Dorchester, Florence, and Horry. The wetlands were associated with zero to second order streams in four river basins: Salkahatchie, Edisto, Santee, and Pee Dee. SC DHEC produced a draft guidebook (SC DHEC 2003) that was submitted to EPA in fulfillment of the grant agreement. The draft guidebook was not published, but rather rewritten to be consistent with a template developed for headwater wetlands in the Gulf Coastal Plain (Noble et al. 2007). The U.S. Army Corps of Engineers Engineer Research and Development Center published the rewritten guidebook in 2011. The published guidebook used the data that SC DHEC had collected to calibrate many of the model variables (Noble et al. 2011).

South Carolina Department of Natural Resources, Marine Resources Division

The South Carolina Department of Natural Resources (SCDNR) Division of Marine Resources is responsible for managing and conserving the state's marine and estuarine resources. The division conducts monitoring and research on the state's marine resources and makes

recommendations for the management of those resources. The ACE Basin NERR is located programmatically within SCDNR. Currently, SCDNR is listed as a partner on monitoring conducted under the NERR program (see Section 4.2.1).

4.1.3 Georgia

Georgia Department of Natural Resources, Coastal Resources Division

The Coastal Resources Division (GA CRD) is the state agency entrusted to manage Georgia's coastal marshes, beaches, waters, and marine fisheries resources for the benefit of present and future generations. The division's service area extends from the inland reach of the tidal waters to 3 miles offshore. (Note: the Environmental Protection Division services the inland portion of Georgia; data and information from this division were not included in this report or within the data catalog.)

Living Shorelines. Living Shorelines are novel engineering approaches constructed to protect lands adjacent to estuarine waters from erosion. They provide a “greener” alternative to conventional armored shorelines that are constructed to protect lands lying adjacent to estuarine waters from erosion. Living Shoreline monitoring metrics were developed by utilizing the *Oyster Habitat Restoration Monitoring and Assessment Handbook* (Baggett et al., 2014). This monitoring program is conducted in partnership with the University of Georgia Marine Extension and Georgia Sea Grant and the College of Coastal Georgia.

Marsh Dieback. This program was created in 2003 to monitor the health of Georgia's salt marshes and to assist local governments and academic institutions in data collection. Monitoring metrics were developed by the Georgia Coastal Research Council (2003). This program is conducted in partnership with University of Georgia, Savannah State University, and Sapelo Island NERR.

Marsh Edge Assessment. Salt marsh edge is often used as habitat for juvenile finfish and invertebrates. Furthermore, marsh edge habitat with the presence of oyster reefs has been identified as essential fish habitat, and routine monitoring of this habitat began in 2015. The intent of this program is to assess and quantify marsh edge habitat in coastal Georgia by measuring vegetation, nekton abundance and diversity, and water quality. Monitoring metrics were developed by the GA CRD.

National Wetlands Inventory Plus (NWIPlus). In 2011, Georgia updated National Wetlands Inventory (NWI) data for the state's six coastal counties with an added set of abiotic descriptors to describe the wetlands' landscape position, landform, water flow path, and waterbody type (i.e., LLWW descriptors) to create an NWIPlus database. The NWIPlus data are used to better characterize wetlands in this region and to be able to predict wetland functions at the landscape level. [GIS data]

4.1.4 Florida

Florida Department of Environmental Protection

Florida does not have a wetland monitoring and assessment program. Currently, Florida emphasizes regulating impacts to wetlands rather than monitoring them. The Department of Environmental Protection has participated in both the 2011 and 2016 NWCAs and these data reside with the EPA National Aquatic Resource Surveys (NARS) Program (see Section 4.2). The Department of Environmental Protection is not included in the Coastal Wetlands Monitoring Data Catalog; however, they are a partner in other monitoring programs.

Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute

The Florida Fish and Wildlife Research Institute's work includes assessment and restoration of ecosystems and studies of freshwater and marine fisheries, aquatic and terrestrial wildlife, imperiled species, and red tides. This institute develops the information science required to analyze and disseminate research products and engages in outreach activities to complement all programs.

Coastal Habitat Integrated Mapping and Monitoring Program's (CHIMMP). The goals of CHIMMP include aiding coordination of mapping and monitoring efforts in the state of Florida through workshops, pilot studies, and collaborative reports in order to increase communication, minimize duplicate efforts, and identify data gaps, needs and priorities. This study is a pilot monitoring program to compare a variety of monitoring methods.

Florida Cooperative Land Cover. These data are an ecologically-based land cover from existing sources and review of aerial photography. The mapping is conducted in partnership with the Florida Natural Areas Inventory and is updated every 6 to 12 months. The Cooperative Land Cover data follows the Florida Land Cover Classification System. A full list of Florida mapping and monitoring programs is available at <http://ocean.floridamarine.org/CHIMMP/> under the "Florida mapping and monitoring resources" link. [GIS data]

Tampa Bay Estuary Program

The mission of the Tampa Bay Estuary Program (TBEP) is to build partnerships to restore and protect Tampa Bay through implementation of a scientifically sound, community-based management plan. TBEP was established in 1991 as a partnership of Hillsborough, Manatee, and Pinellas counties; the cities of Tampa, St. Petersburg, and Clearwater; the Southwest Florida Water Management District; the Florida Department of Environmental Protection; and the U.S. Environmental Protection Agency.

Critical Coastal Habitat Assessment (CCHA). The CCHA monitoring program includes a network of nine transects that extend from the water's edge through a mosaic of coastal

wetland and upland habitat. Vegetation, porewater, and accretion data are monitored every 3 to 5 years to examine ecosystem response to sea level rise.

4.2 Joint State and Federal Agencies

4.2.1 National Estuarine Research Reserve Systems (NERRS)

The goal of the NERR Sentinel Site Program is to conduct long-term monitoring of intertidal vegetation to provide a better understanding of the ecological characteristics of these dynamic coastal communities and discern the impacts of local and global environmental changes on the estuarine ecosystem. Following the NERRS protocols for biological monitoring, specific objectives include 1) characterize patterns in sediment elevation and plant species composition, abundance, and cover across the water to upland gradient and over time; 2) determine the influence of environmental characteristics on sediment elevation and vegetation patterns; and 3) determine the impact of large-scale environmental changes (e.g., climate change, storm events, sea level rise) on the intertidal vegetation community.

Permanent plots and transects are established at one or more sites in each reserve, and consistent protocols for monitoring vegetation are used across all of the reserves. This program is part of the NERRS System-Wide Monitoring Program (SWMP), and complements the SWMP standardized water quality and weather monitoring programs that have been in place for over a decade. NERRs in the South Atlantic region include:

- The North Carolina NERR consists of four reserves and managed as a federal-state partnership between the National Oceanic and Atmospheric Administration (NOAA) and the North Carolina Department of Environmental Quality, Division of Coastal Management. Seven fixed transects with permanent sampling stations extending from the marsh-water interface to the marsh-upland transition are sampled annually during peak biomass in North Carolina (July–August). Following this protocol, emergent marsh is monitored in three of four NCNERR components—the Rachel Carson, Masonboro Island, and Zeke’s Island Reserves.
- The North Inlet-Winyah Bay NERR in South Carolina is a partnership between NOAA and the University of South Carolina’s Belle W. Baruch Institute for Marine and Coastal Sciences. Six fixed vegetation transects containing a total of 60 stations are sampled annually at the end of the growing season for species cover, density, and canopy height. Porewater and surface elevation tables (SETs) are also located within each plot.
- The Ashepoo-Combahee-Edisto (ACE) Basin NERR is a partnership between NOAA and the South Carolina Division of Natural Resources. Two vegetation monitoring areas are located at Edisto Beach State Park. Each area has three transects with

sampling plots along each transect. Porewater and SETs are also located with each plot.

- Sapelo Island NERR in Georgia is a federal-state partnership between NOAA and the Georgia Department of Natural Resources' Wildlife Resources Division. SINERR has four SWMP water quality stations, one meteorological station, and four SETs. SINERR participates in GA CRD's Living Shoreline Work Group. Both LIDAR and hyperspectral imagery are used to map and assess tidal vegetation communities.
- Guana Tolomato Matanzas NERR in Florida is a partnership between NOAA and Florida's Department of Environmental Protection. Six low marsh sites throughout the reserve are sampled in spring and fall every year. Each site consists of three replicate platforms with five vegetation plots and one SET at each platform.

4.2.2 Albemarle-Pamlico National Estuary Partnership (APNEP)

APNEP is a cooperative hosted by the North Carolina Department of Environmental Quality under a grant from the EPA. The mission of APNEP is to identify, protect, and restore the significant resources of the Albemarle-Pamlico estuarine system.

Submerged Aquatic Vegetation

During 2007–2008 the first aerial survey of submerged aquatic vegetation (SAV) in North Carolina was coordinated and funded by the SAV Partnership, of which APNEP is a founding member. APNEP also funded and published an interpretative SAV map, which was later featured in the 2012 APNEP Ecosystem Assessment. With a baseline established, APNEP again supported SAV monitoring by funding and coordinating another aerial survey of the Albemarle-Pamlico sounds between 2012 and 2014. The second map is scheduled for release in 2017 and will allow for the detection of trends in SAV coverage for the first time. [GIS data]

4.3 Federal Agencies

4.3.1 U.S. Environmental Protection Agency – Office of Wetlands, Oceans, and Watersheds

National Aquatic Resource Surveys (NARS). NARS are statistical surveys designed to assess the status of and changes in quality of the nation's coastal waters, lakes and reservoirs, rivers and streams, and wetlands. Using sample sites that are randomly selected, these surveys provide a snapshot of the overall condition of the nation's waters. Because the surveys use standardized field and laboratory methods, the results from different parts of the country and between years can be compared.

4.3.2 U.S. Fish and Wildlife Service, Southeast Region Inventory and Monitoring

The U.S. Fish and Wildlife Service (USFWS) Southeast Region Inventory & Monitoring (I&M) Branch mission works collaboratively to assess the status of National Wildlife Refuge System (NWRS) lands, waters, and biota and support achievement of conservation objectives at multiple spatial scales. They are specifically tasked to work closely with refuges, conservation partnerships such as Landscape Conservation Cooperatives, and other service programs to address critical refuge information needs and evaluate effectiveness of conservation strategies on refuges.

Coastal Wetland Elevation Monitoring (CWEM). The CWEM program is being conducted on 18 National Wildlife Refuges within the South Atlantic Landscape Conservation Cooperative in coordination with partners at NOAA, the U.S. Geological Survey, the National Park Service, and other regions of the USFWS. This monitoring effort involves collecting surface elevation from SETs, accretion from marker horizons, porewater salinity, and vegetation community data at permanent monitoring sites deployed in selected priority wetland habitats to provide data to refuge managers on the status of and trends in wetland conditions within refuges.

4.3.3 National Oceanic and Atmospheric Administration, National Centers for Coastal Ocean Science, Center for Coastal Fisheries and Habitat Research

The NOAA Center for Coastal Fisheries and Habitat Research (CCFHR) conducts research on the effects of coastal habitat change and restoration on living marine resources such as seagrasses, marshes, reefs, and fish. Major programs include 1) Ecology of Harmful Algal Blooms; 2) Marine Restoration and Spatial Planning; and 3) Ecological Responses to Climate Change. The center is located in Beaufort, North Carolina and shares space with NOAA Fisheries and NCNERR staff.

Defense Coastal/Estuarine Research Program (DCERP)

DCERP was designed to conduct basic and applied research in support of the U.S. Department of Defense's ecosystem-based management approach to sustain its military training mission while optimizing its stewardship of natural resources. The Coastal Wetlands Monitoring Program of DCERP was designed and developed by NOAA CCFHR to 1) improve understanding of the physical, biological, and ecological processes that determine the stability and community structure of the coastal wetlands at Marine Corps Base Camp Lejeune (near Jacksonville, NC); 2) quantify spatial and temporal (inter-annual) variability in key parameters affecting marsh carbon, nutrient, and sediment fluxes; 3) provide data to support development of forecasting tools and models; and 4) use these tools to guide adaptive management actions to improve the sustainability of coastal wetlands to climate change and man-made impacts.

Marsh Shoreline Monitoring Program

The objective of NOAA's CCFHR Marsh Shoreline Monitoring Program is to track annual changes in marsh vegetation, surface elevation, and shoreline position to determine the impact of stone sills, sea level rise, and other environmental drivers on marsh vegetation. NOAA partners with NCNERR to monitor salt marshes in late summer for peak biomass and other parameters. Permanent plots established in a stratified sampling regime are used. Sites include natural fringing marshes with and without oyster reefs, as well as marsh sills built as part of Living Shoreline programs.

4.4 Academic Institutions

4.4.1 Belle W. Baruch Institute for Marine and Coastal Sciences (University of South Carolina)

National Science Foundation Long-term Research in Environmental Biology (NSF-LTREB) at North Inlet, SC

The Belle W. Baruch Institute for Marine and Coastal Sciences conducts research and supports education to improve the management of marine and coastal resources and advance basic science for the well-being of people and their environment. The NSF-LTREB was established to examine the relationships and feedbacks between salt marsh primary productivity, biogeochemical cycling, and marsh elevation, and use this information to develop a model that predicts marsh stability, primary production and elevation adjustments to changes in the rate of sea-level rise.

4.4.2 Coastal Carolina University (South Carolina)

The Environmental Quality Lab is housed within the Waccamaw Watershed Academy at Coastal Carolina University's Center for Marine and Wetland Studies. It is operating the Long Bay Observation System. The purpose of this program is to monitor nearshore atmospheric and ocean water quality conditions. The coastal observation network includes meteorological and water quality stations located on fishing piers in Long Bay.

4.4.3 North Carolina State University (NCSU)

Both the Department of Forestry and Environmental Resources and the Department of Biological and Agricultural Engineering are conducting or have conducted wetland monitoring in North Carolina.

Timberlake Observatory for Wetland Restoration

This research project started in 2006 to examine the consequences of a large-scale wetland restoration project in the coastal plain. It has evolved to examine how saltwater intrusion and changes in precipitation alter the functioning of coastal wetlands. This program is

conducted by NCSU Department of Forestry in partnership with researchers at Duke University and East Carolina University.

North Carolina Wetland Monitoring Network

Through a grant from the EPA, the NCSU Department of Biological and Agricultural Engineering is continuing and expanding the work done by the North Carolina Division of Water Resources by monitoring the hydrology, water quality, soils, and biota at 16 long-term wetland monitoring sites across the Piedmont and Coastal Plain regions of North Carolina. The work is being conducted during 2015–2017.

4.4.4 University of Georgia Marine Extension and Georgia Sea Grant

The University of Georgia's Marine Extension Service (MAREX) and Georgia Sea Grant provide research, education, training, and science-based outreach to assist Georgia in solving problems and realizing opportunities for its coastal and marine environments. By advancing research, education and training, and outreach, MAREX and Georgia Sea Grant promote the economic, cultural, and environmental health of Georgia's coast and help prepare citizens to become good stewards of coastal ecosystems and watershed resources.

Coastal Georgia Adopt-A-Wetland Program

This hands-on education program promotes wetland conservation through volunteer monitoring. Wetlands are valuable coastal resources, playing an important role in water quality, sediment retention, flood control and wildlife habitat. This program is designed to complement the Georgia Adopt-A-Stream program, which is coordinated by the Department of Natural Resources Environmental Protection Division.

4.5 Other

4.5.1 The Nature Conservancy—The South Carolina Chapter

Oyster Reef Restoration and Enhancement Program

The Nature Conservancy and the South Carolina Department of Natural Resources received funding through the NOAA community-based restoration program to test the viability of oyster castles as a substrate for continued oyster growth. Studies have demonstrated that boat wakes can increase the erosion rate of salt marsh and the presence of oyster reefs may limit the impact. To date, abundant oyster growth has been observed on the oyster castles. In addition to using the project to test the effectiveness of oyster castles in establishing habitat, monitoring was put in place to examine how the castles might reduce shoreline erosion and promote marsh grass growth.

Living Shoreline Programs

The Nature Conservancy (TNC) has implemented three living shoreline programs located at Winyah Bay, Oak Point, and Goldbug Island. These projects include installation of oyster castles and vegetation for habitat restoration and shoreline stability. TNC partners with state, local, and academic partners to monitor the success of each project. Information about these programs is available on The Nature Conservancy's Natural Infrastructure website (<http://projects.tnc.org/coastal/>).

4.5.2 Georgia Coastal Ecosystems Long Term Ecological Research

The GCE-LTER site was established by the National Science Foundation in 2000. The study domain encompasses three adjacent sounds (Altamaha, Doboy, and Sapelo) on the coast of Georgia, and includes upland (mainland, barrier islands, and marsh hummocks), intertidal (fresh, brackish, and salt marsh), and submerged (river, estuary, and continental shelf) habitats. The GCE field site is based at the University of Georgia Marine Institute on Sapelo Island, and the program is administered at the University of Georgia, Department of Marine Sciences in Athens, Georgia. The Sapelo Island NERR is fully encompassed by the GCE-LTER study domain.

GCE-LTER Climate Monitoring

Four meteorological stations, operated and maintained by various institutions affiliated with the GCE-LTER program, are used to characterize the weather and climate over a large spatial scale within the GCE-LTER domain. Three of these stations are located on Sapelo Island at Marsh Landing, Flume Dock, and the Marine Institute. The Marine Institute maintains a National Weather Service station for daily minimum/maximum temperatures and precipitation, and data exist back to 1957. The Marsh Landing and Flume Dock stations measure various semi-hourly hydrological and quarter-hourly meteorological parameters, and data exist back to 1986. Campbell Scientific Instruments equipment belonging to the Sapelo Island NERR program and made available for the GCE-LTER project were upgraded to LTER Level 2 climate standards and installed at Marsh Landing in 2002. This station now serves as the primary LTER meteorological station for intercomparison studies and ClimDB. A fourth station is located on Hudson Creek in Meridian and is maintained by USGS and GCE personnel. This station has been operational since March 2001 and provisional data on hydrological and meteorological parameters are acquired semi-hourly and hourly, respectively.

GCE-LTER Continuous Salinity, Temperature, and Water Level Monitoring

The objective of the GCE Continuous Salinity, Temperature, and Water Level Monitoring program is to document spatial and temporal variability of salinity and its relationship to water level and river discharge. Long-term measurements of conductivity, temperature, and subsurface pressure are collected at 30-minute intervals at eight sites in the GCE-LTER

domain. These monitoring sites were chosen to span the salinity gradient as well as to take advantage of existing physical structures (e.g., docks or pilings) for mounting instruments. The long-term moorings are located in transect regions used for quarterly oceanographic surveys and near GCE-LTER marsh study sites.

GCE-LTER Water Quality Monitoring

The GCE-LTER project monitors nutrient chemistry, chlorophyll concentrations, and vertical profiles of salinity, temperature, and photosynthetically-available radiation monthly to document environmental gradients across the GCE landscape.

4.5.2 St. Johns River Water Management District (SJRWMD)

The SJRWMD is responsible for managing groundwater and surface water resources in all or part of 18 counties in northeast and east-central Florida. Its mission is to protect the district's natural resources and support Florida's growth by ensuring the sustainable use of Florida's water for the benefit of the people of the district and the state.

The purpose of the *Coastal Wetland Restoration and Evaluation* monitoring program is to evaluate coastal wetland restoration methods and success and to assess the condition of coastal wetlands. SETs, established to assess the impact of impounded wetland management on sediment processes, are now part of a network of sites in the northern Indian River Lagoon. Additional SETs were established to evaluate the success of coastal wetland restoration efforts.

5. MONITORING METHODS

The section provides references and web links to monitoring methods for the data contained within the Coastal Wetlands Monitoring Data Catalog developed for this project. Additional information about the monitoring programs and their methods are located within the database.

5.1 Biological Components

5.1.1 Vegetation

Carolina Vegetation Survey (CVS) Methods

The CVS method is used by the EPA National Wetland Condition Assessment and by the North Carolina Division of Water Resources. Vegetation species data are collected for presence, cover, and woody stem sizes in 10 m by 10 m quadrants or modules. A full description of the methodology, including data sheets, is available at

<http://cvs.bio.unc.edu/methods.htm>

- Peet, R.K., T.R. Wentworth, and P.S. White. 1998. A flexible, multipurpose method for recording vegetation composition and structure. *Castanea* 63:262-274.
<http://cvs.bio.unc.edu/pubs/castanea63;262.pdf>

Transect Method

The general approach for the Transect method consists of fixed transects with permanent sampling plots that can be stratified or otherwise located within vegetation zones or defined segments of the ecotone, mangrove forest, marsh, or submerged aquatic vegetation bed. This method is part of the NERRS vegetation monitoring protocol so that vegetation trends can be assessed over time and space.

- Moore, K. 2013. NERRS SWMP Vegetation Monitoring Protocol: Long-term Monitoring of Estuarine Vegetation Communities. National Estuarine Research Reserve System Technical Report. 36 pp.
http://gtmnerr.org/documents/Research_Publications/NERRS_Vegetation_Monitoring_2013-09-06.pdf

Point-Centered Quarter Method

Point-Centered Quarter (PCQ) sampling is a non-plot methodology involving measuring distances for a random sample of trees, typically along a transect, and recording the characteristics of interest. This method is typically faster and requires less equipment than the plot-based techniques of the CVS. This method is used by Florida's CHIMMP and Tampa Bay Estuary Program's Critical Coastal Habitat Assessment Program.

- Mitchell, K. 2015. Quantitative Analysis by the Point-Centered Quarter Method. <https://arxiv.org/pdf/1010.3303.pdf>
- Cottam, G., and J.T. Curtis. 1956. The use of distance measures in phytosociological sampling. *Ecology* 37(3):451–460. <http://www.jstor.org/stable/1930167>

Vegetation Classification Systems

The Cowardin Classification System (Cowardin et al. 1979) describes the hydrologic region, vegetation or habitat type, and disturbances of wetlands and aquatic systems. This classification system is used by the National Wetlands Inventory. The Cowardin classification is identified for each station in the Coastal Wetlands Monitoring Data Catalog. Source: <https://www.fws.gov/wetlands/Documents/Classification-of-Wetlands-and-Deepwater-Habitats-of-the-United-States.pdf>

The U.S. National Vegetation Classification is supported by a formal partnership between federal agencies, the Ecological Society of America (ESA), and NatureServe, working through the Federal Geographic Data Committee (FGDC) Vegetation Subcommittee. This is a hierarchical system that classifies all vegetation communities in the U.S. Source: <http://usnvc.org/overview/>

Other Vegetation Methods

- Curtis, A.C., J. Asper, S. Eastman, and L. C. Baron. 2013. Photoplot-based monitoring of salt marsh vegetation. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP-1.3.9.
- Kent, M. 2011. *Vegetation Description and Data Analysis: A Practical Approach*, 2nd Edition. Wiley-Blackwell; 428 pages.
- Morris, J.T. and B. Haskin. 1990. A 5-year record of aerial primary production and stand characteristics of *Spartina alterniflora*. *Ecological Society of America* 71:6, 2209-2217. <http://onlinelibrary.wiley.com/doi/10.2307/1938633/abstract>

See Section 5.7.1 for a description of Georgia’s Marsh Die-back monitoring protocols that monitor physical, chemical, and biological characteristics of marshes including vegetation, epifauna, and porewater.

5.1.2 Amphibians

Many amphibian species are sensitive to environmental disturbances and act as indicators of the quality of their surroundings (US EPA 2002a). Due to the abundance of amphibians in North Carolina and their sensitivity to disturbance, the North Carolina Division of Water Resources has collected amphibians’ presence and abundance data during several of their monitoring programs including the 2011 Intensification Study conducted in partnership with SC DHEC. Amphibian monitoring is best conducted during the annual breeding season. A semi-qualitative amphibian survey of approximately three man hours per site was

performed in early spring (February/March) and early summer (May/June). Sites were systematically searched for amphibians with the use of dip nets and potato rakes. Sweep nets were used to search for amphibians (frogs, tadpoles, egg masses, and larval salamanders) in areas with standing water. The potato rakes were used to turn over logs, woody debris, and leaves in the wetland and surrounding upland buffer area (no more than 200 m from the wetland). Moss hammocks overhanging water or within a few feet of water were searched for cavities and peeled back on three sides and replaced to search for female salamanders guarding eggs. Crayfish holes were also searched for salamanders.

5.1.3 Macroinvertebrates

Macroinvertebrates are a common indicator of water quality and health of stream systems, but macroinvertebrate monitoring in wetlands occurs less frequently (U.S. EPA 2002b). The North Carolina Division of Water Resources and South Carolina DHEC has explored the use of macroinvertebrates as an indicator of wetland conditions. D-shaped nets (600-micron) were used to sweep a 1 m area with 3 or 4 sweeps per station. Sweep net stations were conducted using sweeping or jabbing motions with the net to maximize the area of suitable microhabitat covered. The leaf and woody materials were then elutriated from the net, and a visual search of leaf packs and woody debris was made before discarding. The samples were preserved in the field and identified in the laboratory.

Snail density is monitored by NOAA and NCNERRS in North Carolina salt marshes to study the impact of this grazer community on marsh plant persistence. Silliman et al. (2005) has conducted extensive research on the top-down effect of predator abundance on marsh productivity. Without predators such as crabs, snail numbers can increase and convert marshland to mudflats through invasion of a growth-suppressing fungi that is spread by the snail. Therefore, snail density or counts can be an important component of monitoring salt marshes.

- Silliman, B.R. and M.D. Bertness. 2002. A trophic cascade regulates salt marsh primary production. *Proceedings of the National Academy of Sciences* 99(16):10500-10505. doi: 10.1073/pnas.162366599
- Dr. Silliman's website: <http://superpod.ml.duke.edu/silliman/>

5.2 Hydrology

Hydrology is one of the most important features of a wetland. Three hydrologic variables can be defined that are useful for characterizing wetland hydrologic behavior: the water level, hydropattern, and residence time. These variables are best captured by continuous water level monitoring at a wetland. When continuous data collection is not possible, information on secondary indicators of hydrology are recorded. References for data collection with these methods are included here.

5.2.1 Continuous

- Sprecher, S. W. (2000). Installing Monitoring Wells/Piezometers in Wetlands, ERDC TN-WRAP-00-02, U.S. Army Research and Development Center, Vicksburg, MS. <https://el.ercd.dren.mil/elpubs/pdf/tnwrap00-2.pdf>
- U.S. EPA. 2008. Methods for Evaluating Wetland Condition: Wetland Hydrology. Office of Water, U.S. Environmental Protection Agency, Washington, DC. EPA-822-R-08-024. https://www.epa.gov/sites/production/files/documents/wetlands_20hydrology.pdf
- NOAA. 2013. User's Guide for GPS Observations. Technical Report. National Oceanic and Atmospheric Administration, National Ocean Service, Center for Operational Oceanographic Products and Services. March. http://tidesandcurrents.noaa.gov/publications/Users_Guide_for_GPS_Observations_updated_March_2013_FINAL.pdf

5.2.2 Indicators of Hydrology

- U.S. Army Corps of Engineers. 2010. Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Atlantic and Gulf Coastal Plain Region (Version 2.0), ed. J.S. Wakeley, R.W. Lichvar, and C.V. Noble. ERDC/EL TR-10-20. Vicksburg, MS: U.S. Army Engineer Research and Development Center. http://www.usace.army.mil/Portals/2/docs/civilworks/regulatory/reg_supp/AGCP_regsupV2.pdf
- United States Department of Agriculture, Natural Resources Conservation Service. 2010. Field Indicators of Hydric Soils in the United States, Version 7.0. L.M. Vasilas, G.W. Hurt, and C.V. Noble (eds.). USDA, NRCS, in cooperation with the National Technical Committee for Hydric Soils. https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_050723.pdf
- Vepraskas, M.J., X. He, D.L. Lindbo, and R.W. Skaggs. 2002. Calibrating hydric soil field indicators to long-term wetland hydrology. *Soil Science Society of America* 68(4):1461-1469. doi:10.2136/sssaj2004.1461

5.3 Soils and Elevation

5.3.1 Soil Chemistry

Soils cycle nutrients, store pollutants, mediate groundwater, and provide habitat for microorganisms, invertebrates, and other more complex organisms (Richardson and Vepraskas 2001). Biogeochemical processes characteristic of hydric soils directly influence wetland condition and the delivery of associated ecosystem services. Soil structure and chemistry can indicate water quality and hydrology (Hargreaves et al. 2003, Mitsch and Gosselink 2007).

- NWCA Field Operations Manual – Soil Chemistry.
https://www.epa.gov/sites/production/files/2013-11/documents/fom_with_errata.pdf

5.3.2 Sediment Accretion

NOAA Sentinel Site Program – Surface Elevation Table (SET) Inventory

- <http://oceanservice.noaa.gov/sentinelsites/pdf/set-inventory-summary.pdf>

USFWS – The Surface Elevation Table and Marker Horizon Techniques: A protocol for monitoring wetland elevation dynamics.

- <https://catalog.data.gov/dataset/the-surface-elevation-table-and-marker-horizon-technique-a-protocol-for-monitoring-wetland>

National Park Service, Integrated Resource Management Applications – The Surface Elevation Table and Marker Horizon Technique: A Protocol for Monitoring Wetland Elevation Dynamics (Lynch et al. 2015)

- <https://irma.nps.gov/DataStore/Reference/Profile/2225005>

Other References:

- Cahoon, D.R., J.C. Lynch, P. Hensel, R. Boumans, B.C. Perez, B. Segura, and J.W. Day, Jr. 2002. A device for high precision measurement of wetland sediment elevation: I. Recent improvements to the sedimentation-erosion table. *Journal of Sedimentary Research* 72(5):730–733.
- Cahoon, D.R., J.C. Lynch, B.C. Perez, B. Segura, R. D. Holland, C. Stelly, G. Stephenson, and P. Hensel. 2002. High-precision measurements of wetland sediment elevation: II. The rod surface elevation table. *Journal of Sedimentary Petrology* 72:734–739.
- Asper, J., and A. C. Curtis. 2013. Salt Marsh Elevation Monitoring. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP-1.3.6

5.4 Porewater

- Curtis, A. C. 2012. Soil porewater equipment construction and data collection. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP-1.3.8. National Park Service, Athens, Georgia.

5.5 Rapid Assessment Methods

5.5.1 USA-Rapid Assessment Method (USA-RAM)

USA-RAM is a wetland rapid assessment method developed and used in EPA’s National Wetland Condition Assessment in 2011. One of the objectives of developing USA-RAM was to serve as a national wetland rapid assessment method and as a starting point for states or

regions that wanted to develop wetland rapid assessments. USA-RAM was not used in the 2016 NWCA.

- U.S. Environmental Protection Agency. 2011. National Wetland Condition Assessment: Field Operations Manual. EPA-843-R-10-001. U.S. Environmental Protection Agency, Washington, DC. Available at: https://www.epa.gov/sites/production/files/2013-11/documents/fom_with_errata.pdf

5.5.2 NC Wetland Assessment Method (NC WAM)

NC WAM was developed by the North Carolina Division of Water Resources and is a Level 2, rapid assessment of wetlands based on functional value. The primary objective of NC WAM was to provide an accurate, rapid assessment of wetland function requiring no more than 15 minutes of on-site time. Three functions are assessed by the method: hydrology, water quality, and habitat. Each score is assigned to a category of "high," "medium," or "low." An overall score rates the wetland area, and the three major functions are also rated. Field-based monitoring data from several North Carolina Division of Water Resources' monitoring programs were used to validate the scoring system.

- NC WAM User's Guide: <http://deq.nc.gov/document/nc-wam-40-user-manual>

5.5.3 Ohio Rapid Assessment Methods (ORAM)

ORAM was developed by Mack (2001) to evaluate wetland condition. ORAM contains six assessment metrics: wetland area, upland buffers and surrounding land use, hydrology, habitat alteration and development, special wetlands, and plant communities. Several of North Carolina's Division of Water Resources' monitoring programs calculated ORAM scores.

- Field Sheets: http://www.epa.state.oh.us/portals/35/401/oram50sf_s.pdf
- Mack, J.J. 2001. Ohio EPA Rapid Assessment Method for Wetlands, Manual for Using Version 5.0. *Ohio EPA Technical Bulletin Wetland/2001-1-1*. Ohio Environmental Protection Agency, Division of Surface Water, 401 Wetland Ecology Unit, Columbus, Ohio.

5.5.4 Hydrogeomorphic Approach to Wetland Assessment

SC DHEC initiated development of a hydrogeomorphic guidebook for assessing the functions of a regional subclass of wetlands that are important to water quality and under pressure from coastal development, producing the first draft, and collecting data that were used to calibrate many of the model variables of the published guidebook:

- Noble, C.V., E.O. Murray, C.V. Klimas, W. and Ainslie. 2011. Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing the Functions of Headwater Slope Wetlands on the South Carolina Coastal Plain, ERDC/EL TR-11-11, U.S. Army Corps of Engineers Engineer Research and Development Center, Vicksburg, MS.

“The Hydrogeomorphic (HGM) Approach is a system for developing functional indices to assess a wetland’s capacity to perform functions similar to those of comparable wetlands in a region. The approach was initially designed to be used in the context of the Clean Water Act Section 404 Regulatory Program permit review process to consider alternatives, minimize impacts, assess unavoidable project impacts, determine mitigation requirements, and monitor the success of mitigation projects” (Noble et al. 2011).

- USACE ERDC HGM web page:
<https://wetlands.el.ercd.dren.mil/hgmhp.html>

5.5.5 Other Rapid Assessment Methods (not listed in database)

Florida Wetland Rapid Assessment Procedure (WRAP)

The Florida WRAP was developed by the South Florida Water Management District to assist the regulatory evaluation of mitigation sties. The WRAP variables include wildlife utilization, wetland vegetation cover, adjacent buffer, indicators of hydrology, and water quality treatment potential.

- Miller, R.E. and B. E. Gunsalus. 1997. Wetland Rapid Assessment Procedure (WRAP). Technical Publication REG-001. Natural Resources Management Division, South Florida Water Management District.
<http://dpanther.fiu.edu/sobek/FI12090414/00001>

5.6 Geospatial Monitoring Methods

5.6.1 National Wetlands Inventory

NWI was established by the USFWS in 1974 to conduct a nationwide inventory of U.S. wetlands to provide its biologists and others with information on the distribution of wetlands to aid in wetland conservation efforts. This geospatial information is used by federal, state, and local agencies, academic institutions, and private industry for management, research, policy development, education, and planning activities. Digital data can be viewed and downloads are available through the USFWS Wetlands Mapper (<https://www.fws.gov/wetlands/index.html>).

5.6.2 Landscape Development Intensity (LDI) Index

The LDI Index is a Level 1 assessment technique that estimates the potential impacts from anthropomorphic influences on land cover by evaluating land cover in a designated area.

LDI values are essentially human-related disturbance scores that are associated with intensity of the land-use based on non-renewable energy flow. Higher LDI Index values indicate land use for the given watershed was more heavily impacted by human usage. LDI has been used by North Carolina Division of Water Resources and has been calculated at various scales (i.e., watershed and 100-meter wetland buffer).

- Brown, M.T. and M.B. Vivas. 2005. Landscape Development Intensity Index. *Environmental Monitoring and Assessment* 101:289-309. doi:10.1007/s10661-005-0296-6

5.7 Other

5.7.1 Georgia Coastal Research Council – Marsh Die-Back Monitoring Protocol

This protocol provides a standardized method for monitoring physical, chemical, and biological characteristics of marshes. They recommend that sites be established in both marsh die-off and control areas, and that they be monitored quarterly (March, June, September, and December) for vegetation (stem counts, plant height, and leaf color), epifauna (snails, crabs, mussels), and porewater (salinity, pH, and Eh).

- http://www.gcrc.uga.edu/MarshDieback/protocol_standard.htm

5.7.2 NOAA's Returning the Tide: A Tidal Restoration Guidance Manual for the Southeastern United States

The goal of this manual is to increase and improve habitat restoration in estuarine environments impacted by the creation of barriers to tidal hydrology. Chapter 7 offers recommendations on the components of a coastal wetland monitoring plan.

- http://www.habitat.noaa.gov/toolkits/tidal_hydro/download_all_manual_chapters.pdf

5.7.3 Citizen Wetland Monitoring Protocols

- Currin, C.A., P.C. Delano, and L.M. Valdes-Weaver. 2007. Utilization of a citizen monitoring protocol to assess the structure and function of natural and stabilized fringing salt marshes in North Carolina. *Wetlands Ecology Management*. 16:97-118. DOI 10.1007/s11273-007-9059-1.
<https://coastalscience.noaa.gov/about/docs/Currinetal.WME.vol2.pdf>

Georgia Adopt-A-Wetland Monitoring Protocols. The University of Georgia Marine Extension Service coordinates the Coastal Georgia Adopt-A-Wetland Program.

- Website: <http://marex.uga.edu/wetland/>

5.7.4 Oyster Restoration Monitoring Protocols

- Baggett, L.P., S.P. Powers, R. Brumbaugh, L.D. Coen, B. DeAngelis, J. Greene, B. Hancock, and S. Morlock, 2014. Oyster habitat restoration monitoring and assessment handbook. The Nature Conservancy, Arlington, VA, USA., 96pp. Used by Georgia Coastal Resource Division. <http://www.oyster-restoration.org/wp-content/uploads/2014/01/Oyster-Habitat-Restoration-Monitoring-and-Assessment-Handbook.pdf>
- Walters, L., R. Brockmeyer, E. Hernandez, N. Dix, and A.S. Noel. Oyster Condition Assessment Protocol. Used in northeast and central Florida. [unpublished] <https://docs.google.com/viewer?a=v&pid=sites&srcid=ZGVmYXVsdGRvbWFpbnxndG1veXN0ZXJhbmR3cXRhc2tmb3JjZXxneDoyZDg3YjNIMzU4MjBkZWJk>

6. RECOMMENDATIONS

The outputs from this project provide a foundation to strengthen coastal wetlands monitoring in the South Atlantic region and have fostered relationships among workgroup participants. An important next step will be to link activities between wetland monitoring programs and watershed planning efforts within each state, and ultimately, throughout the region. Cross-training between, regulatory professionals, academia, and grassroots environmental organizations could further build capacity for states to work together to protect important coastal ecosystems, while coastal communities work toward meeting their economic needs. The information contained in the Coastal Wetlands Monitoring Data Catalog and this project report provide many of the resources and contacts needed to move toward achieving these sometimes competing goals. Furthermore, connecting inland actions to coastal efforts will be critical to ensuring the long-term health coastal systems that are important both ecologically and economically.

The workgroup recognizes the following opportunities for and obstacles to developing regional coastal wetlands monitoring guidelines, and suggested specific next steps for developing that catalog further and for improving its accessibility.

6.1 Opportunities

- To achieve the goal of regional coastal wetland monitoring guidelines, there needs to be an organization that can provide leadership and facilitate necessary collaboration among workgroup members and others in the region conducting monitoring and using monitoring data. The workgroup identified potential organizations that could lead this effort including the Southeast Wetlands Workgroup, the Center for Watershed Excellence (Clemson), and the Southeast Association of Marine Laboratories.

- The database and report is a first step toward sharing methods regionally among monitoring programs. This is especially important with the development of new technologies such as unmanned aerial vehicles (i.e., drones), remote sensing techniques, and data analyses methods. A regional workgroup would also be helpful identifying current needs for monitoring, assessing and documenting baseline conditions in order to assess changes in coastal wetland conditions going forward for stressors like a changing climate and sea levels.
- Another opportunity afforded by development of regional monitoring guidelines is the sharing of assessment tools such as the coastal wetlands resiliency score developed by NERRS researchers. This sharing of assessment tools also provides an opportunity to validate existing tools, including wider for wider applicability such as in parts of a region other than where they were developed.
- Outreach opportunities need to be identified and acted upon by workgroup members to transfer what has been learned and to encourage continued work on common goals. The Southeastern Estuarine Research Society, Spring Meeting was suggested as an outreach opportunity. Information about the workgroup and about database development were presented in a poster session at the National Water Quality Monitoring Conference in Tampa, Florida in May 2016, in a webinar to the National Floodplain in October 2016, and in a talk at the EPA Region 401 Annual Wetlands and 401 Workshop in November 2016.

6.2 Obstacles

- Obstacles to development of regional coastal wetlands monitoring guidelines include the different purposes (or needs) of monitoring programs, which generally support their organizational needs versus contributing to a regional effort. It may be difficult to implement regional monitoring methods that also support site-or program-specific needs.
- The differing spatial or temporal scales of monitoring programs (e.g., site-specific, state, regional) may also be obstacles to developing regional guidelines.
- The need for leadership and oversight of a regional effort is an obstacle as well as an opportunity. Organizations typically need funding to facilitate meetings and plan workshops for meeting attendees.
- The focus of the Coastal Wetlands Monitoring Data Catalog and this Report was point-based, station data. There is also a need to identify how to scale-up point data so information may be applied at the regional level assessing coastal wetland conditions.
- Another challenge is in making use of various data that may have been collected by different programs and for different purposes, with different levels of precision, quality control, etc. Even when monitoring methods are the same, the design of the

study can limit the usefulness of the data in answering questions that were not considered up front.

6.3 Next Steps: Data Catalog

While compiling information on the coastal wetlands monitoring programs in the region along with the associated data into a catalog was one of the major products of this project, another product that was realized through the workshops was to identify a set of recommended actions or next steps to maintain and further enhance the data catalog:

- **Standardized parameter names**—The National Water Quality Monitoring Council is working on developing standardized names for water quality parameters. There is a potential opportunity to partner with the council to develop standardized wetlands parameter names.
- **Inclusion of monitoring methods**—The purpose of the report was to summarize the monitoring methods for the programs and station in the database. There is a need to include information about the methods in the data catalog.
- **Web-based search and query and edit functions**—Funding limitations prohibited the development of a web-based application. However, the database was designed so that it could be converted to a web-enabled platform in the future. Currently, a data administrator will have to manually revise and add data.
- **Ability to map stations**—The workgroup would also like to be able to view stations and search station information through an interactive mapper by drawing a box around an area of interest.
- **Expansion**—Including academic institutions, volunteer monitoring, and mitigation monitoring programs in the database will increase the data available.
- **Opportunity to submit comments on the GSAA website**—While the database is not web-enabled, the workgroup recommends a way for users to submit comments or questions through SECOORA. This information would inform future enhancements to the database and user interface.
- **Track the users of the database**—The workgroup also suggested the users of the database be tracked over time for at least 1 year to determine the demand for future enhancements and to measure the success of outreach activities. Gathering information on who is using monitoring data and how monitoring data is being used is an essential step that feeds back into improving monitoring programs.
- **Include geospatial data**—A future enhancement would be to include geospatial data within the database. Currently, geospatial data is summarized in Appendix D.

7. REFERENCES

- Baggett, L.P., S.P. Powers, R. Brumbaugh, L.D. Coen, B. DeAngelis, J. Greene, B. Hancock, and S. Morlock, 2014. Oyster habitat restoration monitoring and assessment handbook. The Nature Conservancy, Arlington, VA, USA., 96pp. Available at: <http://www.oyster-restoration.org/wp-content/uploads/2014/01/Oyster-Habitat-Restoration-Monitoring-and-Assessment-Handbook.pdf>
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- Noble, C.V., J.S. Wakeley, T.H. Roberts, and C. Henderson. 2007. Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing the Functions of Headwater Slope Wetlands on the Mississippi and Alabama Coastal Plains, ERDC/EL TR-07-9, U.S. Army Engineer Research and Development Center, Vicksburg, MS.
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- Noble, C.V., E.O. Murray, C.V. Klimas, and W. Ainslie, W. 2011. Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing the Functions of Headwater Slope Wetlands on the South Carolina Coastal Plain, ERDC/EL TR-11-11, U.S. Army Engineer Research and Development Center, Vicksburg, MS.
- Richardson, J.L. and M.J. Vepraskas. 2001. Wetland Soils: Genesis, Hydrology, Landscape, and Classification. Lewis Publishers, Boca Raton, Florida, USA.

- Silliman, B.R. and M.D. Bertness. 2002. A trophic cascade regulates salt marsh primary production. *Proceedings of the National Academy of Sciences* 99(16):10500-10505. doi: 10.1073/pnas.162366599
- South Carolina Department of Health and Environmental Control (SC DHEC). 2003. A regional guidebook for applying the hydrogeomorphic approach to assessing wetland functions of headwater riverine wetlands in the Atlantic Coast Flatwoods of South Carolina. Draft report to EPA Region 4, Atlanta. Cooperative Agreement Number: CD984344-98-0
- U.S. Environmental Protection Agency (US EPA) 2002a. Methods for evaluating wetland condition: introduction to wetland biological assessment. Office of Water, U.S. Environmental Protection Agency, Washington, D.C., USA. EPA-822-R-02-014.
- U.S. Environmental Protection Agency (US EPA) 2002b. Methods for evaluating wetland condition: developing an invertebrate index of biological integrity for wetlands. Office of Water, U.S. Environmental Protection Agency, Washington, D.C., USA. EPA-822-R-02-019.
- U.S. Environmental Protection Agency (US EPA). 2009. Core Elements of an Effective State and Tribal Wetlands Program. Available at:
https://www.epa.gov/sites/production/files/2015-10/documents/2009_03_10_wetlands_initiative_cef_full.pdf
- U.S. Environmental Protection Agency (US EPA). 2016. Coastal Wetlands. Available at:
<https://www.epa.gov/wetlands/coastal-wetlands#whatAre>.

Appendix A: Data Dictionaries

Table A-1. Organization Field Descriptions

Field Name	Data Type	Character Limit
Organization Name	Text	150
Organization Acronym	Text	25
Organization Description	Memo	65,536
Organization Type	Selection List	-
Type Details	Text	50
Organization Web Page	Hyperlink	-
Contact Names	Text	100
Email	Text	150
Phone	Text	50
Mailing Address	Text	255
City	Text	50
State	Selection List	-
Zip Code	Text	25

Table A-2. Monitoring Program Field Descriptions

Field Name	Data Type	Character Limit	Description
Organization	Selection List	-	Organization associated with the program
Program Name	Text	150	
Program Acronym	Text	60	
Program Description	Memo	65,536	
Purpose	Memo	65,536	
Quality of Data	Memo	65,536	
Contact Information	Text	255	Contact information (if different than organization)
Funding Source	Text	150	
Data Collected By	Memo	65,536	
Program Web Page	Hyperlink	-	
Scale of Program	Selection List	-	Associated geographic scales – local, national, regional, state, multiple states

Table A-3. Station Field Descriptions

Field Name	Data Type	Character Limit	Description
Program Name	Selection List	-	Program associated with each station
Site Code	Text	50	
Site Name	Text	100	
Description	Memo	65,536	
State	Section List	-	State in which site is located
County	Text	50	County in which site is located
Latitude (DD)	Numeric	-	Site latitude in decimal degrees
Longitude (DD)	Numeric	-	Site longitude in decimal degrees
Property Ownership	Text	150	
HUC8	Text	8	USGS82-digit Hydrologic Unit Code where the monitoring station is located
HUC12	Text	12	USGS 12-digit Hydrologic Unit Code where the monitoring station is located
Waterbody Name	Text	100	Name of the USGS waterbody associated with the HUC12 where the monitoring station is located.
Waterbody Classification	Text	50	
Is it a wetland?	Selection List	-	Is this site associated with a wetland? (yes, no, unknown)
Wetland Type	Text		Wetland type based on NC Wetland Assessment Method classification system. If the monitoring station is a not a wetland, the user can enter another name or use "not applicable" for this field. More information: https://deq.nc.gov/about/divisions/water-resources/water-resources-data/water-quality-program-development/ncwam-manual
Cowardin Type	Text		Wetland classification codes are a series of letters and numbers that are used by the National Wetlands Inventory and defined by Cowardin et al (1979). From drop down or enter other. More information: http://www.fws.gov/wetlands/data/wetland-codes.html
HGM Type	Text		The hydrogeomorphic approach to assessing wetland function. Seven wetland classes defined by Brinson (1993): depression, riverine, mineral flats, organic flats, tidal fringe, lacustrine fringe, slopes. From drop down list. More information: http://el.erdc.usace.army.mil/wetlands/class.html

Table A-4. Parameter Category Descriptions

Category	Definition
Atmospheric Conditions	Data characterizing daily conditions of the atmosphere or weather in terms of air temperatures, barometric pressure, wind, precipitation, and photosynthetically active radiation.
Biology	Data relating to flora and fauna of wetlands include vegetation, algae, benthic macroinvertebrates, and fish.
Hydrology	Data relating to water level and saturation of the wetlands include a description of hydrologic indicators or conditions and quantitative well/gauge data.
Physical/Chemical Water Properties	Data characterizing the chemical and physical condition of surface water include water temperature, pH, dissolved oxygen, nutrients, metals, and sediment.
Porewater	Data characterizing the shallow groundwater contained in the wetland sediment.
Rapid Assessment Methods	On-site assessment of wetlands to characterize the condition or function of wetlands based on visual observations. Examples include USARAM, ORAM, and NC WAM.
Soils and Elevation	Data characterizing chemical (e.g., pH, metals) and physical (e.g., bulk density) soil properties, narrative descriptions soil horizons, and elevation (e.g., marker horizon, surface elevation).

Appendix B: Coastal Wetlands Organizations

Organization Name	Description	Type	Web Page	Contact Information
NATIONAL				
Environmental Protection Agency - Office of Wetlands, Oceans, and Watersheds - National Aquatic Resource Surveys	The National Aquatic Resource Surveys (NARS) are statistical surveys designed to assess the status of and changes in quality of the nation's coastal waters, lakes and reservoirs, rivers and streams, and wetlands. Using sample sites selected at random, these surveys provide a snapshot of the overall condition of the nation's water. Because the surveys use standardized field and lab methods, we can compare results from different parts of the country and between years.	Government - Federal	https://www.epa.gov/national-aquatic-resource-surveys/background-national-aquatic-resource-surveys	Sarah Lehmann Lehmann.sarah@Epa.gov 202-566-1379
U.S. Fish and Wildlife Service, Southeast Region Inventory and Monitoring	The USFWS Southeast Region Inventory & Monitoring (I&M) Branch mission is to work collaboratively to assess the status of National Wildlife Refuge System (NWRS) lands, waters, and biota, and support achievement of conservation objectives at multiple spatial scales. They are specifically tasked to work closely with refuges, conservation partnerships such as Landscape Conservation Cooperatives, and other USFWS programs to address critical refuge information needs and evaluate effectiveness of conservation strategies on refuges.	Government - Federal	http://www.fws.gov/southeast/imnet/work/	Nicole Rankin nicole_ranki@fws.gov 843-928-3264 ext 211
FLORIDA				
Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute	The Fish and Wildlife Research Institute's work includes assessment and restoration of ecosystems and studies of freshwater and marine fisheries, aquatic and terrestrial wildlife, imperiled species, and red tides. The institute develops the information science required to analyze and disseminate research products and engages in outreach activities to complement all programs.	Government - State	http://myfwc.com/research/about/	Ryan Moyer ryan.moyer@myfwc.com 727-502-4986 Kara Radabaugh kara.radabaugh@myfwc.com
Guana Tolomato Matanzas National Estuarine Research Reserve	The GTMNERR is one of 28 reserves in the United States protected for long-term monitoring, research, and education (see www.nerrs.noaa.gov). It is a partnership between the National Oceanic and Atmospheric Administration and Florida's Department of Environmental Protection. GTMNERR participates in the System-Wide Monitoring Program (SWMP), which is designed to measure short-term variability and long-term change in estuaries around the nation.	Government - Other	www.gtmnerr.org	Nikki Dix (Research Director) nikki.dix@dep.state.fl.us 904-823-4500 Pam Marcum (Biologist)

Organization Name	Description	Type	Web Page	Contact Information
St. Johns River Water Management District	The St. Johns River Water Management District is responsible for managing groundwater and surface water resources in all or part of 18 counties in northeast and east-central Florida. Counties entirely in the district are Brevard, Clay, Duval, Flagler, Indian River, Nassau, Putnam, Seminole, St. Johns and Volusia. Counties partially in the district are Alachua, Baker, Bradford, Lake, Marion, Okeechobee, Orange and Osceola. Their mission is “to protect our natural resources and support Florida’s growth by ensuring the sustainable use of Florida’s water for the benefit of the people of the district and the state.”	Government - Other	http://sjrwmd.com	Charles Jacoby, Ron Brockmeyer cjacoby@sjrwmd.com , rbrockmeyer@sjrwmd.com 386-329-4243, 386-329-4495
Tampa Bay Estuary Program	The mission of the Tampa Bay Estuary Program is to build partnerships to restore and protect Tampa Bay through implementation of a scientifically sound, community-based management plan. The Tampa Bay Estuary Program was established in 1991 as a partnership of Hillsborough, Manatee, and Pinellas counties; the cities of Tampa, St. Petersburg, and Clearwater; the Southwest Florida Water Management District; the Florida Department of Environmental Protection; and the U.S. Environmental Protection Agency.	Government - Other	www.tbep.org	Gary Raulerson, Ed Sherwood graulerson@tbep.org , esherwood@tbep.org 727-893-2765
GEORGIA				
University of Georgia Marine Extension and Georgia Sea Grant	UGA Marine Extension and Georgia Sea Grant provide research, education, training and science-based outreach to assist Georgia in solving problems and realizing opportunities for its coastal and marine environments. By advancing research, education and training, and outreach, UGA Marine Extension and Georgia Sea Grant promote the economic, cultural, and environmental health of Georgia's coast and prepare citizens to become good stewards of coastal ecosystems and watershed resources. UGA Marine Extension and Georgia Sea Grant are units of Public Service and Outreach at the University of Georgia, supporting Georgia's short- and long-term prosperity.	Other	http://marex.uga.edu/	Mary Sweeny-Reeves msweeney@uga.edu 912-598-2350

Organization Name	Description	Type	Web Page	Contact Information
Georgia Department of Natural Resources, Coastal Resources Division	The Coastal Resources Division is the state agency entrusted to manage Georgia's coastal marshes, beaches, waters, and marine fisheries resources for the benefit of present and future generations. The Division's service area extends from the inland reach of the tidal waters to three miles offshore.	Government - State	http://coastalgadnr.org/	Jan M. Mackinnon, Jan.Mackinnon@dnr.ga.gov 912-264-7218 Benjamin F. Maher Ben.Maher@dnr.ga.gov
Sapelo Island National Estuarine Research Reserve	Sapelo Island National Estuarine Research Reserve (SINERR) is dedicated to research, education, stewardship, and sound management of coastal resources.	Government - Other	http://www.sapeloenerr.org	Rachel Guy rachel.guy@dnr.ga.gov 912-485-2251
Georgia Coastal Ecosystems Long Term Ecological Research	The Georgia Coastal Ecosystems Long Term Ecological Research site (GCE) was established by the National Science Foundation in 2000. The study domain encompasses three adjacent sounds (Altamaha, Doboy, Sapelo) on the coast of Georgia and includes upland (mainland, barrier islands, marsh hammocks), intertidal (fresh, brackish and salt marsh), and submerged (river, estuary, continental shelf) habitats. The GCE field site is based at the University of Georgia Marine Institute on Sapelo Island, and the program is administered at the University of Georgia Department of Marine Sciences in Athens, Georgia.	Organization - Non-government	http://gce-lter.marsci.uga.edu/	Merryl Alber malber@uga.edu 706-542-5966
NORTH CAROLINA				
North Carolina State University, Biological and Agricultural Engineering	Part of the University of North Carolina School system.	Academic Institutions	http://www.bae.ncsu.edu/	Mike Burchell mrburche@ncsu.edu 919-513-7348
North Carolina State University, Department of Forestry and Environmental Resources	Part of the University of North Carolina School system.	Academic Institutions	www.ncsu.edu	Marcelo Ardon mlardons@ncsu.edu 919-515-5573

Organization Name	Description	Type	Web Page	Contact Information
National Oceanic and Atmospheric Administration, National Centers for Coastal Ocean Science, Center for Coastal Fisheries and Habitat Research	<p>The Center for Coastal Fisheries and Habitat Research (CCFHR) conducts research on the effects of coastal habitat change and restoration on living marine resources such as seagrasses, marshes, reefs, and fish. Major programs include (1) Ecology of Harmful Algal Blooms; (2) Marine Restoration and Spatial Planning; and (3) Ecological Responses to Climate Change. The Center is located Beaufort, North Carolina and Kasitsna Bay, Alaska. We share space with NOAA Fisheries and the North Carolina Estuarine Research Reserve staff in Beaufort, and offer field-housing to visiting researchers and students in Kasitsna Bay.</p>	Government - Federal	https://coastalscience.noaa.gov/about/centers/ccfhr	Carolyn Currin Carolyn.currin@noaa.gov 252-728-8749
North Carolina Division of Water Resources	<p>State water resources division within the state environmental protection agency (NC Department of Environmental Quality)</p>	Government - State	http://deq.nc.gov/about/divisions/water-resources	Cyndi Karoly cyndi.karoly@ncdenr.gov 919-743-8479 Kristie Gianopulos Kristie.Gianopulos@ncdenr.gov 919-743-8416
North Carolina National Estuarine Research Reserve	<p>The North Carolina National Estuarine Research Reserve (NCNERR) is part of the National Estuarine Research Reserve System (NERRS), a network of 28 protected areas established for research and education. The NCNERR is comprised of 4 reserves and managed as a federal-state partnership between the National Oceanic Atmospheric Administration and the North Carolina Department of Environmental Quality. The NCNERR participates in the NERRS System-Wide Monitoring Program (SWMP), which is designed to measure short-term variability and long-term change in estuarine water quality, biological systems, and land cover.</p>	Government - Other	http://www.nccoastalreserve.net/	Brandon Puckett, brandon.puckett@ncdenr.gov 252-838-0851 Rebecca Ellin rebecca.ellin@ncdenr.gov 252-838-0880

Organization Name	Description	Type	Web Page	Contact Information
SOUTH CAROLINA				
SCDNR Marine Resources Division	The Division of Marine Resources is responsible for the management and conservation of the state's marine and estuarine resources. The division conducts monitoring and research on the state's marine resources and makes recommendations for the management of those resources.	Government - State	http://www.dnr.sc.gov/divisions/marine.html	Denise Sanger sangerd@dnr.sc.gov
Belle W. Baruch Institute for Marine and Coastal Sciences	The Belle W. Baruch Institute for Marine and Coastal Sciences conducts research and supports education to improve the management of marine and coastal resources and advance basic science for the well-being of people and their environment.	Academic Institutions	www.baruch.sc.edu	James Morris, morris@inlet.geol.sc.edu 803-777-5288 Karen Sundberg sundberg@biol.sc.edu 843-904-9037
Coastal Carolina University	The Environmental Quality Lab (EQL) is housed within the Waccamaw Watershed Academy at Coastal Carolina University's Center for Marine and Wetland Studies. The mission of the academy is to deliver educational, research, and public outreach services to the university and the local region.	Academic Institutions	http://www.coastal.edu/intranet/wwa/	Susan Libes, susan@coastal.edu 843-349-4019 Paul Gayes, ptgayes@coastal.edu Rich Viso rviso@coastal.edu
South Carolina Department of Health and Environmental Control	The South Carolina Department of Health and Environmental Control (DHEC) is the state regulatory agency charged with promoting and protecting the state's public health and its land, air, coastal resources and water quality as authorized by federal and state law.	Government - State	http://www.scdhec.gov/	DHEC Help Desk info@dhec.sc.gov 803-898-DHEC (3432)
Ashpoo-Combahee-Edisto (ACE) Basin National Estuarine Research Reserve	The ACENERR is one of 28 reserves in the U.S. protected for long-term monitoring, research, and education (see www.nerrs.noaa.gov). It is a partnership between NOAA and the South Carolina Division of Natural Resources. The ACENERR participates in the System-Wide Monitoring Program (SWMP), which is designed to measure short-term variability and long-term change in estuaries around the nation.	Government - Other	http://www.dnr.sc.gov/marine/NERR/	Phil Maier maierP@dnr.sc.gov 843-546-6129

Organization Name	Description	Type	Web Page	Contact Information
The Nature Conservancy - South Carolina Chapter	TNC works in 69 countries and all 50 U.S. states to protect a myriad of habitats to preserve the diversity of life on Earth. From coral reefs to deserts, TNC works to protect the lands and waters that plants and animals need to survive—for us and for future generations.	Organization - Non-government		Joy Brown joy_brown@tnc.org 843-937-8807 x35

Appendix C: Coastal Wetlands Monitoring Programs

Monitoring Program	Organization	Program Description	Purpose of Program	Scale	Web Page
NATIONAL AND REGIONAL ORGANIZATIONS					
NWCA	Environmental Protection Agency - Office of Wetlands, Oceans, and Watersheds - National Aquatic Resource Surveys	The National Wetland Condition Assessment (NWCA) is a collaborative survey of our Nation's wetlands. The NWCA examines the chemical, physical and biological integrity of wetlands through a set of commonly used and widely accepted indicators. The sampling design for the NWCA is a probability-based network that provides statistically-valid estimates of ecological condition for a population of wetlands with known confidence.	The NWCA is designed to answer basic questions about the extent to which our nation's wetlands support healthy ecological conditions and the prevalence of key stressors at the national and regional scale. It is intended to complement and build upon the achievements of the U.S. Fish and Wildlife Service Wetland Status and Trends Program, which characterizes changes in wetland acreage across the conterminous United States.	National	https://www.epa.gov/national-aquatic-resource-surveys/nwca
CWEM	U.S. Fish and Wildlife Service, Southeast Region Inventory and Monitoring	Coastal wetland elevation monitoring is being conducted on 18 National Wildlife Refuges within the South Atlantic Landscape Conservation Cooperative in coordination with partners at NOAA, USGS, NPS, and other regions of the USFWS.	This monitoring effort involves collecting surface elevation from rod surface elevation tables, accretion from marker horizons, porewater salinity, and vegetation community data at permanent monitoring sites deployed in selected priority wetland habitats to provide data to refuge managers on the status of and trends in wetland conditions within refuges.	Regional	http://www.fws.gov/southeast/IMnetwork/abiotic.html
FLORIDA					
CHIMMP	Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute	CHIMMP's goals include aiding coordination of mapping and monitoring efforts in the state of Florida through workshops, pilot studies, collaborative reports in order to increase communication, minimize duplicate efforts and identify data gaps, needs, and priorities.	-	State	http://ocean.floridamarine.org/CHIMMP/

Monitoring Program	Organization	Program Description	Purpose of Program	Scale	Web Page
CWRE	St. Johns River Water Management District	Sediment Elevation Tables (SET), established to assess the impact of impounded wetland management on sediment processes, are now part of a network of sites in the northern Indian River Lagoon (IRL). Additional SETs were established to evaluate the success of coastal wetland restoration efforts.	To evaluate coastal wetland restoration methods and success and to assess the condition of coastal wetlands.	Regional	http://sjrwmd.com/coastalrestoration
CCHA	Tampa Bay Estuary Program	CCHA includes a network of 9 Tampa Bay transects that extend from the water's edge through a mosaic of coastal wetland and upland habitat. Vegetation, porewater, and accretion data will be monitored every 3-5 years to examine ecosystem response to sea level rise.	Develop a long term monitoring program to assess the status, trends, and ecological function of the mosaic of critical coastal habitats to detect changes due to natural, and indirect anthropogenic impacts including sea level rise and climate change, and improve future management of habitats	Regional	http://www.tbep.tech.org/
SWMP-GTMNERR	Guana Tolomato Matanzas National Estuarine Research Reserve	Permanent plots and transects are established throughout the Reserve to study the changes in emergent vegetation structure and sediment elevation over time. This program is part of the National Estuarine Research Reserve System-Wide Monitoring Program, which involves a consistent protocol for monitoring vegetation across the nation's estuaries.	The primary goal of this project is to conduct long-term monitoring of emergent intertidal vegetation within the GTMNERR to provide a better understanding of the ecological characteristics of this dynamic community and discern the impacts of local and global environmental changes on the estuarine ecosystem.	National	http://nerrsdata.org

Monitoring Program	Organization	Program Description	Purpose of Program	Scale	Web Page
GEORGIA					
GCE-LTER-CLIM	Georgia Coastal Ecosystems Long Term Ecological Research	Four meteorological stations, operated and maintained by various institutions affiliated with the GCE LTER program, are used to characterize the weather and climate over a large spatial scale within the GCE LTER domain.	Monitor long-term meteorological data within the GCE domain	Local	http://gce-lter.marsci.uga.edu/public/research/mon/climate.htm
GCE-LTER-STWL	Georgia Coastal Ecosystems Long Term Ecological Research	The objective of the GCE Continuous Salinity, Temperature and Water Level Monitoring program is to document spatial and temporal variability of salinity and its relationship to water level and river discharge. Long-term measurements of conductivity, temperature and sub-surface pressure are collected at 30 minute intervals at 8 sites in the GCE-LTER domain.	These monitoring sites were chosen to span the salinity gradient as well as to take advantage of existing physical structures (e.g. docks or pilings) for mounting instruments. The long-term moorings are located in transect regions used for quarterly oceanographic surveys and near to GCE-LTER marsh study sites.	Local	http://gce-lter.marsci.uga.edu/public/research/mon/sounds_creeks.htm
GCE-LTER-WQM	Georgia Coastal Ecosystems Long Term Ecological Research	The GCE LTER project monitors nutrient chemistry, chlorophyll concentrations, and vertical profiles of salinity, temperature and photosynthetically-available radiation monthly to document environmental gradients across the GCE landscape.	Long-term water quality monitoring	Local	http://gce-lter.marsci.uga.edu/public/research/research.htm
LS (GA CRD)	Georgia Department of Natural Resources, Coastal Resources Division	Living Shorelines are novel engineering approaches which provide alternatives to conventional armored shorelines that are constructed to protect lands lying adjacent to estuarine waters from erosion.	To provide assistance to public and private landowners in permitting, monitoring, outreach, and education associated with Living Shorelines.	Regional	http://coastalgadnr.org/LivingShorelines

Monitoring Program	Organization	Program Description	Purpose of Program	Scale	Web Page
MD (GA CRD)	Georgia Department of Natural Resources, Coastal Resources Division	Marsh dieback occurrences in coastal Georgia gained publicity in 2002. A collaborative research council involving multiple partners was formed in order to monitor and assess marsh dieback sites along the Georgia coast.	To monitor the health of Georgia's salt marshes by responding to reports of marsh dieback and to assist local government and academic institutions in data collection.	Regional	http://www.gcrc.uga.edu/FocusAreas/marsh_dieback.htm
MEA (GA CRD)	Georgia Department of Natural Resources, Coastal Resources Division	Salt marsh edge is widely known as habitat for juvenile finfish and invertebrates. Furthermore, marsh edge habitat with the presence of oyster reefs has been identified as essential fish habitat, and routine monitoring of this habitat began in 2015.	To assess and quantify marsh edge habitat in coastal GA by measuring vegetation, nekton abundance and diversity, and water quality.	Regional	http://coastalgadnr.org/
SWMP-SINERR	Sapelo Island National Estuarine Research Reserve	The monitoring program (known as the System-Wide Monitoring Program, or SWMP) provides long-term data on water quality, weather, biological communities, habitat, and land-use and land-cover characteristics.	Research, coupled with the monitoring data, provides a strong, science-based foundation for addressing coastal management challenges.	National	http://cdmo.baruch.sc.edu
GA AAW	University of Georgia Marine Extension and Georgia Sea Grant	This is a hands-on education program that promotes wetland conservation through volunteer monitoring. Wetlands are valuable coastal resources, playing an important role in water quality, sediment retention, flood control, and wildlife habitat. This program is designed to complement the Georgia Adopt-A-Stream program.	The goals the program are to educate the public on the importance of wetlands, increase public awareness of water quality issues, train citizens to monitor and protect wetlands and collect baseline wetland health data.	Regional	http://marex.uga.edu/wetland/

Monitoring Program	Organization	Program Description	Purpose of Program	Scale	Web Page
NORTH CAROLINA					
DCERP	National Oceanic and Atmospheric Administration, National Centers for Coastal Ocean Science, Center for Coastal Fisheries and Habitat Research	DCERP is designed to conduct basic and applied research in support of the U.S. Department of Defense's ecosystem-based management approach to sustain its military training mission while optimizing its natural resources stewardship. Marine Corps Base Camp Lejeune in Jacksonville, NC was selected as the host installation for this 10-year integrated research and monitoring program.	The DCERP Coastal Wetlands Monitoring Program designed to (1) Improve understanding of the physical, biological, and ecological processes that determine the stability and community structure of the coastal wetlands ecosystem; (2) Quantify spatial and temporal (inter-annual) variability in key parameters affecting marsh carbon, nutrient, and sediment fluxes; and (3) Provide data to support development of forecasting tools and models.	Local	https://dcerp.rti.org
Marsh Shoreline (NOAA)	National Oceanic and Atmospheric Administration, National Centers for Coastal Ocean Science, Center for Coastal Fisheries and Habitat Research	NOAA and NC NERRS monitor salt marshes in late summer for peak biomass and other parameters. Permanent plots established in a stratified sampling regime are used. Sites include natural fringing marshes with and without oyster reefs, as well as marsh sills built as part of Living Shoreline programs.	The objective is to track annual changes in marsh vegetation, surface elevation and shoreline position, to determine the impact of stone sills, SLR, and other environmental drivers on marsh vegetation.	Local	
SEIWA	North Carolina Division of Water Resources	The Southeast Isolated Wetland Assessment (SEIWA) explored the condition and fate of geographically isolated wetlands (GIWs) in an 8-county portion of the coastal plain of North and South Carolina. SEIWA employed a phased approach based on three levels of wetland assessment described by EPA.	The purpose of this monitoring assessment was to determine if geospatial datasets could be used to identify geographically isolated wetlands (GIWs); estimate the rate or extent of loss of GIWs; determine the function and characteristic biotic features of GIWs, and determine the hydrology of GIWs.	Regional	

Monitoring Program	Organization	Program Description	Purpose of Program	Scale	Web Page
NCDWR Headwater Wetlands	North Carolina Division of Water Resources	This program was the beginning of the NC wetland monitoring program and focused on the monitoring of physical, chemical, and biological parameters of one type of wetland-headwater wetlands.	The purpose of this program was to elucidate the differences and similarities among amphibians, macroinvertebrates and vegetation along a gradient of human disturbance within specific wetland types in North Carolina.	State	
North Carolina Wetland Mitigation Evaluation - Aquatic Biota	North Carolina Division of Water Resources	This program focused on macroinvertebrate and amphibian communities on 4 traditional NC wetland compensatory mitigation restoration sites and 4 non-traditional and non-compensatory WRC wetland restoration sites, as compared to communities in 8 matched reference wetlands.	The purpose of this study was to assess success of traditional wetland restoration techniques used for NC compensatory mitigation and non-traditional WRC restoration techniques by comparing amphibian and macroinvertebrate use of the two types of restoration sites to reference sites.	State	
NCDWR Field Verification	North Carolina Division of Water Resources	This program is an expansion of the NC wetland monitoring program and focused on three wetland types: Small Basin wetlands, Bottomland Hardwood Forests, and Riverine Swamp Forests.	The purposes of this program are to: (1) continue the process of establishing a wetlands monitoring program in North Carolina by monitoring different wetland types; and (2) continue to provide data for the verification and validation of the North Carolina Wetlands Assessment Method (NCWAM).	State	

Monitoring Program	Organization	Program Description	Purpose of Program	Scale	Web Page
NCDWR Isolated Wetland Connectivity	North Carolina Division of Water Resources	Isolated wetlands in the coastal plain counties of NC and SC were evaluated for their hydrological function and pollution absorption capacity and surveyed to develop biocriteria.	The objective of this research was to gain a better understanding of the hydrologic connectivity, pollution absorption capacity and biocriteria of IWs through intensive field study and to determine if there has been a net-loss of IWs in NC following implementation of a permitting program for IWs in NC.	Regional	http://ncdenr.s3.amazonaws.com/s3fs-public/Water%20Quality/Surface%20Water%20Protection/PDU/Grant%20Final%20Reports/IWC%20Final%20Report%20vs02-19-2013-FINAL.pdf
NWCA-NC	North Carolina Division of Water Resources	The 2011 National Wetland Condition Assessment (NWCA) was the first collaborative survey of the Nation's wetlands, to be repeated on a five-year cycle. In addition to the EPA's NWCA data collection, the NCDWR used Level 2 rapid assessment methods to characterize each wetland site. Data were collected on 47 wetland sites in NC.	The purpose of this monitoring program was to augment EPA's first national survey of wetlands. Additional rapid assessments were added to compliment the EPA's protocol and gather additional information for NC's purposes using the NCWAM and ORAM.	State	
NWCA Intensification NC	North Carolina Division of Water Resources	This monitoring was an extension of the EPA's 2011 National Wetland Condition Assessment (NWCA), and was conducted in 2012/2013. North Carolina, South Carolina, and Alabama were awarded an Intensification grant from the EPA to perform a regional wetland assessment that would add to the EPA's NWCA, but at a regional level, not just a state level.	The purpose of this monitoring program was to use the same survey/sampling methods from the EPA's National Wetlands Condition Assessment effort with some additional methods that have been used in NC's wetlands monitoring programs for several years such as sampling for amphibians and macroinvertebrates, taking water quality samples over time, and monitoring the hydrology.	Multiple states	

Monitoring Program	Organization	Program Description	Purpose of Program	Scale	Web Page
North Carolina Wetland Mitigation Evaluation - Pilot Study	North Carolina Division of Water Resources	The Environmental Law Institute (ELI) subcontracted both NCDWR and NC State University to collect wetland data on 30 compensatory wetland mitigation sites in North Carolina that were permitted after 2006, at least four years old, riparian or riverine and considered successful by regulatory agencies. The results of the NC study were compared to and synthesized by ELI with the 2011 Ohio Mitigation Pilot Study.	The purpose of the ELI study was to evaluate the ecological integrity of NC wetland compensatory mitigation projects overall and by each of the three types; permittee responsible, mitigation bank, and in-lieu fee.	State	http://www.eli.org/compen-satory-mitigation
SWPM (NCNERR)	North Carolina National Estuarine Research Reserve	The emergent marsh monitoring component of the National Estuarine Research Reserve System-Wide Monitoring Program is designed to assess changes in the spatial and temporal distribution of emergent vegetation. Following this protocol, emergent marsh is monitored in 3 (of 4) NCNERR components—the Rachel Carson, Masonboro Island, and Zeke’s Island Reserves.	The primary purpose of NCNERR’s emergent marsh monitoring program is to routinely assess indicators of change in the composition and diversity of marsh communities within NCNERR.	National	http://cdmo.baruch.sc.edu/
NC WMN	North Carolina State University, Biological and Agricultural Engineering	Through a grant from the U.S. Environmental Protection Agency, North Carolina State University (NCSU) is continuing and expanding the work done by NC DWR by monitoring the hydrology, water quality, soils, and biota at 16 long-term wetland monitoring sites across the Piedmont and Coastal Plain regions of North Carolina.	Through a grant from the U.S. Environmental Protection Agency, NCSU is continuing and expanding the work done by NC DWR by monitoring the hydrology, water quality, soils, and biota at 16 long-term wetland monitoring sites across the Piedmont and Coastal Plain regions of North Carolina.	State	https://ncwetlands.wordpress.ncsu.edu/

Monitoring Program	Organization	Program Description	Purpose of Program	Scale	Web Page
TOWeR	North Carolina State University, Department of Forestry and Environmental Resources	This research project started in 2006 to examine the consequences of a large-scale wetland restoration (440 ha) project in the coastal plain. It has evolved to examine how saltwater intrusion and changes in precipitation alter the functioning of coastal wetlands.	To understand the effects climate change and land use legacies on coastal wetlands	Regional	www.marceloardon.weebly.com
SOUTH CAROLINA					
SWMP-ACENERR	Ashepoo-Combahee-Edisto (ACE) Basin National Estuarine Research Reserve	The wetland monitoring project, which is part of the Reserve's larger monitoring program, is designed to assess the vulnerability of tidal wetlands to changes associated with anticipated climate changes such as prolonged periods of drought and wet years.	The purpose of the wetland project to describe plant communities with respect to elevation and tidal range; to evaluate short-term changes in response to spatial and temporal variability and track long-term changes in plant communities.	Local	http://www.dnr.sc.gov/marine/NERR/
LoBOS	Coastal Carolina University	Coastal observation network including meteorological and water quality stations located on fishing piers in Long Bay.	To monitor nearshore atmospheric and ocean water quality conditions	Regional	http://bccmws.coastal.edu/lbos/
NSF-LTREB	Belle W. Baruch Institute for Marine and Coastal Sciences (University of South Carolina)	Long-term measurements of salt marsh primary production, marsh elevation and sediment chemistry.	To examine the relationships and feedbacks between salt marsh primary productivity, biogeochemical cycling and marsh elevation, and use this information to develop a model that predicts marsh stability, primary production and elevation adjustments to changes in the rate of se-level rise.	Local	http://ww2.biol.sc.edu/~morris/annprod.html

Monitoring Program	Organization	Program Description	Purpose of Program	Scale	Web Page
TNC Oyster Restoration	The Nature Conservancy - South Carolina Chapter	The Nature Conservancy (TNC) and the SC Department of Natural Resources received funding through the NOAA Community-based Restoration Program to test the viability of the oyster castles as a substrate for continued oyster growth. Studies have demonstrated that boat wakes can increase the erosion rate of salt marsh and the presence of oyster reefs may limit the impact.	To test the effectiveness of oyster castles in establishing habitat, reducing shoreline erosion, and promoting marsh grass growth.	State	
Oak Point Living Shoreline	The Nature Conservancy - South Carolina Chapter	Use of bagged shell to stabilize marsh edge and support habitat development. SCDNR Geological Survey monitored sediment accretion. Monitoring results showed sediments accreted quickly behind and on the reef materials. Sedimentation precluded oyster recruitment and growth.	Stabilize marsh edge and support habitat development.	State	http://projects.tnc.org/coastal/
Goldbug Living Shoreline	The Nature Conservancy - South Carolina Chapter	The Goldbug Island Living Shoreline project consists of a 240' long reef and is made of wooden pallets, oyster castles, cement blocks, and bagged shell to stabilize marsh edge. TNC will be monitoring water quality, oyster recruitment, oyster growth and marsh vegetation growth. SCDNR will be assessing sediment composition and accretion behind the reef.	Habitat restoration, shoreline stabilization	State	http://projects.tnc.org/coastal/

Monitoring Program	Organization	Program Description	Purpose of Program	Scale	Web Page
TNC Winyah Bay Living Shoreline	The Nature Conservancy - South Carolina Chapter	The North Island project included 360 castle blocks that were sited along the edges of existing marsh grass populations that displayed signs of erosion. Monitoring included a vibracore analysis on the islands to access the sediment profile shoreline and historic shoreline map.	Habitat Restoration and environmental benefits.	State	http://projects.tnc.org/coastal/
SC HGM	South Carolina Department Health and Environmental Control	DHEC was awarded a wetland protection grant from the United States Environmental Protection Agency Region 4 to develop a regional HGM guidebook.	The purpose of the project was to develop a hydrogeomorphic (HGM) guidebook for assessing the functions of a regional subclass of wetlands important to water quality and under pressure from coastal development, partly due to their small size and adjacency to uplands.	State	None

Appendix D: Geographic Information System (GIS) Monitoring Data

Organization	Monitoring Program	GIS Dataset Name	GIS Dataset Description	Publication Date	URL
NOAA Center for Coastal Fisheries and Habitat Program	DCERP	New River Estuary Shoreline Characterization	This shapefile consists of the 2004 shoreline that was edited in the field in order to characterize the shoreline. The data was edited within ArcGIS, using GPS equipment to obtain the position of the boat relative to the shoreline. Fields were created for the shapefile including, Shoreline type, vegetation/species type, shoreline modification type, and relief. A unique identification code was created by concatenating the four field values of the four fields. A new field Veg_2 was added in January 2013 to code the vegetation and shoreline type.	1/17/2013	https://dcerp.rti.org/
NOAA Center for Coastal Fisheries and Habitat Program	DCERP	ICW Digitized Shoreline	The shoreline was digitized as the land water boundary in 2004, 1989, and 1956 imagery. The imagery was obtained from the Installation Geospatial Information & Services Office, ITSD, BLSD, MCB Camp Lejeune, NC. These shorelines were digitized to be used to calculate shoreline-change rates within the New River Estuary as part of the Defense Coastal/Estuarine Research Program. Each shoreline was digitized separately and then merged to create one shapefile containing the shorelines of all three years.	6/17/2009	https://dcerp.rti.org/
NOAA Center for Coastal Fisheries and Habitat Program	DCERP	ICW Shoreline Characterization	Shoreline characterization of the Intracoastal waterway within the boundaries of Marine Corps Base Camp Lejeune. Data was collected by ground truth methods and included boat operations. The shoreline of the ICW was characterized by boat in April and June 2010 using Global Positioning Systems (GPS) equipment and ArcGIS software. The previously digitized 2009 shoreline was edited within ArcGIS, using GPS equipment to obtain the position of the boat relative to the shoreline. Four fields were created for the shoreline shapefile, including: shoreline type, vegetation/species, modification type and relief. A unique identifying code was created by concatenating the field values of the four fields. in January 2013 the field Veg_2 was created for the output of SLtype and Vegtype coding.	1/22/2013	https://dcerp.rti.org/

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NOAA Center for Coastal Fisheries and Habitat Program	DCERP	New River Estuary Digitized Shoreline	The shoreline was digitized as the land water boundary in 2004, 1989, and 1956 imagery. The imagery was obtained from the Installation Geospatial Information & Services Office, ITSD, BLSO, MCB Camp Lejeune, NC. These shorelines were digitized to be used to calculate shoreline-change rates within the New River Estuary as part of the Defense Coastal/Estuarine Research Program. Each shoreline was digitized separately and then merged to create one shapefile containing the shorelines of all three years.	6/17/2009	https://dcerp.rti.org/
NC Division of Environmental Quality	Coastal Management Division	North Carolina Coastal Region Evaluation of Wetland Significance (NC-CREWS)	The North Carolina Coastal Region Evaluation of Wetland Significance, or NC-CREWS, is a watershed-based wetlands functional assessment model that uses geographic information systems (GIS) software and data to assess the level of water quality, wildlife habitat, and hydrologic functions of individual wetlands. The primary objective of the NC-CREWS wetland functional assessment is to provide users with information about the relative ecological importance of wetlands for use in planning and the overall management of wetlands. The structure of NC-CREWS is hierarchical. The model consists of four levels: (1) overall functional significance of the wetland; (2) specific functions and potential risk of wetland loss; (3) subfunctions; and (4) parameters and subparameters evaluated to determine the level and extent of functions. The model evaluates 39 separate characteristics of the wetland and its watershed (14-digit hydrologic units). Using GIS analysis, a High, Medium, or Low rating is assigned to each of the subparameters that describe the landscape and internal wetland characteristics. The subparameter ratings are successively combined to produce ratings for parameters; parameter ratings are combined to produce ratings for subfunctions; subfunction ratings are combined to produce ratings for primary functions. The primary functions are combined to form an overall wetland rating of the wetland's ecological significance. NC-CREWS produces 3 possible overall wetland rating scores: Exceptional Significance, Substantial Significance, or Beneficial Significance.	1999	https://deq.nc.gov/about/divisions/coastal-management/coastal-management-data/setback-factor-maps-1998-shoreline/nc-crews-wetlands-functional-assessment

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Albemarle Pamlico NEP	SAV Monitoring Program	Submerged Aquatic Vegetation	During 2007-2008 the first aerial survey of submerged aquatic vegetation (SAV) in North Carolina was coordinated and funded by the SAV Partnership, of which APNEP is a founding member. APNEP also funded and published an interpretative SAV map, which was later featured in the 2012 APNEP Ecosystem Assessment. With a baseline established, APNEP again supported SAV monitoring by funding and coordinating another aerial survey of the Albemarle-Pamlico sounds between 2012 and 2014. The second map is scheduled for release in 2015 and will allow for the detection of trends in SAV coverage for the first time.	2007-2008	http://portal.ncdenr.org/web/apnep/sav-monitoring
Georgia Coastal Resources Division	Coastal Georgia NWIPLUS	Coastal Georgia NWIPLUS	The State of Georgia recently added LLWW descriptors to their updated wetland inventory data to create an NWIPlus database for six coastal counties. LLWW descriptors are abiotic characteristics that describe a wetland's landscape position, landform, water flow path, and waterbody type. The NWIPlus data will be used to better characterize wetlands in this region and to be able to predict wetland functions at the landscape level.	2011	http://coastalgadnr.org/sites/uploads/crd/CORRELATION%20REPORT%20Georgia_FINAL_September-20-2011.pdf
Florida Fish and Wildlife Conservation Commission (in partnership with Florida Natural Areas Inventory)	Land Cove	Florida Cooperative Land Cover Map	The Florida Cooperative Land Cover Map (CLC) is a partnership between the Florida Fish and Wildlife Conservation Commission (FWC) and Florida Natural Areas Inventory (FNAI) to develop ecologically-based statewide land cover from existing sources and expert review of aerial photography. The CLC follows the Florida Land Cover Classification System and is updated every 6 - 12 months.	2015	http://www.fnai.org/LandCover.cfm