

Chapter 1: Introduction to the North Carolina National Estuarine Research Reserve

1.1: Document Overview

This document is meant to serve as an introductory overview of the properties that make up the North Carolina National Estuarine Research Reserve (NCNERR) and the research and monitoring activities that occur at the Reserves. This material includes: the location of the Reserve properties; the environmental setting of the properties (geologic, biologic and ecologic); the habitat types contained in the properties; the research that has occurred within the properties; Reserve partners and partnership opportunities; and the important coastal management issues and/or threats facing each property. This document is meant to be readable by scientists and non-scientists alike. Knowledge gaps identified in this document will serve as a guide to direct future Reserve activities.

1.2: National Estuarine Research Reserve System

A: Establishment

The National Estuarine Research Reserve System (NERRS) was established by section 315 of the Coastal Zone Management Act (CZMA) of 1972 as amended. This landmark legislation was designed to encourage the participation and cooperation of state, local, regional, and federal agencies and governments having programs affecting the coastal zone of the United States. Through the Act, Congress declared that it was national policy to:

(1) to preserve, protect, develop, and where possible, to restore or enhance, the resources of the Nation's coastal zone for this and succeeding generations;

(2) to encourage and assist the states to exercise effectively their responsibilities in the coastal zone through the development and implementation of management programs to achieve wise use of the land and water resources of the coastal zone, giving full consideration to ecological, cultural, historic, and esthetic values as well as the needs for compatible economic development, which programs should at least provide for--

(A) the protection of natural resources, including wetlands, floodplains, estuaries, beaches, dunes, barrier islands, coral reefs, and fish and wildlife and their habitat, within the coastal zone,

(B) the management of coastal development to minimize the loss of life and property caused by improper development in flood-prone, storm surge, geological hazard, and erosion-prone areas and in areas likely to be affected by or vulnerable to sea level rise, land subsidence, and saltwater intrusion, and by the destruction of natural protective features such as beaches, dunes, wetlands, and barrier islands,

(C) the management of coastal development to improve, safeguard, and restore the quality of coastal waters, and to protect natural resources and existing uses of those waters,

(D) priority consideration being given to coastal-dependent uses and orderly processes for siting major facilities related to national defense, energy, fisheries development, recreation, ports and transportation, and the location, to the maximum extent practicable, of new commercial and industrial developments in or adjacent to areas where such development already exists,

(E) public access to the coasts for recreation purposes,

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(F) assistance in the redevelopment of deteriorating urban waterfronts and ports, and sensitive preservation and restoration of historic, cultural, and esthetic coastal features,

(G) the coordination and simplification of procedures in order to ensure expedited governmental decisionmaking for the management of coastal resources,

(H) continued consultation and coordination with, and the giving of adequate consideration to the views of, affected Federal agencies,

(I) the giving of timely and effective notification of, and opportunities for public and local government participation in, coastal management decisionmaking,

(J) assistance to support comprehensive planning, conservation, and management for living marine resources, including planning for the siting of pollution control and aquaculture facilities within the coastal zone, and improved coordination between State and Federal coastal zone management agencies and State and wildlife agencies, and

(K) the study and development, in any case in which the Secretary considers it to be appropriate, of plans for addressing the adverse effects upon the coastal zone of land subsidence and of sea level rise; and

(3) to encourage the preparation of special area management plans which provide for increased specificity in protecting significant natural resources, reasonable coastal-dependent economic growth, improved protection of life and property in hazardous areas, including those areas likely to be affected by land subsidence, sea level rise, or fluctuating water levels of the Great Lakes, and improved predictability in governmental decisionmaking;

(4) to encourage the participation and cooperation of the public, state and local governments, and interstate and other regional agencies, as well as of the Federal agencies having programs affecting the coastal zone, in carrying out the purposes of this title;

(5) to encourage coordination and cooperation with and among the appropriate Federal, State, and local agencies, and international organizations where appropriate, in collection, analysis, synthesis, and dissemination of coastal management information, research results, and technical assistance, to support State and Federal regulation of land use practices affecting the coastal and ocean resources of the United States; and

(6) to respond to changing circumstances affecting the coastal environment and coastal resource management by encouraging States to consider such issues as ocean uses potentially affecting the coastal zone.

Section 304 of the CZMA defines the coastal zone

(1) The term "coastal zone" means the coastal waters (including the lands therein and thereunder) and the adjacent shorelands (including the waters therein and thereunder), strongly influenced by each other and in proximity to the shorelines of the several coastal states, and includes islands, transitional and intertidal areas, salt marshes, wetlands, and beaches. The zone extends, in Great Lakes waters, to the international boundary between the United States and Canada and, in other areas, seaward to the outer limit of State title and ownership under the Submerged Lands Act (43 U.S.C. 1301 et seq.), the Act of March 2, 1917 (48 U.S.C. 749), the Covenant to Establish a Commonwealth of the Northern Mariana Islands in Political Union with the United States of America, as approved by the Act of March 24, 1976 (48 U.S.C. 1681 note), or section 1 of the Act of November 20, 1963 (48 U.S.C. 1705), as applicable. The zone extends inland from the shorelines only to the extent necessary to control shorelands, the uses of which have a direct and significant impact on the coastal waters, and to control those geographical areas which are likely to be affected by or vulnerable to sea level rise. Excluded from the coastal zone are lands the use of which is by law subject solely to the discretion of or which is held in trust by the Federal Government, its officers or agents.

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Since its inception in 1972, the NERRS has grown to a network of 27 Reserves in 23 different states (Figure 1.1).



*Figure 1.1: Map of the National Estuarine Research Reserve System.
Courtesy of NOAA.*

The Reserves are operated as a partnership between the National Oceanic and Atmospheric Administration (NOAA) and the coastal states and territories. NOAA provides funding, national guidance and technical assistance, while the states provide matching funds, personnel, and managerial oversight. Each Reserve is managed on a daily basis by a lead state agency, university or non-profit organization, with input from local partners and citizens. This partnership program between NOAA and the coastal states and territories protects more than one million acres of estuarine land and water, which provide essential habitat for wildlife; offer educational opportunities for students, teachers and the public; and serve as living research laboratories for scientists.

The NERRs are managed based on the following vision and mission statements (from NERRS Strategic Plan 2005-2010 included as Appendix 1):

Vision: “Healthy estuaries and coastal watersheds where coastal communities and ecosystems thrive.”

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Mission: “To practice and promote coastal and estuarine stewardship through innovative research and education, using a system of protected areas.”

The strategic plan identifies three goals to facilitate these overarching principles. They are:

1. Strengthen the protection and management of representative estuarine ecosystems to advance estuarine conservation, research and education.
2. Increase the use of Reserve science and sites to address priority coastal management issues.
3. Enhance peoples’ ability and willingness to make informed decisions and take responsible actions that affect coastal communities and ecosystems.

The mission, vision and goals of the NERRS serve to support a nationwide effort to enhance coastal zone management, advance estuarine research, and educate current and future generations of coastal stewards (Riley 2006).

B: NERRS Organization

The NERRS is operationally administered under NOAA’s National Ocean Service by the Estuarine Reserves Division. The Estuarine Reserves Division provides national coordination and ensures the NERRS are fully integrated with other NOAA programs and activities. The NERRS is also supported by a non-profit organization, the National Estuarine Research Reserve Association (NERRA). NERRA was created in 1987 to promote and advance the NERRS. NERRA is dedicated to the protection, understanding, and science-based management of our nation’s estuaries—the valuable areas where the river meets the sea. NERRA works with Congress, NOAA, and public and private partners to increase support for research, monitoring, education, and stewardship within the NERRS. NERRA also provides public education and outreach to improve awareness and understanding of the importance of estuaries and coasts. The NERRS is organized into research, education and stewardship sectors. These sectors all have unique goals and programs as outlined below but work together in a collaborative manner that supports the NERRS mission.

C: NERRS National and System-wide Initiatives

a: Research

The research sector is focused on enhancing scientific understanding of all aspects of estuarine function. This includes, but is not limited to, eutrophication and water quality changes, coastal ocean processes, climate change, invasive species, the interaction between land and water, and flora and fauna ecological interactions. This is accomplished through three core programs conducted by all 27 NERRS: 1) site research; 2) the system wide monitoring program (SWMP); and 3) the Graduate Research Fellowship (GRF).

Site research refers to the high quality hypothesis driven research projects that are conducted within the Reserves. These projects are conducted both by Reserve staff and outside

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researchers. These projects provide the baseline science needed to develop sound management decisions and quality education material. Support for these projects is provided by a variety of funding sources including NOAA, the National Science Foundation, the Environmental Protection Agency, Sea Grant, and many more. These projects also provide countless partnership opportunities as visiting scientists and NERRS staff work together on research projects. One partnership and funding agency in particular, NOAA's Cooperative Institute for Coastal and Estuarine Environmental Technology, highly encourages proposals that demonstrate collaboration with the NERRS and that are conducted within NERRS' boundaries.

SWMP refers to the monitoring program conducted at all 27 NERRS across the country. SWMP consists of three phases. Phase 1 is to monitor abiotic parameters. These include atmospheric conditions and water quality. Atmospheric conditions are monitored using Campbell Scientific (815 West 1800 North Logan, Utah 84321-1784) weather stations, and water quality conditions are monitored using Yellow Springs Instruments (1700/1725 Brannum Lane Yellow Springs, OH 45387-1107) 6600 series and newer in-situ sondes. Parameters measured include air temperature, relative humidity, barometric pressure, rainfall, wind speed, and wind direction for atmospheric conditions and dissolved oxygen, pH, temperature, conductivity and turbidity for water quality conditions. Phase 2 is to monitor biological parameters. These include submerged aquatic vegetation (SAV) and emergent marsh spatial and temporal distribution, nekton biodiversity, and benthic infauna biodiversity. Phase 3 is to map watershed and land habitat types, and quantify changes through time. SWMP phase 1 was initiated in the early 1990s with two sampling stations per reserve and has grown to include four water quality locations and one atmospheric sampling site within each Reserve. Sampling for nutrients (NO_2^- / NO_3^- , NH_4^+ , and PO_4^{3-}), and Chlorophyll *a* was added to SWMP in 2002. In the mid 2000s SWMP phase 1 was incorporated as part of the national backbone of the Integrated Ocean Observing System. The Integrated Ocean Observing System is a multi-agency network of federal and regional coastal and ocean observing systems designed to expand our ability to collect, deliver, and use ocean information. This upgrade provided satellite transmitters for each Reserve for one water quality and one atmospheric sampling location. The transmitters allow the data to be viewed in near real time by anyone with a network connection. This rapid data transmission allows the data to be used daily by many user groups to plan activities. All of the SWMP data is stored, quality checked and assured and maintained by NOAA's Centralized Data Management Office. Data managed by the CDMO can be accessed online at <http://cdmo.baruch.sc.edu>. Phase 2 and 3 of SWMP are being implemented as funding allows. Most Reserves are conducting biological monitoring associated with phase 2 of SWMP. Phase 3 is the most recent aspect of SWMP to be implemented. Pilot projects were conducted at 5 Reserves to develop and finalize the methods to make up a national protocol for SWMP phase 3. NERRS was one of these pilot Reserves. The results from our phase 3 pilot project are included in this document. The rest of the Reserves will be conducting phase 3 over the next 5 years.

Created in 1997, the GRF is a program designed to encourage and enable talented young scientists to contribute to the knowledge base, provide the science to support coastal decision-making and train future coastal scientists and policy-makers. The GRF program provides funding to master's and Ph-D. level graduate students for projects conducted within the NERRS. The projects are based on the Reserves' local needs, the Reserve system's national priorities and the students' interest. GRF awards have supported students from over 78 different academic institutions. The GRF is one of the largest graduate programs supported by NOAA, and thanks

to the federal state partnership structure of the NERRS is uniquely capable at translating new research findings into better coastal policy.

b: Education

National Estuarine Research Reserves are federally designated to “enhance public awareness and understanding of estuarine areas, and provide suitable opportunities for public education and interpretation.” The NERRS is one of only four programs within NOAA in which education is federally mandated, and the Reserve system provides a wide range of educational programs to fulfill that mandate. The education sector targets professionals who make decisions about coastal resources on a regular basis, such as planners, conservation council members, resource managers and community leaders, through its Coastal Training Program. In addition to targeting coastal decision makers, the education sector also offer hands-on field classes for K-12 students and support for teachers through professional development programs in marine education. The national K-12 Estuarine Education Program (KEEP) provides teachers and students with the knowledge, appreciation and skills to act as stewards of estuarine environments. Students and teachers can also learn about estuaries by actively participating in the EstuaryLive Program, which is an interactive, web-based, field trip available nationwide. One final goal of the education sector is to utilize SWMP data and other research results in the creation of educational products. This collaboration between the education and research sector ensures rapid and successful knowledge transfer.

The Coastal Training Program ensures that community members and coastal decision makers have up-to-date, science-based information that they need to make informed decisions about coastal resources. Coastal Training Programs offered by Reserves focus on issues such as coastal habitat conservation and restoration, biodiversity, water quality and sustainable resource management. Programs target a range of audiences, including land-use planners, elected officials, regulators, land developers, community groups, environmental non-profits and coastal businesses and are developed in a variety of formats ranging from seminars, hands-on skill training, participatory workshops, lectures, and technology demonstrations. These training programs provide a range of opportunities for professionals to network across disciplines, and develop new collaborative relationships to solve complex environmental problems. Through this program, National Estuarine Research Reserves can ensure that coastal decision-makers have the knowledge and tools they need to address critical resource management issues of concern to local communities.

The NERRS K-12 Estuarine Education Program was developed to increase ocean literacy in students and teachers. KEEP not only teaches students about coastal and estuarine processes, but it also develops and strengthens data literacy, critical thinking, team building, and problem solving skills in students of all ages. The program has four basic goals: 1) increase ocean literacy of K-12 students and teachers about coastal and estuarine ecosystems; 2) increase the number of teachers trained to teach students about estuarine and coastal ecosystems; 3) promote a better understanding of the National Estuarine Research Reserve System; and 4) encourage responsible stewardship of estuarine, natural and cultural resources. KEEP uses a multifaceted approach that is designed to provide teachers with appropriate estuarine-based lessons plans as well as hands-on field experiences for teachers and students within the Reserves.

The NERRS is currently developing new curriculum for K-12 students and teachers as part of its K-12 Estuarine Education Program. This curriculum, called Estuaries 101, will teach

key principles and concepts of estuarine ecology and illustrate how estuaries relate to other human and ecological systems, while teaching to national and state science standards. Place-based activities using the NERRS' SWMP and the NOAA Chesapeake Bay Interpretive Buoy System will allow teachers to bring relevant, real-time scientific data into the classroom. In 2008, NERRS educators will train and support teachers on the use of KEEP products, such as the 9–12 grade portion of Estuaries 101 and the powerful web-interface that manipulates data for teaching various estuarine concepts. To compliment existing professional teacher development programs, Teachers on the Estuary (TOTE) programs will be offered nationwide which emphasize ocean literacy principles and concepts and introduces teachers to the Estuaries 101 curriculum and the web-interface. The training will provide meaningful use of regional estuarine data in the classroom. Another national education initiative that is part of KEEP is the EstuaryLive Program. EstuaryLive broadcasts are free, live Internet field trips held in estuaries around the country. These broadcasts are designed for classroom use and can be viewed by anyone. Participating Reserves host different sessions on a variety of estuarine topics.

c: Stewardship

The stewardship sector's primary focus is to ensure that the properties and resources of the Reserve remain in a natural state that supports education and research activities. At the same time, the Stewardship sector must manage the impacts of traditional uses of the resources and provide for public access to the sites. Stewardship activities include the preservation of critical habitats and protection of native plant and animal species, particularly listed (endangered, threatened and rare) species. Although there are no system-wide stewardship programs at this time due to the widely varying issues and management needs at each Reserve, some common system-wide themes include restoration activities, invasive species management, visitor use impacts, and trash and debris control.

The stewardship sector works very closely with the education and research sectors, jointly conducting projects such as biological monitoring, habitat mapping, and public field trips. Stewardship staff also partners extensively with state and federal agencies, academic institutions, and non-governmental organizations, helping to promote the Reserve's programs and leveraging additional resources that contribute to the accomplishment of its mandates.

1.3: North Carolina National Estuarine Research Reserve

A: North Carolina Environmental Setting

North Carolina lies between 33.5° and 37° north latitude and between 75° and 84.5° west longitude midway along the U.S. Eastern seaboard (Figure 1.2). The total area of the State is 52,712 square miles (136,524 km²), of which 49,142 square miles (127,278 km²) are land and 3,570 squares miles (9,246 km²) are water. North Carolina contains three distinct land regions, the Mountain Region, the Piedmont Region, and the Coastal Plain and two unique biogeographical provinces, the Virginian and Carolinian (Figure 1.2).

The land and water areas of the Coastal Plain comprise nearly half the area of the State. North Carolina contains the nation's second largest estuarine/lagoonal system (Paerl et al. 2001),

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covering more than 2.3 million acres (9,308 km²). The soils of the coastal plain consist of soft sediment, with little or no underlying hard rock near the surface.

There are no distinct wet and dry seasons in North Carolina. Summer precipitation is typically highest, with July being the wettest month. Summer rainfall is also the most variable, occurring mostly in connection with showers and thunderstorms. Autumn is the driest season, with November the driest month. Precipitation during winter and spring occurs mostly in connection with migratory low pressure storms, which appear with greater regularity and in a more even distribution than summer showers. Snow and sleet are rare on the coastal plain. The average relative humidity does not vary greatly from season to season but is generally the highest in winter and lowest in spring. The lowest relative humidities are found over the southern Piedmont, where the year around average is about 65 percent. The highest are along the immediate coast, averaging around 75 percent.

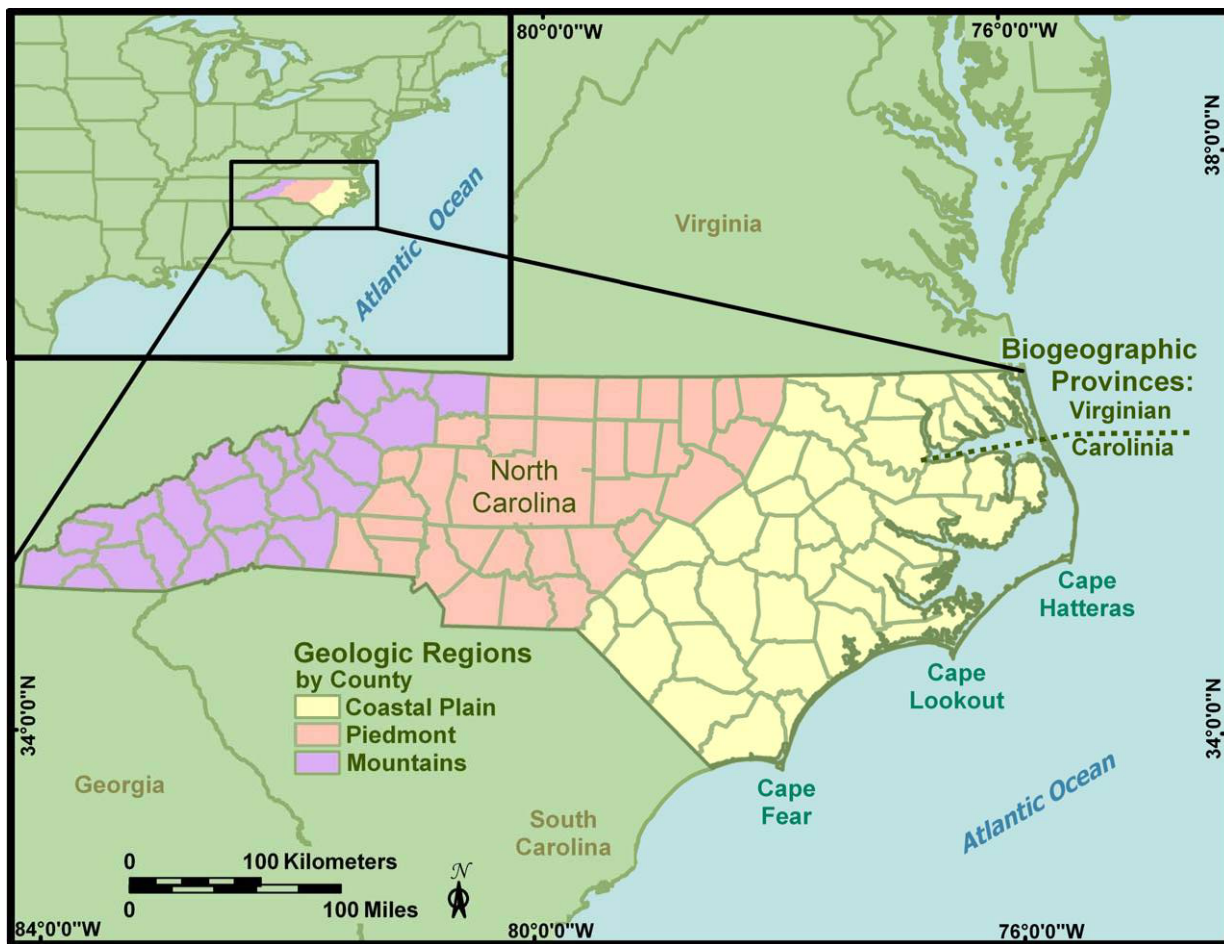


Figure 1.2: North Carolina geological regions and biogeographical provinces.

Temperature in North Carolina is extremely variable and depends on many factors such as altitude and the influence of Oceanic currents. In all seasons, the average temperature varies more than 20 °F (~11 °C) from the eastern most coastal areas compared to the highest mountain peaks. Temperatures as low as 0 °F (~ -18 °C) are rare outside the mountains. Winter temperatures in the eastern portions of the coastal plain are modified by the Atlantic Ocean, which raises the average winter temperature and decreases the average day-to-night range

compared to more inland areas. The rise in average daily temperatures is greater in May than in any other month. The average daily maximum reading in midsummer is below 90 °F (~32 °C) for most localities. Morning temperatures along the coast are usually 10 to 15 °F (~5.5 to 8 °C) lower than the afternoon maximum. Autumn is the season of most rapidly changing temperature, the daily downward trend being greater than the corresponding rise in spring. The drop-off is greatest during October, and continues at a rapid pace in November, so that average daily temperatures by the end of that month are within about five degrees of the lowest point of the year (all climate data obtained from the State Climate Office of North Carolina).

The immediate coastal regions of North Carolina are influenced greatly by the prevailing ocean currents. Two ocean currents, the Gulf Stream and the Labrador Current, converge off of Cape Hatteras (Figure 1.3). The Gulf Stream provides a warming effect to the southern coastal areas, and the Labrador Current provides a cooling effect for the northern coastal section. In the immediate coastal areas this can cause several degrees of difference between the northern (cooler) and southern (warmer) coastal areas. The convergence of these currents provides a rich biological region off the North Carolina coast where species from both the Carolinian (warmer) and Virginian (cooler) biogeographic provinces coexist. The mixing of the warm and cold waters also helps fuel oceanic storms off the coast of North Carolina. North Carolina is subject to two types of oceanic storms, tropical storm/hurricanes and Nor'Easters. Both types of storms can produce large amounts of precipitation and gale force winds. Tropical storms and hurricanes are warm cored systems with a closed circulation containing a defined eye wall structure. These storms are a yearly threat from July through November, and feed off the warm waters of the Gulf Stream. Nor'Easters typically form during the winter months when a cold cored low pressure system, associated with a front, moves up the coast and intensifies due gradients in atmospheric conditions along the Labrador/Gulf Stream interface. Both storm types can influence areas well inland from the coast.

There are also large differences in tidal range, salinity, and size of the back barrier sounds in North Carolina moving from the Virginia to South Carolina border (Figure 1.4). In the northern region, the back barrier sounds (Currituck and Albemarle) are medium sized and due to

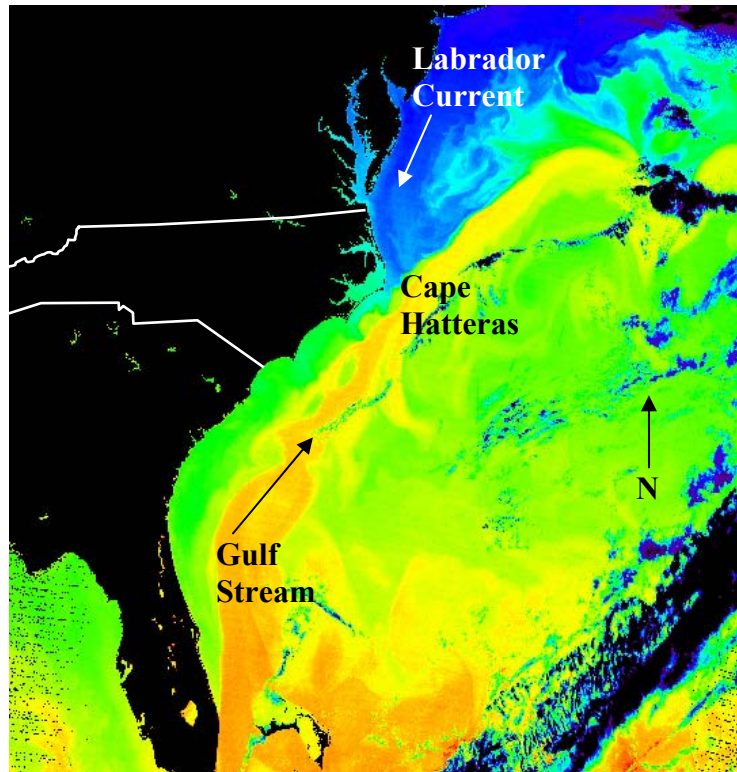


Figure 1.3: Ocean currents off of the coast of North Carolina. The warm waters of the Gulf Stream show up in yellow and move northward, the cold waters of the Labrador Current show up in blue and move southward.

their distance to ocean inlets effectively cut off from the coastal ocean. As a result, diurnal tides in the Currituck and Albemarle Sounds are essentially non-existent. Water level changes in the sounds are primarily attributable to wind driven forcing. Salinity values in these sounds are much lower

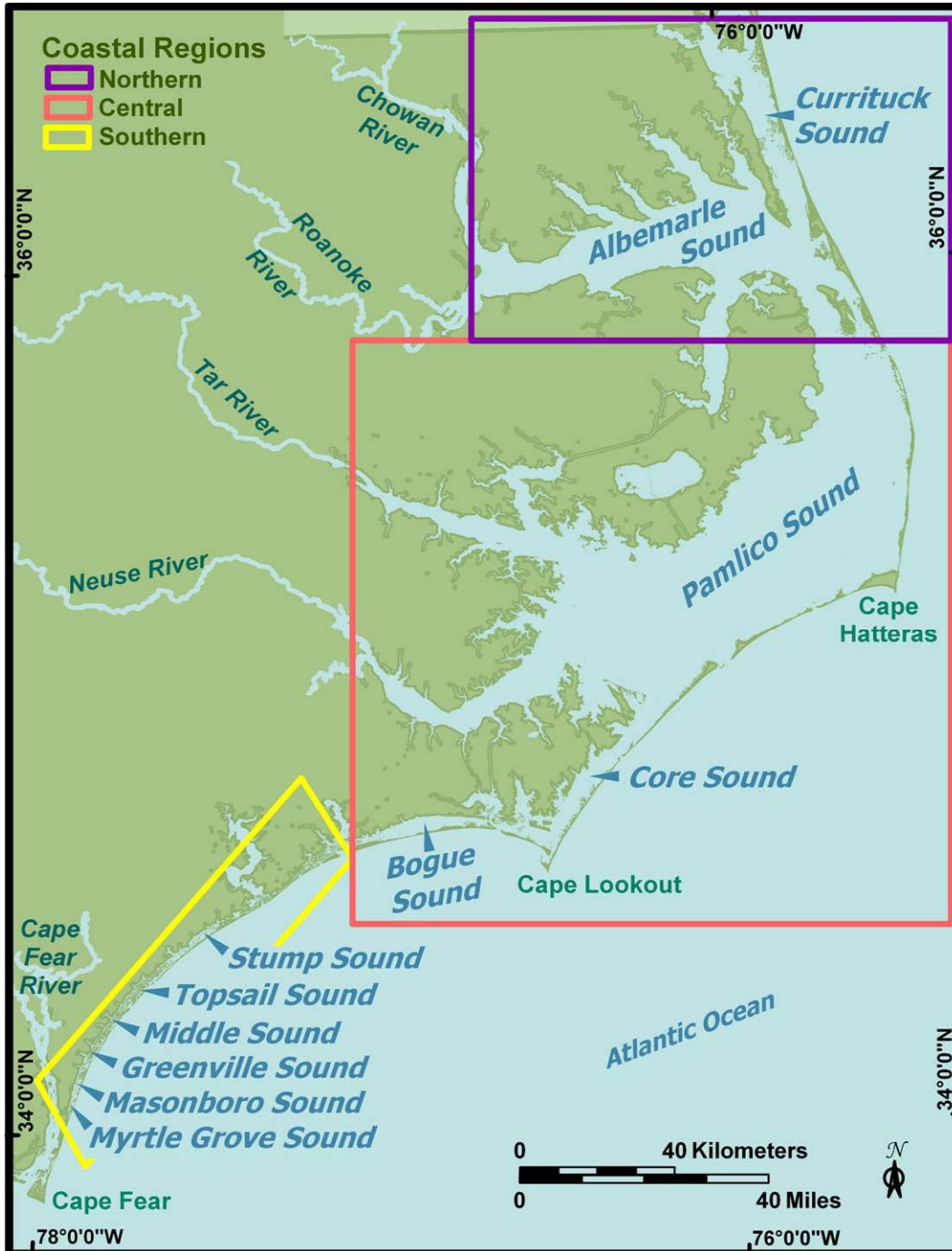


Figure 1.4: North Carolina coastal regions and back barrier sounds.

(2-7 ppt) compared to those values from the coastal ocean (35 ppt) and those from the sounds farther south. In the central region of North Carolina, there is one extremely large sound

(Pamlico) and several small ones to the south (Core, Back, and Bogue). Tidal range in these sounds ranges from 0.5 to 3.5 ft (~0.2 – 1 m) depending on distance from an ocean inlet. Salinity in the sounds in 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 Groove) are smaller than those to the north as the barrier islands tend to be much closer to the mainland than those northward. Consequently, their tidal range is closer to the coastal ocean values which in this region range from 3 to 6 ft (~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 make the estuarine environments in the northern, central and southern parts of the state very different.

B: NCNERR Site Selection and Designation

The diverse range of habitats in North Carolina noted above made it an ideal location for a NERR. In order to capture the full breadth of this diversity, a multi-component NERR was planned for the State. This approach allowed all the estuarine ecosystems present in the State to be represented and protected. In 1982 the state of North Carolina received its first federal award toward the establishment of the NCNERR. Four properties were selected to become components of NCNERR. Three of the components were designated in 1985 (Currituck Banks, Rachel Carson, and Zeke's Island) and Masonboro Island was designated six years later in 1991. These properties comprise over 10,000 acres of land and water habitat and protect land from the northern, central and southern parts of North Carolina. (Figures 1.4 and 1.5).

C: State Coastal Reserve Program

The four properties that make up the NCNERR are part of the larger North Carolina Coastal Reserve Program (NCCR). The NCCR contains 10 Reserves (including the 4 NERR locations), representing more than 32,000 acres (Figure 1.5). The State Reserves from north to south are: Kitty Hawk Woods; the Emily and Richardson Pryer Buckridge Coastal Reserve; Buxton Woods; Permuda Island; Bald Head Woods; and Bird Island (Figure 1.5). The NCCR was authorized by the N.C. General Assembly in 1989 to protect unique coastal locations. The overarching goal for the NCCR is preservation of the land for long-term research, education, stewardship and public use. The environmental setting and research activities at the State Coastal Reserves are beyond the scope of this document. Information regarding the state Reserves can be found on the NCCR website (www.nccoastalreserve.net).

D: Administrative Structure

The lead state partner for NCNERR is the North Carolina Department of Environment and Natural Resources - Division of Coastal Management (DCM). The DCM implements the State's Coastal Area Management Act, the Dredge and Fill Law and the federal CZMA of 1972 in the 20 coastal N.C. counties (Figure 1.5), using rules and policies of the N.C. Coastal Resources Commission. The main office for DCM is located in Morehead City, N.C. (Figure 1.5). The core staff positions for NCNERR are DCM employees. This arrangement is ideal as it allows for rapid incorporation of new information learned from research into coastal policy.

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The NCCR, of which the NCNERR is a part, is administered out of four offices (Figure 1.5). The main office is located in the central region in Beaufort, North Carolina. This office is a joint facility shared between the NCCR and the NOAA Center for Coastal Fisheries and Habitat Research. This arrangement allows NCNERR and the NOAA lab to share meeting rooms, shop facilities and greatly enhances collaboration. This office permanently houses the Reserve: manager; research coordinator; education coordinator; coastal training program coordinator; and an education specialist. Space also exists for additional staff members when needed and to accommodate program growth. The University of North Carolina at Wilmington (UNCW) is subcontracted by DCM to administer 7 full-time permanent contract positions for Reserve staff and to provide office facilities and logistical support for four NCCR staff in the southern region. This office is located in New Hanover County at the Center for Marine Science.

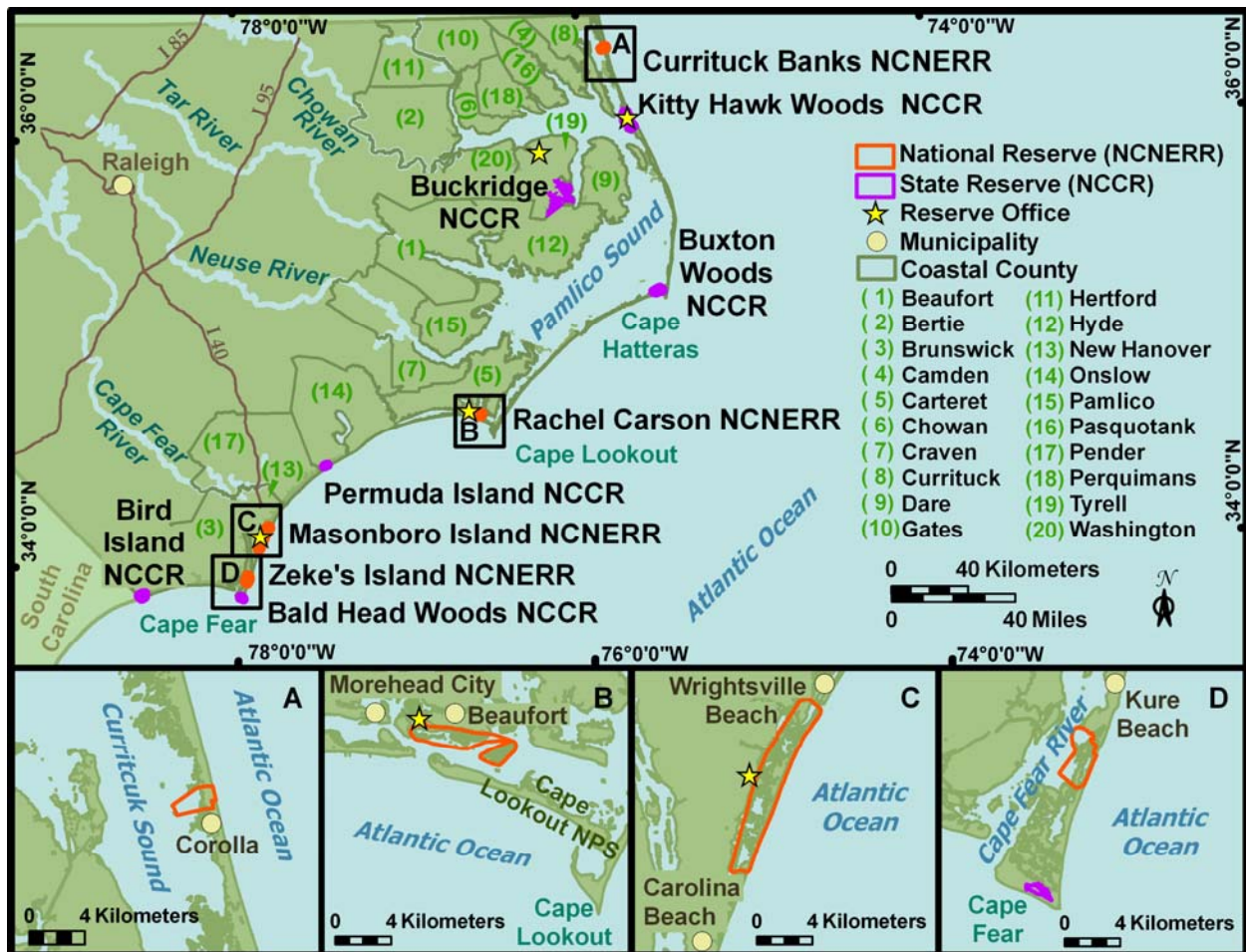


Figure 1.5: North Carolina national (red) and state (purple) reserve component locations. Coastal area counties are outlined in grey and identified by numbers. Reserve offices are denoted by the yellow star.

This arrangement is codified by a long-standing memorandum of understanding between UNCW and DCM. The staff located in this office includes the stewardship coordinator, two research assistants and a geographic information system (GIS) specialist. A northern region office is located in Dare County, at the Kitty Hawk Woods NCCR in Kitty Hawk, N.C. This office houses the northern sites manager and a contractual part-time research assistant. The final

NCCR office is located in Tyrell County in Columbia, N.C. This office houses the Buckridge Coastal Reserve manager. This office is co-located with the North Carolina Division of Marine Fisheries. This arrangement like the office in Beaufort, N.C. provides many advantages for shared resources and collaboration.

E: Administrative Partners

Several other institutions support the day to day activities of NCNERR. The Duke Marine Lab has provided, at greatly reduced cost boat dockage at our Rachel Carson Reserve component. The University of North Carolina – Institute of Marine Sciences provides laboratory space for NCNERR staff in the Morehead City/Beaufort area. The University of North Carolina – Coastal Studies Institute provides laboratory space for Reserve staff in the Kitty Hawk/Currituck area. The North Carolina Wildlife Resources Commission – Outer Banks Center for Wildlife Education in Corolla, N.C. provides NCNERR staff with boat resources for activities on Currituck Sound. The Carolina Estuarine Reserve Foundation is a local non-profit organization that supports NCNERR. The foundation provides NCNERR with community outreach, and financial support. This is not meant to be an exhaustive list of NCNERR's partners; however, without the assistance of these organizations, the capabilities of NCNERR would be greatly diminished.

F: Components of NCNERR

The smallest, most northern and only Reserve component located in the Virginian biogeographic province is the 960 acre (3.9 km²) Currituck Banks. Currituck Banks is located in Currituck County, just north of the village of Corolla. This component comprises pristine maritime forest, beach intertidal areas, dune swales, and brackish marshes. Water areas within the Currituck Banks component contain vast beds of freshwater submerged aquatic vegetation. These SAV beds provide important habitat for fish and feeding areas for migratory waterfowl.

The central portion of the State is represented by the 2,625 acre (10.6 km²) Rachel Carson component. This component is located in Carteret County between the town of Beaufort, Harkers Island and the Cape Lookout National Seashore. The Rachel Carson component contains large areas of salt-marsh and vast stretches of sand and mud flats. Upland areas are vegetated by scrub-shrub species and small trees. Water areas within the Rachel Carson component contain shellfish beds and three species of seagrass.

The Rachel Carson component is named after famed naturalist Rachel Carson, a pioneer female scientist who is considered the founding force behind today's environmental movement. In July of 1938, Rachel Carson came to Beaufort, N.C. and worked for the U.S. Fisheries Station. She fell in love with the area and researched the marshes and islands that now make up the Reserve, and especially enjoyed observing shorebirds and discovering the marsh pools, ponds and sand flats (Lear 1997). Rachel Carson's first book, *Under the Sea Wind*, was published in 1941 and opened with a long evocation of a May evening at Beaufort's Town Marsh and Bird Shoal (see Figure 3.1) (Cecelski 2000). During the Reserve dedication it was named in honor of Rachel Carson and her many accomplishments.

The largest Reserve component is the 5,047 acre (20.4 km²) Masonboro Island. This component consists of a pristine undeveloped barrier island. It is situated in New Hanover County between the towns of Wrightsville Beach and Carolina Beach. Masonboro Island

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contains beach intertidal areas, dune swales and an extensive backside salt marsh-tidal creek system. Shellfish beds consisting of predominately oysters and clams are found within the tidal creeks of Masonboro Island.

The southern most Reserve component is the 1,165 acre (4.7 km²) Zeke's Island component. Zeke's Island encompasses land in both Brunswick and New Hanover counties, and is located just south of Kure Beach. Zeke's Island contains beach intertidal areas, dune swales, large areas of salt marsh, upland forested areas, sand and mud flats.

1.4: NCNERR Strategic Plan

The NCNERR is administered according to its management plan. The management plan is updated every five years to reflect national, state, and local needs. This process allows NCNERR to be adaptive to new and changing priorities. The current national priorities are highlighted in the NERRS strategic plan (Appendix 1). The NCNERR management plan can be found at the NCCR website (www.nccoastalreserve.net). The overarching goal of the NCCR/NCNERR is to provide high quality research and locations for research, education outreach activities aimed at disseminating the results of the high quality research, and land stewardship to ensure the properties remain natural and unchanged for future generations. The mission and vision statements for NCNERR are:

Vision: Healthy estuaries and coastal watersheds where ecological communities thrive and the human community benefits in North Carolina.

Mission: To promote informed management and stewardship of North Carolina's estuarine and coastal habitats through research, education and example.

To help foster these vision and mission statements, a set of goals have been developed. These include:

1. Humans understand the natural systems, their connections to them, and the benefits derived from them.
2. Applicable research informs coastal policy.
3. NCNERR habitats and land use of associated watersheds are characterized and connections understood.
4. Habitat is protected and the public has directed access to NCNERR components.
5. NCNERR operations, infrastructure, and stature are improved.

The vision, mission, and goals were developed by NCNERR staff through strategic planning and logic model tools with the assistance of the NOAA Coastal Services Center. The goals integrate NCNERR programs, obscuring the lines between education, research, and stewardship.

1.5: SWMP History and Current Framework

The multi-component design of NCNERR is supported by three offices. During the formative years of NCNERR, there was not enough staff to conduct research, education and stewardship activities at all components. This problem was alleviated by concentrating sector activities to certain Reserve components. The research staff and activities were concentrated in Wilmington, N.C. at the Masonboro and Zeke's Island components. The education activities and staff were concentrated in the Beaufort, N.C. area at the Rachel Carson component. The stewardship staff and activities were located in Kitty Hawk, N.C. and primarily worked at the Currituck Banks component. Through staff reorganization, creation of new positions and new partnerships the NCNERR is working toward a new philosophy where activities of all sectors are conducted at all locations.

SWMP was initiated during the period of time when most of the NCNERRs research activities were concentrated in the southern region. Thus the Masonboro and Zeke's Island components are where the SWMP phase 1 monitoring stations are located. There are two water quality monitoring stations at both Masonboro and Zeke's Islands for a total of four. There is also a weather station located at Masonboro Island. In order to maintain the long-term dataset (>10 years), it is not desirable to relocate these sampling stations. But, given the varied estuarine climates within North Carolina noted in section 1.3, it is desirable to have water quality sampling at Rachel Carson and Currituck as well. Efforts have been made to accommodate this when funding and staff resources made it possible. These sampling stations are maintained exactly like those at Masonboro and Zeke's Islands but are not considered official SWMP stations. These stations at Rachel Carson and Currituck are considered SWMP-like. The data from the SWMP-like stations is of the same quality as that from the SWMP stations. Data from the SWMP and SWMP-like stations are located in each Reserve component's respective chapter.

1.6: Research Strategic Plan

The research sector of NCNERR is managed according to all the above listed management documents and overall vision statements. Complimenting these documents is the NERRS Research and Monitoring Plan (2006-2011) (Appendix 2). This document provides four goals that direct the system-wide research and monitoring efforts.

- Goal 1: Biological, chemical, physical, and ecological conditions of Reserves are characterized and monitored to describe reference conditions and to quantify change.
- Goal 2: Scientists conduct research at Reserves that is relevant to coastal management need and increase basic understanding of estuarine processes.
- Goal 3: Scientists, educators, and coastal managers have access to NERRS datasets, science products and results.

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Goal 4: The scientific, coastal management and education communities, as well as the general public, use data, products, tools, and techniques generated at the NERRS.

These national plans and documents provide excellent direction to the research sector of NCNERR. However, to be truly useful, the research sector at NCNERR must deal with issues important to local managers, scientist and citizens. To determine what the locally important research issues were, a needs assessment was conducted by our coastal training program. The needs assessment was directed at local: scientist; resource managers; and citizens. The results from this endeavor showed that research was needed in the following areas: 1) Water quality degradation and eutrophication; 2) Shellfish bed degradation and sustainability; and 3) Habitat mapping and change. Additional sector guidance was derived from the research and monitoring needs identified by the North Carolina Coastal Habitat Protection Plan (Appendix 3). All of these national, regional and local needs were considered when developing the strategic goals for the research sector of NCNERR. Four strategic goals were devised.

Strategic Goal 1) Conduct all phases of the SWMP at all four NCNERR components.

Strategic Goal 2) Conduct and/or facilitate research activities at all four components with priority given to projects dealing with eutrophication, fecal contamination, and habitat change.

Strategic Goal 3) Seek partnerships to further the capabilities and credibility of the research sector

Strategic Goal 4) Disseminate through outreach activities and publications the findings of research activities conducted in NCNERR.

1.7: North Carolina Coastal Issues

There are several overarching issues faced by North Carolina's entire coast that will be pervasive themes throughout this document as they affect all components of NCNERR. These include both anthropogenic as well as natural processes. Issues affecting all NCNERR components include eutrophication, altered land use and cover, invasive species, tropical and coastal storm impacts, and sea level rise. While these are not all the issues affecting the Reserve components, they are ones that impact all of them.

Eutrophication leads to excessive phytoplankton production. This can lead to a multitude of water quality problems including hypoxia, decreased light penetration, altered community composition, loss of SAV, and decreased fish and shellfish populations. Recovery from eutrophication can take long periods of time even if the causes of the eutrophication are immediately halted (Nixon 1995; Paerl et al. 1998; Mallin et al. 2000a; Niemi et al. 2004).

Altered land use and cover is a critical issue because how the land is used and the type of cover on it has large impacts on its ability to sequester nutrients and pollution rather than convey them to surface waters. Natural land covers such as forest and marsh have large buffering capacities. They tend to trap nutrients and sediment prior to them entering surface waters.

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Developed land tends to have very little capacity to absorb nutrients and pollution. This is because developed land has increased impervious surfaces such as roofs, roads, and parking lots. These surfaces do not let water infiltrate the ground and high percentages of impervious surfaces have been correlated with degraded water and sediment quality (Mallin et al. 2000b; Holland et al. 2004). Consequently runoff from these surfaces usually picks up whatever contaminants and nutrients are on them and rapidly moves these materials to surface waters (Mallin et al. 2000b; Mallin et al. 2001).

Invasive species is one of the largest and most pervasive problems facing not only North Carolina but also the nation. An invasive species is one that begins to live and reproduce in an area where it is not naturally found. This is problematic because when this happens there usually are not any of the species natural predators to keep it in check, and the new species tends to utilize resources at the expense of an existing native one. Invasive species are usually very opportunistic and hard to get rid of once established.

North Carolina's geography makes it prone to strikes by tropical and coastal storm systems. These storms can bring tremendous amounts of wind and rain to the State. They also are capable of causing large amounts of coastal erosion and can even cause new inlets to form. All of these issues are important for the properties of NCNERR.

Sea level rise is occurring along the North Carolina coast. Estimates for the amount of rise range from 0.3 to 3.0 mm/year, with most values between 1-2 mm/year (Gormitz 1995). Reliability of these estimates has been questioned due to the data quality, physical processes and a high level of spatial variability (Gormitz 1995). Some estimates range for sea level rise to be approximately 48-50 cm higher by 2100 (Gormitz 1995; Gregory and Oerlemans 1998). There are many potential problems associated an increase in sea level. The most important in terms of the Reserve properties is loss of marsh habitat. If the sea level rise is faster than the ability of the marsh to accrete sediment and build itself up, then the marshes will be swamped (Moorhead and Brinson 1995). This would cause not only a decrease in the size of all the Reserve properties, but also would represent a loss of vital nursery habitat.