

North Carolina Sentinel Site Cooperative

Implementation Plan



Federal Fiscal Years 2013 - 2017

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I. Introduction

The North Carolina (N.C.) Sentinel Site Cooperative (NCSSC) was established in 2012 as part of a National Oceanic and Atmospheric Administration (NOAA)-wide effort to provide coastal communities and resource managers with information on the potential impacts of sea level rise on coastal habitats. This document serves as the NCSSC Implementation Plan for Federal Fiscal Years 2013-2017 (FFY 13-17). The implementation plan describes the intent and path forward for the N.C. Cooperative for the next five years and provides a means to track progress. The plan will be updated every five years with actions and operating plans updated annually.

Overview of the Sentinel Site Program

NOAA established the Sentinel Site Program (SSP) to utilize existing assets, programs, and resources to address coastal management issues of local, regional, and national significance through a place-based, issue-driven, and collaborative approach. The SSP capitalizes on existing investments in NOAA trust resources, such as National Marine Sanctuaries, National Estuarine Research Reserves, and observing systems, to include a continuum of NOAA and partner capabilities from research and monitoring to management and decision-making to address sea level change and coastal inundation. The SSP outlines an innovative business model to better leverage resources across NOAA and its partners to increase efficiencies, integrate multiple parallel efforts, and provide information and tools to help communities and resource managers adapt to sea level change and inundation.

Five Sentinel Site Cooperatives were selected by NOAA for implementation based on their scientific relevance to addressing sea level change and inundation, capacity for leveraging existing resources, partners, assets, and potential to inform and respond with management action. The pilot Cooperatives include Hawaii, the San Francisco Bay area, the Chesapeake Bay, North Carolina, and the Northern Gulf of Mexico.

The SSP directly addresses a number of NOAA's Next Generation Strategic Plan goals and objectives including:

- Climate Adaptation and Mitigation
 - Improved scientific understanding of the changing climate system and its impacts
 - Assessments of current and future states of the climate system that identify potential impacts and inform science, service, and stewardship decisions
 - A climate-literate public that understands its vulnerabilities to a changing climate and makes informed decisions
- Healthy Oceans
 - Improved understanding of ecosystems to inform resource management decisions
 - Recovered and healthy marine and coastal species
 - Healthy habitats that sustain resilient and thriving marine resources and communities
- Resilient Coastal Communities and Economies
 - Resilient coastal communities that can adapt to the impacts of hazards and climate change

- Improved coastal water quality supporting human health and coastal ecosystems services
- Comprehensive ocean and coastal planning and management.

In addition, the SSP directly addresses the NOAA Habitat Blueprint vision of “healthy habitats that sustain resilient and thriving marine and coastal resources, communities, and economies,” as well as supporting all five of its expected outcomes:

- Sustainable and abundant fish populations,
- Recovered threatened and endangered species,
- Protected coastal and marine areas and habitats at risk,
- Resilient coastal communities, and
- Increased coastal/marine tourism, access, and recreation.

The Habitat Blueprint has identified the five Sentinel Site Cooperatives as potential habitat regional initiatives that can facilitate long term habitat science and conservation.

Why is a Sentinel Site Cooperative Needed in North Carolina?

North Carolina represents a unique suite of characteristics that make it well suited to pilot a Sentinel Site Cooperative.

Sea Level Rise Vulnerability

The coast of North Carolina has one of the highest vulnerabilities to sea level rise (SLR) on the Atlantic coast (Thieler and Hammar-Klose, 1999 and CCSP 2009), due to its high wave exposure, low-relief coastal slope, and abundance of barrier islands (Figure 1). The likelihood of SLR effects on this coast was made clear by the N.C. Coastal Resource Commission’s Science Panel on Coastal Hazards (NCCRC 2010) which reported that North Carolina is likely to experience between 15 and 55 inches of relative sea-level rise by 2100. The highest relative rise is expected along the northern half of the coast where land subsidence is higher than in the southern half.

Physical and Ecological Setting

North Carolina's coastal plain is low, flat land along the Atlantic Ocean that extends westward from the sounds for 100 to 140 miles (160–225 km) and upward from sea level to 500 feet (150 m). The outer coast is dominated by a world- renowned barrier island complex (the Outer Banks) which, besides being a major tourist destination provides substantial

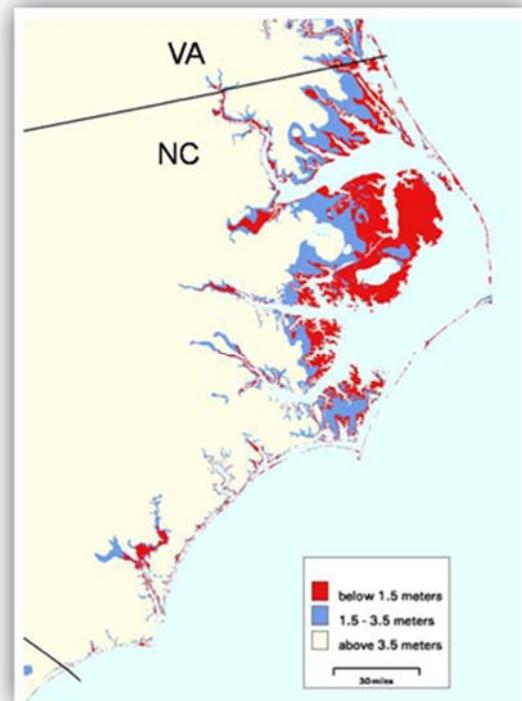


Figure 1. Taken from Titus and Richman (2001) showing the large extent of coastal communities and habitats vulnerable to SLR and inundation in North Carolina.

protection for the sounds and estuaries (Figure 2). The islands stretch more than 175 miles along the coast but they, like the adjacent mainland are often no more than a few meters above current sea level. The protected waters behind the barrier islands are very shallow, and are dominated by the Albemarle and Pamlico Sounds which form the second largest estuarine ecosystem on the east coast of the United States.

There are large differences in tidal range, salinity, and size of the back barrier sounds along the North Carolina coast (Figure 2). In the northern region, the back barrier sounds (Currituck and Albemarle) are medium-sized and due to their distance from ocean inlets, receive little influence from the ocean. As a result, diurnal tides in these sounds are essentially nonexistent and water level changes in these sounds are primarily attributable to wind driven forcing. Salinity values are much lower (2-7 ppt) than in the coastal ocean (35 ppt) and the sounds farther south. Along the central North Carolina coast, there is one extremely large sound (Pamlico) and several small ones to the south (Core, Back, and Bogue). Tidal ranges



Figure 2. North Carolina coastal regions and back barrier sounds.

in these sounds vary from 0.5 to 3.5 feet (~0.2 – 1 m) depending on distance from an ocean inlet. Salinity in the sounds of the central region also varies based on distance from an ocean inlet. Typical values range between 15-25 ppt. The sounds in the southern region of North Carolina (Stump, Topsail, Middle, Greenville, Masonboro, and Myrtle Grove) are smaller than those to the north as the barrier islands tend to be much closer to the mainland than in the north. Consequently, their tidal range is closer to the coastal ocean values which in this region range from 3 to 6 feet (~0.9 – 1.8 m). Salinity in these sounds is also much closer to coastal ocean values ranging from 25-35 ppt. These differences in North Carolina’s back barrier sounds foster a high degree of diversity among the estuarine environments in the northern, central and southern sections of the coast.

The coastal regions of North Carolina are influenced greatly by the two prevailing ocean currents that converge off of Cape Hatteras (Figure 3). The Gulf Stream provides a warming effect to the southern coastal areas, and the Labrador Current provides a cooling effect for the northern coast. This creates a strong thermal gradient between the northern (cooler) and southern (warmer) coastal areas. The mixing of the warm and cold waters can enhance oceanic storms off the coast of North Carolina. Both tropical storms (and hurricanes) and winter Nor'easters produce large amounts of precipitation and gale force winds. The resulting inundation and high wave energy generate significant erosion and sediment transport in these coastal environments. The convergence of these currents provides a richly diverse biological region off the North Carolina coast where species from both the Carolinian (warmer) and Virginian (cooler) biogeographic provinces coexist. The extensive nature of North Carolina's wetlands and submerged grass habitats provide very high ecological value. North Carolina sounds include more than 200,000 acres of seagrasses with the unique overlap of two subtropical and temperate species found nowhere else on the planet. There is also a similar acreage of saltmarsh and associated high marsh. Tropical, subtropical and temperate plant and animal species seasonally coexist here, fueled by the Gulf Stream, migratory flyways, and a moderate climate, including several native species (both flora and fauna) that are listed as threatened.

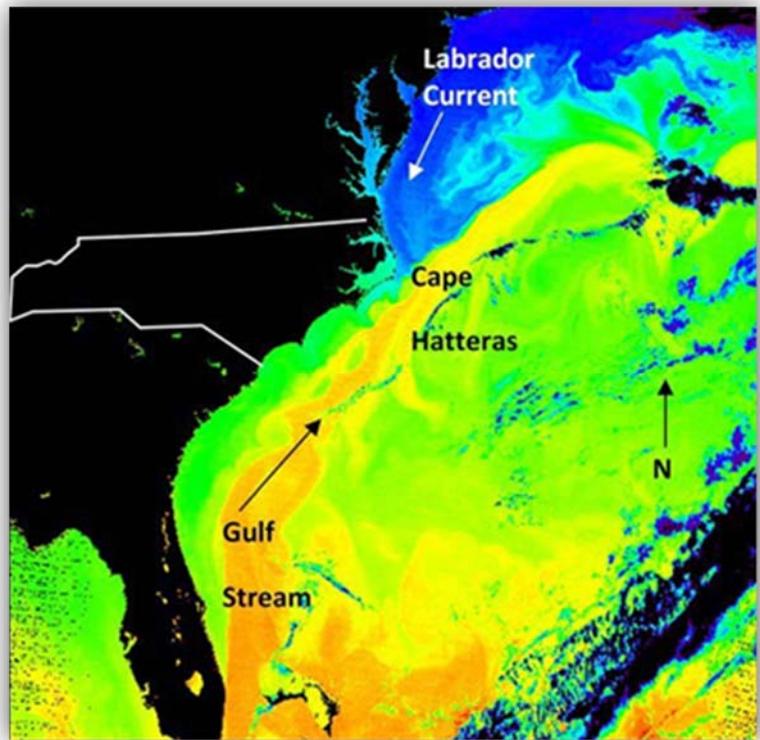


Figure 3. Ocean currents off of the coast of North Carolina. Warm Gulf Stream waters (yellow and orange) move northward, and cold waters of the Labrador Current (blues) move southward.

North Carolina is a biogeographic frontier where the Virginian and Carolinian biogeographic provinces meet at Cape Hatteras. This is where flora and fauna are at the limits of their geographic distribution and it is at these limits where signals of climate change will first be detected. The overlap of biota may also allow extrapolation of results to the broader provinces. The watersheds of the sounds and estuaries, and the shallow nearshore hardbottom habitats with their climatically sensitive ahermatypic scleractinian corals and octocoral communities add to these diverse biological, physical and ecological conditions to endow the North Carolina coast with excellent sentinel geography.

Additionally, many of these habitats are protected within existing management boundaries, including National Park Service National Seashores (Cape Lookout and Cape Hatteras), National Forests, Department of Defense installations, North Carolina Coastal Reserve and National Estuarine Research

Reserves, U.S. Fish and Wildlife National Wildlife Refuges, and The Nature Conservancy Nature Preserves. These locations provide comparatively undisturbed (by human) references to measure and observe both the vulnerability and resiliency of natural communities to SLR.

Economic Setting

The extensive marsh and seagrass systems, sweeping low-relief beaches, and sheltered harbors in North Carolina's twenty county coastal zone support a growing population and high concentration of coastal commerce. The coastal zone is home to approximately 950,000 permanent residents, representing 10% of the State's population. In the last decade the population has increased in almost every county by at least 5% and in many instances, over 25%. Coastal commerce includes shipping ports, historical landmarks, commercial fishing, and tourism. Marine-dependent jobs support approximately 15% of the coastal resident population providing over \$100 million dollars in goods and services, an approximate average among the coastal counties. Moreover, there are large United States Marine Corps bases (~185,000 acres) along the coast that are critical to the Corps' mission readiness. These industries and associated populations are highly vulnerable to SLR and, thus, a large and growing part of the population and the State's economy will be affected by SLR.

Selected Geography for the North Carolina Sentinel Site Cooperative

The NCSCC geography is the central North Carolina coast, as depicted in Figure 4. The selected geography of the Cooperative encompasses all of Carteret County and parts of Craven and Onslow Counties. The boundary extends to the northern banks of the Neuse River and the northern boundary of Carteret County in Pamlico Sound. The boundary then extends east to Cape Lookout National Seashore, south along Bogue Banks, to the western boundary of Onslow County, north to the city of Jacksonville and just south of the city of New Bern in the Neuse River (Figure 4).

The geography includes the Towns of Beaufort, Morehead City, and Havelock, the City of Jacksonville, numerous smaller communities located in Down East North Carolina, and the beachfront communities along Bogue Banks and on either side of New River Inlet. Beaufort is home to the multi-partner NOAA laboratory, which houses NOAA National Ocean Service and National Marine Fisheries Service programs and the North Carolina National Estuarine Research Reserve. The headquarters for the North Carolina Divisions of Coastal Management and Marine Fisheries, three graduate marine science research institutions (Duke University, University of North Carolina, North Carolina State University), Cape Lookout National Seashore, Fort Macon State Park, Pine Knoll Shores Aquarium, North Carolina Maritime Museum, North Carolina Coastal Federation, and the Port of Morehead City are all located in Carteret County. The Cooperative geography also includes United States Marine Corps Base Camp Lejeune in Onslow County and Marine Corps Air Station Cherry Point in Craven County.

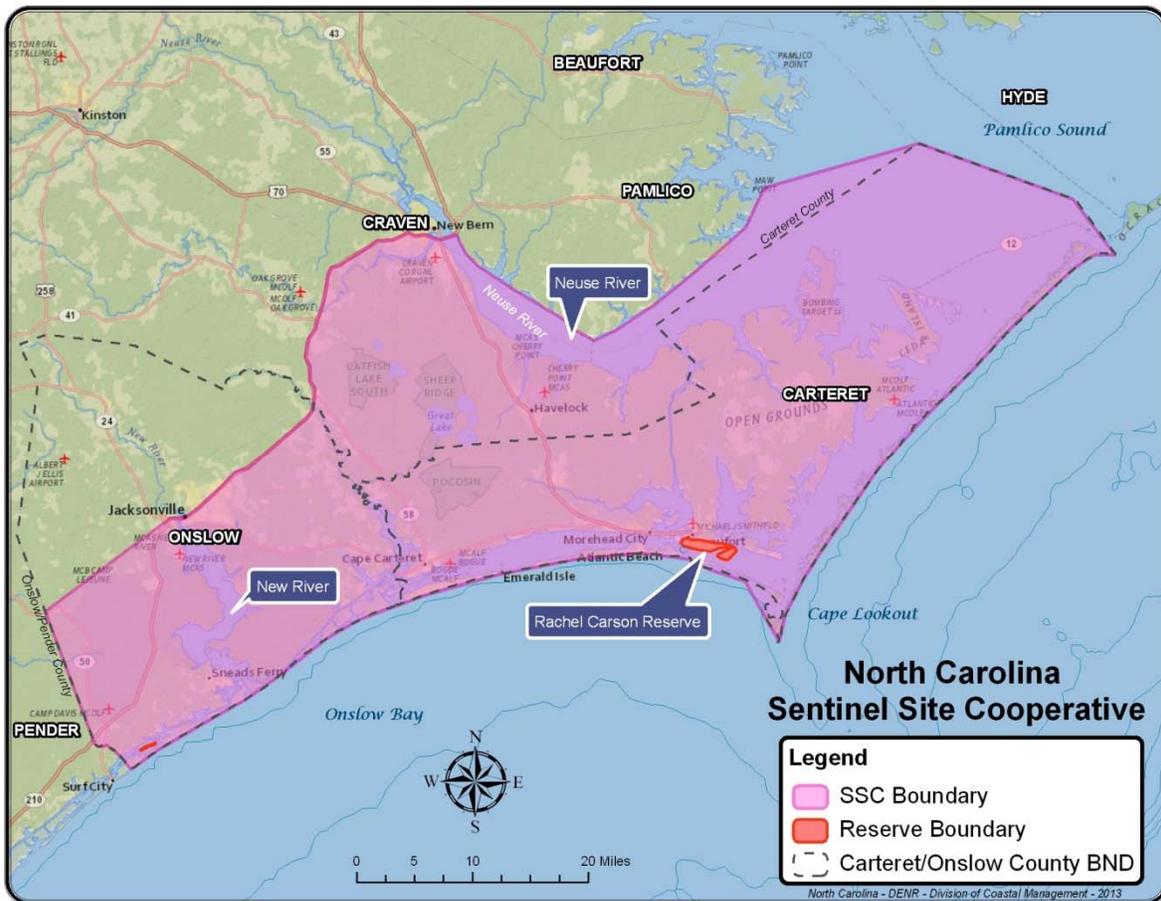


Figure 4. North Carolina Sentinel Site Cooperative Geography.

The geography represents median conditions for the North Carolina coast. The Cooperative therefore offers the potential of future expansion to the entire North Carolina coast based on its success and the gradient in SLR vulnerability from low-lying lagoonal microtidal estuaries in the northeast to small, highly flushed mesotidal estuaries in the southeast as well as the range of socio-economic conditions throughout the area. Cooperative results may also be transferable to the mid-Atlantic and southeast regions of the United States.

Section IV and Appendix 2 contain lists of scientific assets and potential stakeholders for the Cooperative geography. As is evidenced by the scientific assets list, this area is particularly well instrumented and studied due to its physical setting, biological diversity, and high concentration of marine science facilities in the area. This area relies on tourism, ecotourism, and commercial and recreational fishing to sustain its economy which is explicitly linked to the ecosystem services provided by the area's natural resources. The area's military installations also utilize the physical setting of the central coast for various training scenarios which are critical to their operations. This combination of characteristics presents a unique opportunity for the Cooperative to accomplish the end to end implementation of science to decision-making in ensuring the resiliency of these ecosystems and communities to SLR impacts.

How will the North Carolina Sentinel Site Cooperative Accomplish More than Existing Efforts?

The NCSSC utilizes a collaborative business model to bring together stakeholders, including data producers and users, through a core management team (See Section III) to leverage resources across organizations and integrate the multiple efforts within the NCSSC geography to provide better information to help stakeholders address sea level rise and inundation. This includes facilitating collaborative workshops, understanding and addressing information needs, conducting and analyzing research and monitoring across organizations, improving access to high quality data, effectively communicating this information to stakeholders through coordinated educational programs and community involvement, and leading by example through implementation of management strategies by Cooperative participants at the geography's Trust resources. Such a collaborative approach has not been undertaken in this geography nor on sea level rise and inundation in N.C.; the goal of the Cooperative is to capitalize on and enhance the individual strengths of the stakeholders to collectively address this challenge in a more holistic and efficient manner.

II. Goals, Objectives, Actions, Milestones, and Performance

Goals, objectives, actions, milestones, and how performance will be measured for the NCSSC for FFY 13-17 are outlined below. Appendix 1 organizes this content into a timeline, identifies the resources needed to accomplish the actions, and tracks the completion status for each milestone and action. Performance will be measured throughout the active period of each objective and will be reported on at the end of the objective's active period. For example, the active period for Goal 1, Objective 1 is year one (FFY13) and thus, the corresponding performance measure will be measured during year one and reported at the end of year one. Qualitative performance measures, such as success stories, will be piloted throughout implementation of the plan to highlight how the NCSSC is capitalizing on and enhancing the individual strengths of the stakeholders to collectively address sea level rise and inundation within the geography. The work of the NCSSC will also contribute to Government Performance and Results Act measures related to the SSP including:

- Improved climate model performance and utility based on model advancements (planned milestones) and climate assessments benefited (Pilot performance measure);
- Annual percent of U.S. states and territories that use NOAA climate information and service to improve decision making in the face of a changing climate;
- Percentage of U.S. coastal states and territories demonstrating 20% or more annual improvement in resilience capacity to weather and climate hazards (%/yr.); and
- Annual number of coastal marine, and Great Lakes ecological characterizations that meet management needs.

Goal 1: Impacts of SLR on coastal ecosystems will be better understood through NCSSC research and monitoring, and its translation to support coastal decision making.

- a. **Objective 1:** By the end of year one (FFY13), gaps in research and monitoring information related to factors controlling the response of coastal habitats to SLR will be determined and documented.
 - i. **Action 1:** By March 2013, conduct a sentinel site research and monitoring workshop to share related work and identify and prioritize monitoring and research gaps. The potential of integrating relevant monitoring and research results into a shared database will be discussed. The workshop will include a session on how to engage coastal residents in science-based activities (See Goal 3, Objective 2, Action 1).
 - ii. **Milestone 1:** By June 2013, complete a summary report from the research and monitoring workshop that describes existing work and known gaps.
 - iii. **Performance Measures:**
 - 1. Percentage of participants at the research and monitoring workshop that state they intend to participate in the NCSSC through sharing of research and monitoring results, participate in proposal development with NCSSC members, and/or address identified research and monitoring gaps in their work.
 - 2. Number of research and monitoring gaps identified.
 - iv. **Targets:**
 - 1. Fifty percent
 - 2. Five

- b. **Objective 2:** Within the five-year timeframe of the implementation plan, ongoing monitoring will be conducted, and efforts will be made to fill priority gaps.
 - i. **Actions:**
 - 1. Continue ongoing monitoring efforts.
 - 2. Collaborate with partners to increase monitoring efforts to address gaps identified at the research and monitoring workshop.
 - 3. Work with the NOAA SSP Coordinating Committee to secure resources to expand programmatic support for monitoring efforts to address identified gaps.
 - 4. Evaluate existing monitoring data and complete reports addressing trends and questions.
 - ii. **Milestones:**
 - 1. Annually, ongoing monitoring is conducted.
 - 2. By the end of year four, interagency agreements are developed to facilitate new monitoring collaborations.
 - 3. By the end of year four, additional resources are secured to fill monitoring gaps.
 - 4. By the end of year five, monitoring reports are completed.
 - iii. **Performance Measure:**
 - Percent increase in overall monitoring activity.

- iv. **Target:** Ten percent
- c. **Objective 3:** Within the five-year timeframe of the implementation plan, two new collaborative research projects will be initiated to address identified gaps in research on how SLR will impact coastal habitats and their ecosystem services to better understand the changes detected from the monitoring data.
- i. **Actions:**
 1. By the end of year four, identify partners to fill research gaps and assist with proposal writing and project implementation.
 2. By the end of year four, write proposals seeking funding to address how SLR will impact habitats and the ecosystem services they provide to fill research gaps.
 3. In years three through five, implement collaborative research to investigate the impacts of sea level rise on coastal habitats.
 4. By the end of year five, summarize and prepare results into usable formats for relevant audiences.
 - ii. **Milestones:**
 1. Project proposals are submitted.
 2. Project reports for funded proposals are completed.
 - iii. **Performance Measure:** Number of collaborative research projects funded.
 - iv. **Target:** Two funded projects
- d. **Objective 4:** By the end of year four, the NCSSC will understand the key information needs of relevant stakeholders, and identify existing delivery mechanisms to increase coastal decision-makers' and coastal residents' understanding of how SLR will impact coastal habitats and the ecosystem services they provide.
- i. **Action 1:** In year three, conduct a needs assessment of identified stakeholders, and analyze needs assessment survey data. Identify and evaluate existing science information delivery mechanisms and determine gaps as part of the needs assessment.
 - ii. **Milestone 1:** In year four, complete needs assessment report.
 - iii. **Performance Measure:** Percent response rate for the needs assessment.
 - iv. **Target:** Seventy-five percent
- e. **Objective 5:** By the end of year five, results from Objectives 1-4 will inform the development of outreach materials for decision-makers and coastal residents to help them understand the existing science on how SLR will impact coastal habitats and the ecosystem services they provide.
- i. **Actions:**
 1. By year four, work with the SLR Outreach group (e.g. staff from N.C. Sea Grant, N.C. Division of Coastal Management, East Carolina University, and Albemarle-Pamlico National Estuary Program) to develop and implement a SLR messaging and delivery workshop for education and outreach professionals in coastal N.C. This includes:

- a. Incorporating findings from NCSSC monitoring, research, and needs assessment in the workshop, and,
 - b. Using Collaborative Learning techniques to develop messages.
 - 2. Work with the N.C. Coastal Resource Commission’s Science Panel to incorporate new science into the Panel’s SLR Assessment Report update.
 - 3. Communicate monitoring trends and research results to the public and resource managers through workshops, presentations, and technical publications.
 - 4. Develop and begin implementation of a communication strategy for the N.C. Sentinel Site Cooperative that incorporates:
 - a. Updated messages developed in SLR messaging workshop to reflect science,
 - b. Identified and updated delivery mechanisms to direct decision-makers and coastal residents to the new science, and
 - c. How to address identified gaps in science information delivery mechanisms.
- ii. **Milestones:**
 - 1. By the end of year four, create a report outlining messaging/delivery workshop outcomes (including messages, target audiences, and information delivery mechanisms) and next steps.
 - 2. By the end of year three, NCSSC data is included in the updated SLR Assessment Report.
 - 3. By the end of year four, complete NCSSC communication strategy document with implementation timeline for actions.
 - 4. By the end of year five, monitoring trends and research results are incorporated into four outreach materials.
- iii. **Performance Measures:**
 - 1. Percent of invited participants that attend the messaging/delivery workshop.
 - 2. Percent of participants completing the post-workshop evaluation that state they intend to apply the messages developed in their work with decision-makers and coastal residents.
 - 3. Number of outreach materials that incorporate monitoring trends and research results.
- iv. **Targets:**
 - 1. Seventy-five percent
 - 2. Eighty percent
 - 3. Four outreach materials

Goal 2: Resource managers receive and apply the NCSSC scientific information to enhance sustainable and resilient conservation strategies for coastal ecosystems.

- a. **Objective 1:** By the end of year four, identify resource managers and their needs and barriers in implementing SLR adaptation strategies.
 - i. **Actions:**

1. Develop a list of resource managers within the NCSCC geography.
 2. Work with participating resource managers to identify existing ecosystem management strategies; discuss barriers and gaps to managing for SLR, including those that could be addressed through NCSSC research.
 3. Evaluate need for science-based vulnerability assessments and development of adaptation strategies for coastal ecosystems in the NCSSC geography.
- ii. **Milestones:**
1. In years three through five, develop and maintain a list of resource managers.
 2. By the end of year four, host a workshop with resource managers to discuss existing management strategies, barriers and gaps, need for vulnerability assessment and adaptation strategies, and include any available monitoring trends and research results. Create workshop report.
- iii. **Performance Measure:** Percent of identified resource managers in the region that participate in the workshop to discuss management strategies.
- iv. **Target:** Fifty percent
- b. **Objective 2:** By the end of year five, management strategies will be tested and project information will be shared with resource managers.
- i. **Actions:**
1. Develop and test management strategies, such as shoreline stabilization, fertilization and/or thin-layer sediment addition, to increase resilience of coastal marshes. Incorporate results into refined management strategies.
 2. Monitor existing demonstration projects. Install and monitor new demonstration projects that feature best management practices, evaluate their response to SLR, and refine best management practices based on results.
 3. Work with the NOAA SSP Coordinating Committee to secure external resources for actions 1-2.
 4. Share project information with resource managers, other Sentinel Site Cooperatives, and the broader coastal community.
- ii. **Milestones:**
1. By the end of year four, additional resources are secured to develop, monitor, and test management strategies and demonstration projects.
 2. During years three through five, implementation plan project information is incorporated into outreach materials.
- iii. **Performance Measures:**
1. Number of management strategies developed and tested.
 2. Percentage of existing demonstration projects monitored.
 3. Number of outreach materials that incorporate project information.
- iv. **Targets:**
1. One
 2. Fifty percent
 3. Three outreach materials

Goal 3: Coastal residents are better informed to address SLR impacts.

- a. **Objective 1:** Throughout the five-year timeframe of the implementation plan, stakeholder input will be incorporated into the implementation process to engage stakeholders and create buy-in for the NCSSC.

i. **Actions:**

1. By the end of year four, conduct a series of meetings/workshops with stakeholders to raise awareness about the NCSSC, receive input on the implementation plan (Appendix 3), and identify additional participants for the core management team.
 - a. The original implementation plan included the establishment of an advisory committee. References to the advisory committee have been removed from the Implementation Plan as of October 2014. An advisory committee may be considered as we develop the next 5 year Implementation Plan (2018-2022). The core management team and the NCSSC Coordinator will reach out to stakeholders in Years 3-5 under the current Implementation Plan in order to create broad based support for the NCSSC.
2. Refine the list of stakeholder groups (see Appendix 2) within the NCSSC boundary and solicit their participation in meetings and workshops and as potential core management team members.
3. By the end of year three, update the NCSSC two-page communication document to incorporate activities outlined in the implementation plan.
4. By the end of year two, update the implementation plan to include input received from Action 1 and to incorporate the gaps identified through Goal 1, Objective 1 (see Appendix 3).
5. Throughout the five-year implementation plan, convene the core management team semi-annually with additional meetings as needed. The core management team will assist with identifying and addressing information gaps, vetting outreach materials and information delivery mechanisms, and distributing the latest research findings
6. Annually, throughout the five-year implementation plan, update the annual operating plan for the NCSSC.

ii. **Milestones:**

1. By the end of year four, host up to three NCSSC awareness meetings/workshops with stakeholders.
2. Throughout years three through five, the updated communication document is distributed to stakeholders.
3. By the end of year two, the updated implementation plan is distributed to stakeholders and interested parties.
4. By the end of year five, host at least ten core management team meetings.
5. Operating plans are updated annually.

- iii. **Performance Measures:**
 1. Percent of participants at the NCSSC awareness workshops that state they intend to participate in the NCSSC through participation on the core management team, and/or in implementation of NCSSC actions.
 2. Percent of participants at awareness meetings/workshops that state they intend to apply the information learned in their work.
 - iv. **Targets:**
 1. Twenty-five percent
 2. Eighty-five percent
- b. **Objective 2:** By the end of year five, the Sentinel Site Cooperative will develop the framework for a citizen science program that engages coastal communities and residents to enhance ecosystem stewardship.
- i. **Actions:**
 1. Determine what activities and data would be appropriate for coastal residents to collect as part of a citizen science program through discussion at the Sentinel Site research and monitoring workshop (see Goal 1, Objective 1, Action 1).
 2. Create an action plan (including timeline) on what data are appropriate for citizens to collect, how the collection will occur and be managed, how the data will be incorporated into other Sentinel Site monitoring and research projects, and inventory existing volunteer groups that could be tapped to collect data and manage volunteers.
 - ii. **Milestones:**
 1. By the end of year three, determine appropriate activities and data collection for a citizen science program.
 2. By the end of year four, create an action plan for citizen science program.
 - iii. **Performance Measure:** Percent of participants at the NCSSC research and monitoring workshop that state they intend to apply citizen generated science in their work.
 - iv. **Target:** Fifty percent
- c. **Objective 3:** By the end of year five, engage 4th-8th grade science teachers and their students in activities related to NCSSC science and management to improve understanding and stewardship of coastal ecosystems.
- i. **Actions:**
 1. Determine the focus of and develop two curricula for 4th-8th grade students on issues related to NCSSC science and management and aligned with the N.C. Standard Course of Study.
 2. Pilot materials with NCNERR Education Advisory Committee, N.C. Office of Environmental Education, NC Sea Grant, or other Educational programs within the NCSSC geographic area.
 3. Organize two teacher summits focused on newly developed curricula. Include presentations on NCSSC research by NCSSC researchers and field activities. Teachers will take knowledge and activities from the summit to their students (either science classes

or science clubs) for the development of related student projects. Teachers will assist students with projects.

4. Organize two student summits, where students will present their projects to an audience composed of their families and friends.

ii. Milestones:

1. By the end of year three, determine focus of curricula and develop.
2. By the end of year four, presentation materials for teacher and student summits are developed and revised based on pilot.
3. In year 5, implement teacher and student summits.

iii. Performance Measures:

1. Number of 4th -8th grade teachers that participate in each summit.
2. Number of teachers that attend each teacher summit who mentor students for the student summit.
3. Number of 4th-8th grade students that participate in the each student summit.
4. Percentage increase in teacher/student participation in each subsequent summit.

iv. Targets:

1. Fifteen teachers
2. Twelve teachers
3. Twelve students
4. Ten percent

III. Roles and Responsibilities

A clear governance structure and articulated roles and responsibilities will ensure the success of the NCSSC. The NCSSC will be managed through a core management team with topical subcommittees. Additionally, funding for a Cooperative Coordinator was made available in 2014. This person will support the NCSSC and work towards achieving the goals established in this Implementation Plan.

Core Management Team

The core management team is responsible for implementation of the NCSSC including finalizing the Cooperative's implementation plan and updating the plan at five year intervals; developing, completing, and tracking progress on annual operating plans; communicating the work of the Cooperative to interested parties; reporting progress and performance measures to NOAA; and communicating with the National Sentinel Site Program Coordination Committee.

The core management team will be led by a chair and vice chair selected from team membership. The chair will lead the core management team to accomplish the duties above. Final decision making authority rests with the chair. Both the chair and vice chair will serve one-year terms with the vice chair becoming the chair at the end of his/her one-year vice chair term. Terms shall coincide with the calendar year; new leadership shall be identified at the fall core management team meeting of each year so that the new officers begin their terms January 1 of the following year.

The core management team will meet semi-annually and as needed to conduct the business of the Cooperative and report on objectives and operating plan progress. Notes will be published from the meetings and distributed to the team, advisory committee, and the National Sentinel Site Program Coordination Committee. The team chair, or designee, will participate in the monthly National Sentinel Site Program Cooperative conference calls.

The core management team will be composed of representatives from the N.C. Division of Coastal Management (Policy and N.C. Coastal Reserve and National Estuarine Research Reserve staff), National Centers for Coast and Ocean Science's Center for Coastal Fisheries and Habitat Research, National Marine Fisheries Service Southeast Fisheries Center, and the National Climatic Data Center. As the core management team solicits input on the implementation plan, the team will evaluate additional partners that may be appropriate to add to the core management team. The team will also evaluate the need for a memorandum of understanding and by-laws to formalize and guide its work as the Cooperative matures. The core management team will also include a non-voting *ex officio* position for the designated point of contact from the NOAA SSP Coordination Committee, for the purposes of ensuring timely and effective communication of information between the core management team and the SSP Coordination Committee.

Topical Subcommittees

Topical subcommittees may be formed from stakeholders and core management team members. The Topical subcommittees will be organized around Cooperative objectives to conduct and inform the work of the Cooperative. Appendix 2 includes a list of stakeholder organizations that may be appropriate for the Topical subcommittees.

Communication with Interested Parties

The Cooperative recognizes the need to share its work with interested parties. The Cooperative will identify and utilize existing communication mechanisms to accomplish this on a quarterly to semi-annual basis (e.g., NOAA in the Carolinas, Southeast and Caribbean Regional Team, NOAA and NOS communication methods, N.C. Division of Coastal Management newsletter, local government newsletters, etc.) (See Goal 1, Objective 5). The two-page NCSSC communication document will also be updated and publically disseminated throughout the five-year period (See Goal 3, Objective 1).

IV. Resource Identification

Resource assessment and identification is critical to the success of the NCSSC. Agencies participating in the core management team, as currently described, have allocated in-house staff time to the Cooperative through the development of the implementation plan. As the core management team is enhanced by increased participation and the advisory team is formed, additional in-house resources will be contributed to the Cooperative. Despite this, a dedicated staff person is needed to manage the Cooperative, the core management team, and the Topical Subcommittees.

Table 1 provides a general overview of existing monitoring/observing efforts that contribute to the work of the Cooperative. Appendix 1 identifies what types of resources (e.g., funding, staff, or both) are needed to complete the actions and milestones outlined in the implementation plan. These summaries are the first step in assembling a gap analysis for the Cooperative. Reports detailing Year one activities including the research and monitoring workshop and Partner Feedback on the Implementation Plan (Appendix 3) and the Year three needs assessment will complete the gap analysis. Results of the analysis will inform the update of the implementation plan in year two (Goal 3, Objective 1, Action 4) and throughout the project period. Initial gaps are identified in Table 2.

Table 1. General overview of existing monitoring/observing efforts in Cooperative geography.

These are on-hand data/resources that could be integrated with few or no new resources, though continued monitoring may require additional funds. A smaller number of data sets are available in the northern and southern regions of the state. Expanding from the central coast to the entire gradient of N.C. environments would require additional resources to engage other partners working in these areas, as well as to establish additional required data sets.

NOAA NWLON (National Water Level Observation Network) station Beaufort NC, VDatum completed for study area; additional temporary tide gauges established and water level data obtained in other locations associated with various research projects.

NOAA funded research addressing SLR:

- 28 Surface Elevation Tables (SETs) established 2004-2007 in salt marsh habitats within the proposed study area, all have been surveyed to NAVD88 using NGS OPUS protocols and measured semi-annually since establishment.
- SETs were placed in marshes on property managed or owned by NCNERR, NC Aquarium, Cape Lookout National Seashore (NPS), Croatan National Forest, Duke Marine Lab, NOAA CCFHR, NC Maritime Museum

High-resolution LIDAR imagery for the entire coastal zone.

The North Carolina Floodplain Mapping Program is nearing completion of a Sea Level Rise Risk Management Study. The study aims to answer the questions of what changes to coastal flooding hazards will possibly occur between 2009 and 2100 as a result of changes in storminess and sea level, what built and living systems will be exposed to coastal flooding from changes in storminess and sea level, what possible impacts and/or consequences will occur on the exposed built and living systems, and what short- and long-term strategies will result in efficient and effective prevention and/or alleviation of exposure and consequences.

Continuous in-situ water quality monitoring (temperature, pH, turbidity, conductivity/salinity, dissolved oxygen.) using YSI instruments from Back Sound near Middle Marsh. Data periods are 1997-2003, and 2007-present.

Habitat maps of NCNERR (completed using 2006 photography), including emergent persistent marsh, supratidal sand, and upland deciduous forest.

Submerged aquatic vegetation monitoring protocols are under development by the Albemarle-Pamlico National Estuary Program (APNEP) Albemarle – Pamlico Estuarine Study (APES) and NCCOS to guide the state in the implementation of state-wide SAV inventories from marine to tidal freshwater settings.

Aerial imagery and photo interpreted GIS layers of seagrass distribution from 2006-2008 completed for the entire state by a partnership among NCCOS, APNEP, USFWS, NCDENR, East Carolina University and Elizabeth City State University.

Geodetic infrastructure, including NGS benchmarks, CORS stations (including CCFHR facility). NOAA NCCOS staff is currently working with NC Geodetic Survey on a Height Modernization Program in support of coastal wetland research.

Marsh vegetation surveys in natural, transplanted and stabilized marshes semi-annually; 2004-present conducted through NCNERR-NCCOS collaboration, and funded by NOAA Restoration Center and CICEET. Parameters measured include species percent cover, species density, and elevation (Currin et al. 2008).

3yr NOAA CSCOR program [Ecological Effects of Sea Level Rise - EESLR] provided regionalized forecasts on the impact of SLR on geomorphologic, ecological and specifically saltmarsh responses. Most importantly, this project developed a unique, fused bathymorphic GIS product of elevations from the continental shelf to the river falls that facilitates inundation forecasting.

NOAA CCFHR recently completed a 5-yr project funded by Dept. of Defense at Marine Corps Base Camp Lejeune including “Response of coastal marshes to sea level rise” and ‘Forecast influence of natural and anthropogenic factors estuarine shoreline erosion rates”. These studies also established two temporary tide gauges and a tidal datum on the New River Estuary, 16 SETs in a variety of coastal wetlands, an annual wetland monitoring program, and created detailed maps of shoreline habitats and erosion rates.

NOAA CICEET program funded joint NCNERR, NOAA NCCOS and UNC study on effect of shoreline stabilization structures on coastal wetlands and ecosystem services. This project provides baseline data on sediment surface elevations, vegetative cover, and faunal distribution and abundance at shoreline locations in the north, central and southern regions of coastal NC.

Four studies provide data on rates of RSL rise in North Carolina (Horton et al. 2009, Kemp et. al. 2009, Zervas 2004), with date ranges from 12,000 year ago to the present. The first three studies utilized geological data whereas the study covering the shortest time interval utilizes instrumental data and provides complementary hindcasts and forecasts of SLR for NC.

A key synthesis study by Riggs and Ames (2003) titled “Drowning the North Carolina coast: sea-level rise and estuarine dynamics” provided a uniquely unified integration of geomorphologic information and known and expected dynamics from which to formulate impact scenarios under different inundation regimes.

Table 2. Initial Gaps Identified for the NCSSC.

In addition to the resources listed in Appendix 1, the NCSSC has also identified the following initial priority gaps that require resources to fulfill the goals of the Cooperative.

Coordination/Outreach:

- A staff person to manage and coordinate the Cooperative.
 - **Update, October 2014:** NOAA NOS and National Sea Grant provided funding to hire a Coordinator for each of the five Cooperatives. Funding is guaranteed for 1 year. A NCSSC Coordinator was hired in October 2014.
- Outreach and communication resources for sea level rise to inform and enhance Cooperative efforts.
 - **Update, April 2015:** The NCSSC implemented a Quarterly Newsletter to inform partners of Cooperative activities.

Monitoring/Research:

- Sustained funding for current monitoring efforts including NERRS System-wide Monitoring Program, Surface Elevation Tables (SET), and biological monitoring.
- Synthesis of existing research and monitoring data within the NCSSC geography.
 - **Update, April 2015:** The 2013 Research and Monitoring Workshop addressed this gap. Further identification of research and monitoring activities is continuing in 2015.
- Investigative research on sea level rise impacts and thresholds on habitats and migration.
- Regional and local-scale climate information/projections (e.g., downscaled, RCM).

Infrastructure:

- Tide gauge stations in the lower Neuse River (southern Pamlico Sound) for more accurate predictions.
- GPS and/or laser optical triangulation stations to measure subsidence in the NCSSC geography.
- More accurate monitoring and modeling of storm surge.

- Inventory of SETs and other vertical control data in the NCSSC geography to inform strategic placement and development of SET sites to address current gaps.
 - **Update, November 2014:** Carolyn Currin and Jenny Davis (NOAA NCCOS) completed a SET inventory for all 5 Cooperatives and provided maps showing SET locations.

V. Glossary of Acronyms and Terms Used

Ahermatypic	Non-reef building corals
APNEP	Albemarle – Pamlico National Estuary Program
CCFHR	Center for Coastal Fisheries and Habitat Research
CCSP	Climate Change Science Program
CICEET	Cooperative Institute for Coastal and Estuarine Environmental Technology
CO-OPS	NOAA Center for Operational Oceanographic Products and Services
CORS	NOAA NGS Continuously Operating Reference Stations (GPS)
CSCOR	NOAA NCCOS Center for Sponsored Coastal Ocean Research
Curriculum	An effort to guide people through instruction to provide guided learning concepts and methods.
DENR	North Carolina Department of Environmental and Natural Resources
Decision-maker	Individuals whose duties include making decisions that affect the coast and its resources; includes local elected or appointed officials, managers of both public and private lands, natural and cultural resource managers, coastal and community planners, and business owners and operators.
DOI	U.S. Department of the Interior
FFY	Federal Fiscal Year
GIS	Geographic Information System
GPS	Global Positioning System
LIDAR	Light Detection and Ranging (an optical remote sensing technology)
Mesotidal	Having tides between 2 and 4 meters in range
Microtidal	Having tides less than 2 meters in range
NAVD88	North American Vertical Datum of 1988
NC	North Carolina
NCCOS	NOAA National Centers for Coastal Ocean Research
NCCR	North Carolina Coastal Reserve
NCCRC	North Carolina Coastal Resources Commission
NCNERR	North Carolina National Estuarine Research Reserve
NCSSC	North Carolina Sentinel Site Cooperative
NERR	National Estuarine Research Reserve
NERRS	National Estuarine Research Reserve System
NGS	NOAA National Geodetic Survey
NMFS	NOAA National Marine Fisheries Service

NOAA	National Oceanic and Atmospheric Administration
Nor'Easter	An extratropical storm system that tracks northward along the U.S. Atlantic coast.
NPS	DOI National Parks Service
Octocoral	Corals that lack a stony skeleton (soft corals)
OPUS	NOAA NGS Online Positioning User Service
ppt	Parts per thousand (a measure of concentration)
RLS	Relative Sea Level Rise
Resource manager	Any public or private funded individual or organization who manages land, habitats, or species for conservation purposes
SAV	Submerged aquatic vegetation
SET	Surface Elevation Table
SLR	Sea Level Rise
SSP	Sentinel Site Program
SSPCC	NOAA Sentinel Site Program Coordination Committee
Supratidal	The shore area immediately marginal to and above the high tide level
USFWS	U.S. Fish and Wildlife Service

VI. References

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Appendix 1. Timeline and Resources Needed for Implementation Plan. (See Excel spreadsheet.)

Appendix 2. Possible Cooperative Stakeholders.

<u>Federal Agencies</u>	<u>State Agencies</u>	<u>Local Governments</u>	<u>Universities</u>	<u>Non-Governmental Organizations</u>
Croatan National Forest	Albemarle-Pamlico National Estuary Program	Carteret County	Duke University Marine Laboratory	Carteret Crossroads
Cape Lookout National Seashore	Fort Macon State Park	Town of Morehead City	East Carolina University	N.C. Coastal Federation
Department of Defense	N.C. Aquarium at Pine Knoll Shores	Town of Beaufort	N.C. State University's Center for Marine Sciences and Technology	The Nature Conservancy
Environmental Protection Agency	N.C. Clean Water Management Trust Fund	Bogue Banks Communities	University of North Carolina at Chapel Hill's Institute of Marine Sciences	
NOAA Center for Operational Oceanographic Products and Services	N.C. Coastal Resources Commission	Down East Communities	Carteret Community College	
NOAA National Geodetic Survey	N.C. Department of Environment and Natural Resources	Craven County		
NOAA National Marine Sanctuary Program	N.C. Department of Transportation	Town of Havelock		
South Atlantic Landscape Conservation Cooperative	N.C. Division of Emergency Management	Onslow County		

U.S. Army Corps of Engineers	N.C. Division of Marine Fisheries	City of Jacksonville		
U.S. Geological Survey	N.C. Division of Water Quality	Communities surrounding New River		
U. S Fish & Wildlife Service	N.C. Division of Water Resources			
National Park Service	N.C. Geodetic Survey			
	N.C. Maritime Museum			
	N.C. Ports			
	N.C. Sea Grant			
	N.C. Wildlife Resources Commission			

Appendix 3. Partner Feedback on Implementation Plan

The NCSSC solicited partner feedback on the Implementation Plan through facilitated sessions at the March 2013 Research and Monitoring Coordination Workshop and through an online survey administered in the summer of 2013.

A summary of the feedback received at the Workshop was captured in the NOAA Technical Memo *North Carolina Sentinel Site Cooperative: Report on the Sea-Level Rise Research and Monitoring Coordination Workshop*, which is available here:

http://oceanservice.noaa.gov/sentinelsites/pdf/NC_SSC_SLR_Research_Coordination_Wkshop.pdf.

In the Memo, pages 4-5:

The NCSSC Core Management Team distributed the Cooperative's Implementation Plan prior to the workshop for feedback during workshop discussions. Three breakout groups discussed the scope and specific goals and actions of the NCSSC Implementation Plan. Many participants concluded that the overall goals are very broad, and that it is important for the Cooperative to distinguish between present and future goals and actions. Participants questioned what systems are included in the scope of the plan (e.g., natural ecosystems, human infrastructure, culture resources, etc.). While it was accepted that focusing on just natural ecosystems would be much more feasible, there was a concern that leaving out social and economic systems would limit the success of the Cooperative in achieving its goals.

Participants also wanted the plan to more specifically state its targeted stakeholders, and what information about sea-level rise these stakeholders will need. A suggestion was made to partner with the North Carolina Center for the Advancement of Teaching or national environmental educators to meet this need. Participants noted that understanding where decision-makers receive their information, how networks influence communication among stakeholders, and how to best disseminate information about sea-level rise are important next steps. Most participants responded positively to the idea of implementing a citizen science program within the Cooperative. Most of the discussion about citizen science programs focused on the time and resources needed to start this type of program, and whether it would result in accurate data collection or if the greater value would be for education and stewardship purposes. Participants suggested researching already existing citizen science programs or volunteer networks that fit within the goals of the Cooperative.

Breakout groups also discussed the extent of the geography boundary of the Cooperative, and concluded that there is no boundary that will be fully inclusive of all research and monitoring efforts in central coastal North Carolina. A boundary is a NOAA requirement for the NCSSC, but participants noted that the boundary should be flexible and should not limit the Cooperative. The goal of the Cooperative is to start successfully with a focal point in a small area, which was

how the initial boundary was chosen. Participants also noted that as the Cooperative grows, it can consider including other areas. It was noted that the Cooperative is limited by not including all of Pamlico Sound and should consider extending the boundary as far as Bluff Shoal. Pamlico Sound itself is a monitoring gap (continuous water level and water quality measurements are needed), with the exception of some biological monitoring by the NCDMF and collaborative work by the Albemarle Pamlico National Estuary Partnership (APNEP) and UNC-CH, IMS.

The online survey was administered in the summer of 2013. The survey was advertised twice, through Constant Contact emails, on June 25 and August 1. The emails were sent to 93 stakeholders each time and asked that recipients forward the email to interested colleagues. Three responses were collected during the three months the survey was open, one municipal elected/appointed and two college/university staff.

The following responses were collected:

- Question: Page 8 of the Implementation Plan explains the NCSSC Geography. This area was chosen for many reasons including the variety of federal, state, and local agencies in the region. Potential future expansion to the entire N.C. coast is based on the success of the Cooperative. Do you have any comments on the NCSSC Geography? I.e., is the boundary inclusive enough, is your organization's work captured in the Geography, etc.
 - Answers:
 - Is fine and logical for a variety of reasons and the fact that personnel are located there.
 - Yes, our organization's work is captured in the foot print; but the justification for the geographical aspect is off base. The Outer and Inner Banks area in the Albemarle Embayment area is much more vulnerable than the cooperative (sans Down East). It appears the boundary was established based solely on the research cluster or for purely political reasons.
- Question: Do you have any comments on Goal 1 and associated Objectives, Actions (starting on page 11): Impacts of sea-level rise on coastal ecosystems will be better understood through NCSSC research and monitoring, and its translation to support coastal decision-making?
 - Answers:
 - We absolutely need this. Local governments seem to be fighting the truth on sea-level rise. Need to start to prepare NOW!
 - Although this may be actually part of the Goal 1 – a list of what variables are being or need to be monitored should be provided. And what the monitoring is intended to prove. More tide gauges to get a better sense of relative sea-level? Sediment/marsh growth or erosion? Water column chemistry? Etc.
- Question: Do you have any comments on Goal 2 and associated Objectives, Actions (starting on page 14): Resource managers receive and apply the NCSSC scientific information to enhance sustainable and resilient conservation strategies for coastal ecosystems?

- Answer: I believe “People such as coastal zone, resource, and protected area managers; emergency and disaster response personnel; restoration practitioners; coastal research scientists; commercial fisheries managers; members of the maritime commerce and insurance industries; and local planning, tourism, and economic development boards.” in this area have spoken loud and clear on what they want and don’t want from the government when it comes to sea-level rise and adaptation planning. The State’s General Assembly has spoken even louder to this effect – many are going to question why the sentinel site work is even being conducted in the first place. In other words – more than half of the persons that will be identified are not going to want to hear this – that’s not being mean-spirited or is even intended to be a statement about the program. It’s just the reality of the situation.
- Question: Do you have any comments on Goal 3 and associated Objectives, Actions (starting on page 15): Coastal residents are better informed to address sea-level rise impacts?
 - Answer: The public education factor to get citizens involved should be quite an undertaking if it is going to be successful, but the goal overall is a good one. I still question the federal government coming in to local schools without their prior knowledge or even request to do so in the first place.
- Question: Do you have any other comments about the Implementation Plan or the NCSSC?
 - Answers:
 - Given that one of the main goals is to assist communities in their resilience to hazards and climate change an argument could be made to shift the boundaries of the NCSSC to the north to include the counties in northeast NC (e.g., Tyrrell, Washington, Bertie, etc.) These counties are among the poorest in the nation with very few resources available to them to recover major hurricanes and flooding. Therefore, it could be said that their need to develop resilience is greater than that of Carteret and Onslow counties.
 - I'd push for more "human dimensions," things like residential and commercial development using parcel data or remote sensing to quantify patterns of human pressure.

The NCSSC appreciates the effort put into the thoughtful feedback on this Implementation Plan received at the Research and Monitoring Coordination Workshop and through the online survey. Below are specific responses to the feedback received:

- Feedback: Goals are very broad, and that it is important for the Cooperative to distinguish between present and future goals and actions.
 - Response: The goals were intended to be broad. Since the Cooperative is not currently funded, it needs to capitalize on opportunities as they arise. Keeping the goals broad will enable a wide range of projects to occur that contribute to the mission of the Cooperative. The goals also list specific objectives that include actions, milestones, and performance measures that will assist the Cooperative in achieving its goals.

- Feedback: Is the focus just on just natural ecosystems? Including social and economic systems (i.e. human dimensions) might increase success of the Cooperative in achieving its goals.
 - Response: At this point in time, the focus is on natural ecosystems due to funding limitations. However, as the Cooperative grows in resources, so will its scope.
- Feedback: Specifically state Cooperative’s targeted stakeholders and what information about sea-level rise these stakeholders will need.
 - Response: The Cooperative did not have time to specifically identify stakeholder within the Implementation Plan creation timeline. However, through Goal 1, Objective 4 needs assessment, stakeholders and their needs will be identified. There is also discussion in Goal 2, Objective 1 of working with natural resource managers to determine their needs.
- Feedback: Concern over difficulties with implementing a citizen science programs and accuracy of data collected.
 - Response: The Cooperative agrees. It may not be possible to accomplish this within this time period unless significant funds are secured.
- Feedback: Concerns over the Cooperative’s boundary not including more areas vulnerable to the effects of sea-level rise.
 - Response: The Cooperative chose a small boundary because no new resources were dedicated to the Cooperatives when they were formed. It was decided to start small, in the central coast where there is a concentration of resources and partners, and expand the boundaries over time as resources allow.
- Feedback: A list of what variables are being or need to be monitored should be provided.
 - Response: Some of these types of variables were prioritized at the March 2013 Research and Monitoring Coordination Workshop:
 - The need for more water level data.
 - Understanding sediment supply and dynamics and effects of land use changes on sediment dynamics.
 - Improved coastal LIDAR data and bathymetry.
 - More water quality and data collection stations.
- Feedback: Concern over the political obstacles to working with stakeholders on sea-level rise issues.
 - Response: Agree that it may be challenging to engage some stakeholders at this time. So far, the priority has been in working with the research and coastal management communities. The Cooperative hopes to engage natural resource managers in the future. The Cooperative feels that these audiences are more receptive to this information at this time. Hopefully, as time goes on, some of these political obstacles will lessen and the Cooperative will be able to reach more stakeholders.
- Feedback: Concern about federal government conducting public education in local schools.
 - Response: The NCSSC will use existing student and teacher education programs that are well established in the local communities, such as the program implemented by the

North Carolina Coastal Reserve & National Estuarine Research Reserve, to achieve this goal.