

National Estuarine Research Reserve System

Research and Monitoring Plan (2006-2011)



The National Estuarine Research Reserve System is administered by NOAA's National Ocean Service, Office of Ocean and Coastal Resource Management, Estuarine Reserves Division. For more information, please contact Susan White, Research Coordinator, NOAA Estuarine Reserves Division, at Susan.White@noaa.gov. Or, visit <http://www.nerrs.noaa.gov>.

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Executive Summary

This document: 1) describes the current status of research and monitoring efforts within the National Estuarine Research Reserve System (NERRS), 2) describes five research priority areas that the system will focus on over the next five years, and 3) outlines a set of strategies that will enable the system to move forward in conducting and supporting research to address specific coastal management needs as well as improve our basic understanding of estuarine systems.

The five priority research areas were identified with input from a variety of sources including reserve research staff and managers, the NERRS Strategic Plan, and national documents outlining national coastal research needs and priorities. NERRS priority research areas focus on:

- Habitat and Ecosystem Coastal Processes
- Anthropogenic Influences on Estuaries
- Habitat Conservation and Restoration
- Species Management
- Social Science and Economics

Key reserve research goals, objectives, and strategies presented in this research plan will assist the reserve system in addressing the

five research priority areas, as well as meeting strategic goals outlined by the system, in the following five years. Social science and economics are disciplines that could engender relevant research related to the priority areas listed. The research goals outlined for this plan include:

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 needs and increases basic understanding of estuarine processes.

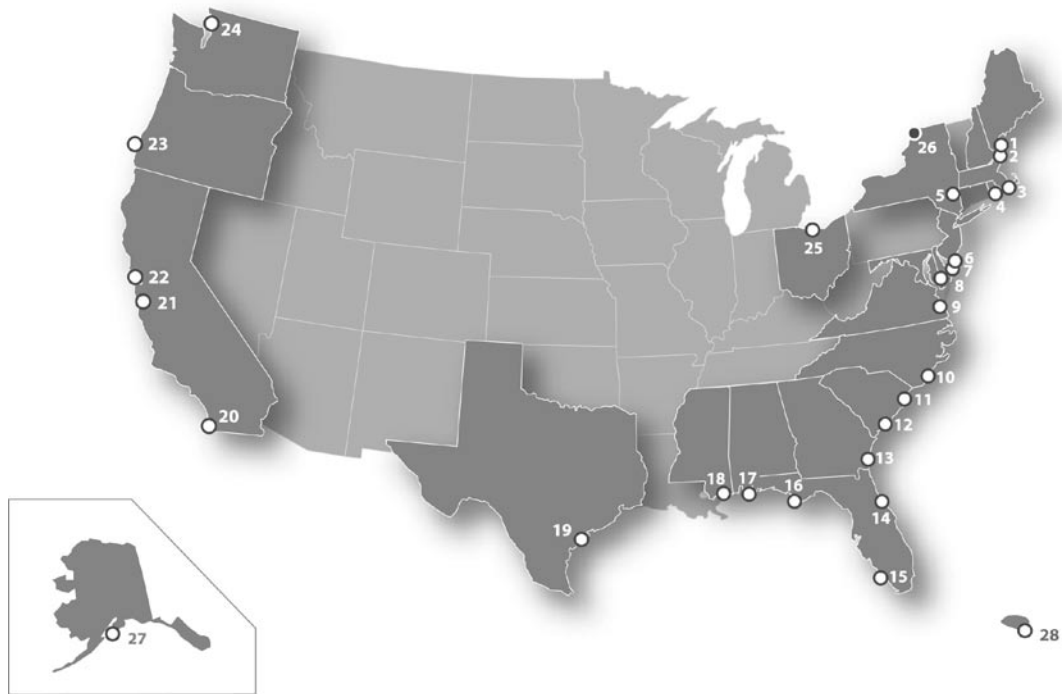
Goal 3: Scientists, educators, and coastal managers have access to NERRS datasets, science products and results.

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.

The NERRS has developed this research and monitoring plan to guide national, regional, and local research efforts that promote the protection and conservation of estuarine habitats through the provision of improved ecological information.

NATIONAL ESTUARINE RESEARCH RESERVES

A network of 27 protected areas



● designated ○ proposed

- | | |
|--|---|
| 1. Wells Reserve, Maine | 15. Rookery Bay Reserve, Florida |
| 2. Great Bay Reserve, New Hampshire | 16. Apalachicola Reserve, Florida |
| 3. Waquoit Bay Reserve, Massachusetts | 17. Weeks Bay Reserve, Alabama |
| 4. Narragansett Bay Reserve, Rhode Island | 18. Grand Bay Reserve, Mississippi |
| 5. Hudson River Reserve, New York | 19. Mission-Aransas, Texas |
| 6. Jacques Cousteau Reserve, New Jersey | 20. Tijuana River Reserve, California |
| 7. Delaware Reserve | 21. Elkhorn Slough Reserve, California |
| 8. Chesapeake Bay Reserve, Maryland | 22. San Francisco Bay, California |
| 9. Chesapeake Bay Reserve, Virginia | 23. South Slough Reserve, Oregon |
| 10. North Carolina Reserve | 24. Padilla Bay Reserve, Washington |
| 11. North Inlet-Winyah Bay Reserve, South Carolina | 25. Old Woman Creek, Ohio |
| 12. ACE Basin Reserve, South Carolina | 26. Proposed Reserve—St. Lawrence River |
| 13. Sapelo Island, Georgia | 27. Kachemak Bay Reserve, Alaska |
| 14. Guana Tolomato Matanzas Reserve, Florida | 28. Jobos Bay Reserve, Puerto Rico |

Introduction

The National Estuarine Research Reserve System (NERRS) is a network of 27 reserves dedicated for long-term research, monitoring, education and resource stewardship. These 27 estuaries and coastal watersheds, representing different biogeographic regions of the United States, were established by the Coastal Zone Management Act of 1972. The reserve system operates as a partnership program 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 or university, with input from local partners. This partnership program between NOAA and the coastal states and territories protects more than 1.3 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 laboratories for scientists.

One of the Guiding Principles of the Estuarine Reserves Division (ERD), as outlined by the NERRS Strategic Plan (2005-2010), is to “demonstrate and facilitate the development of sound science and best practices for improved local and regional coastal resource management.” The reserve system is also mandated to provide protection of estuarine and coastal natural resources and to promote

research and education activities that lead to greater protection of these systems. To facilitate the development of sound science for improved coastal decision making and the protection of natural resources, the reserve system has developed a research and monitoring plan that focuses on integrating the long term research goals of NOAA with those of the reserve system on local, regional, and national scales. As a system, the NERRS will approach research and monitoring from the perspective of an ecosystem approach to management which includes accounting for ecosystem knowledge and uncertainty, engaging in a collaborative and incremental approach to achieving research goals, employing adaptive techniques to improve research efforts, and balancing diverse environmental and societal objectives to inform coastal management decisions.

The purpose of this research plan is to help set priorities, provide a focus for partnership development, and help allocate financial resources and time to high priority issues. In addition, it will inform coastal resource managers and governmental, non-governmental, and academic scientists of the reserve system’s research priorities and capabilities. This will serve to both enhance research collaborations and leverage resources to further the state of coastal research science to support improved coastal management. The research plan will also support reserve research, education, and stewardship staff in their efforts to seek

The National Estuarine Reserve System Research Plan

Audiences	Results
Scientists (governmental, non-governmental, and academic)	Communicates reserve research priorities Guides collaborative projects
Coastal resource managers	Leverages research resources within NOAA and external to the reserves

National Estuarine Research Reserve System

Vision: Healthy estuaries and coastal watersheds where human and ecological communities thrive.

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

external funding for reserve programs related to coastal resource management. As a living document, this five-year reserve research plan provides a basis for refining research priorities and strategies and also allows for the flexibility that is required to support a national research effort that is implemented primarily at local to regional scales. While this iteration of the plan focuses on natural science research, it is anticipated that this plan will be expanded to include research plans that address reserve needs in social science,

restoration science, and education research within five years. Refining and aligning national, regional and local research priorities is challenging, yet efforts to do so will continually improve the relevance and impact of NERRS research efforts. While this research plan guides system-wide priorities, individual reserves will also pursue research and monitoring projects that address questions unique to their sites or regions. Reserve management plans will guide individual site-based research and monitoring priorities.

Background

The National Estuarine Research Reserves were established to provide opportunities for long-term research, education, and stewardship. According to 15 CFR Part 921 National Estuarine Research Reserve System Program Regulations, Subpart A, § 921.1 mission, goals and general provisions, three goals stand out as supporting the development of a coordinated research plan for the NERR system.

- Ensure a stable environment for research through long-term protection of NERR resources,
- Address coastal management issues identified as significant through coordinated estuarine research within the System, and
- Conduct and coordinate estuarine research within the System, gathering and making available information necessary for improved understanding and management of estuarine areas.

The authority to develop a system-wide research plan within the NERRS also resides in Title 16, Chapter 33, §1461 National Estuarine Research Reserve System, of the Coastal Zone Management Act (CZMA). Within the CZMA, specific research guidelines address the need for a plan for coordinated research and the development of related performance measures. Specifically, these guidelines suggest:

- Developing a mechanism for identifying, and establishing priorities among, the

coastal management issues that should be addressed through coordinated research within the System,

- Establishing common research principles and objectives to guide the development of research programs within the System, and
- Establishing performance standards upon which the effectiveness of the research efforts and the value of reserves within the System in addressing the coastal management issues identified may be measured.

NOAA has recently redesigned its approach to research to follow a more interdisciplinary, cross-cutting strategy to address defined priority research areas (NOAA, 5-yr Research Plan, 2005). The new infrastructure for NOAA's research focuses on four mission goals: Ecosystem, Climate, Weather and Water, and Commerce and Transportation Goals. The reserve system is a strong contributing member of the Coastal and Marine Resources Program within the Ecosystems Goal Team. The reserve system also contributes indirectly to the Climate Goal as well as the Weather and Water Goal. The mission of the Ecosystems Goal is to protect, restore, and manage the use of coastal and ocean resources through an ecosystem approach to management. Through the integrative and collaborative efforts of reserve research, education, and training activities, coastal ecosystems will be better understood and coastal decision making will improve.

National Oceanic and Atmospheric Administration

- Vision:** Societally relevant research that forms the scientific basis for more productive and harmonious relationships between humans and their environment.
- Mission:** To conduct research, develop products, provide scientific understanding and leadership and to conduct outreach towards fostering NOAA's evolving environmental and economic mission.

NOAA's Ecosystem Goal Team Selected Outcomes

- **Healthy and productive coastal and marine ecosystems that benefit society.**
- **A well informed public that acts as stewards of coastal and marine ecosystems.**

Existing NERRS Research and Monitoring Programs

NERRS System-Wide Monitoring Program

The NERRS System-Wide Monitoring Program (SWMP; pronounced "swamp") was developed in 1995 to provide researchers, resource managers, educators, and other coastal decision makers quantitative measures with which to assess short-term variability and long-term change in estuarine conditions. At present, the program is moving into its second decade of collecting critical estuarine water quality and meteorological data. A key feature in establishing SWMP was the implementation of a set of consistent standard operating procedures that ensure the long-term collection of data that is comparable across time and locations. As such, SWMP is

able to provide robust data for such things as, for example, trend analysis and change detection of anthropogenic impact assessments, as well as the effects of large-scale forcing (e.g., El Niño/Southern Oscillation and North Atlantic Oscillation, climatic conditions, sea level rise, and global climate change) and localized, stochastic events (e.g., hurricanes and contaminant spills) on estuarine conditions within a reserve. By implementing these standard operating procedures in a coordinated fashion across all 27 reserves, SWMP data can also be used for meaningful comparisons of estuarine conditions at the regional and national levels, thus enhancing the value of the reserves as a system of national reference sites. Thus, SWMP provides valuable short- and long-term data to researchers, natural resource program managers, coastal educators, and other coastal decision-makers.



Photo Credit: NOAA's National Environmental Satellite, Data, and Information Service (NESDIS)

The NERRS System-wide Monitoring Program (SWMP) is able to provide both long-term data for trend analysis and change detection as well as data on the impact of localized, stochastic events such as Hurricane Katrina (2005) on estuarine conditions within reserves.

The NERRS and NOAA established SWMP as a phased monitoring approach that focuses on three different ecosystem characteristics:

Abiotic Factors, including: atmospheric conditions, water quality (nutrients, contaminants, etc.) and physical parameters (salinity, tidal range, groundwater, freshwater inflow, bathymetry, etc.);

Biological Monitoring, including: biodiversity, habitat and population characteristics;

Watershed and Land Use Classifications, including: changes in consumptive and non-consumptive uses.

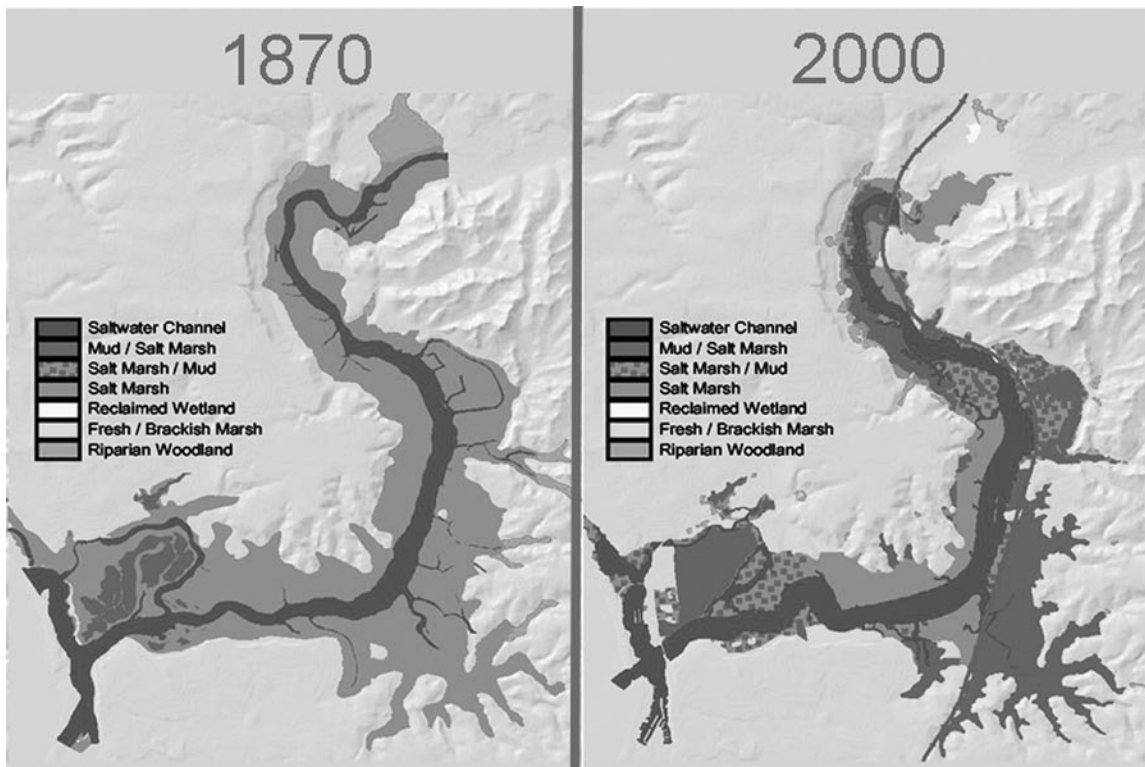
Phase 1 of SWMP focuses on monitoring a suite of water quality and meteorological parameters over a range of spatial (local, regional, national) and temporal (minutes, hours, days, months, years) scales. Data loggers are continuously deployed at a minimum of at least four water quality stations at each reserve to record measurements of conductivity, salinity, temperature, pH, dissolved oxygen, turbidity, and water level at thirty minute intervals. Each reserve also collects monthly measurements

of water column nutrients (e.g. nitrate, nitrite, ammonia, and ortho-phosphate) and chlorophyll-a concentrations at the four stations. In addition, diel sampling (2.5 hour sampling intervals over 25 hours) for nutrients and chlorophyll-a occurs at a minimum of one site each month. At least one weather station at each reserve records meteorological measurements of local temperature, wind speed and direction, relative humidity, barometric pressure, rainfall, and Photosynthetic Active Radiation at 15- to 30-minute intervals. Reserve staff have laid the technical groundwork necessary for the phase-one SWMP data collection network to be integrated into the backbone of the United States' Integrated Ocean Observing System (IOOS), with a near-real-time telemetry system for timely dissemination (NOAA 2004).



Photo Credit: Rookery Bay National Estuarine Research Reserve

Conservative estimates for the volume of data collected by the NERRS abiotic sampling program are: 13.5 million data points for water quality, 34.4 million data points for meteorological monitoring, and 31,104 data points for nutrient monitoring.



Wetland change analysis within the Elkhorn Slough, CA NERR utilizing habitat mapping techniques to quantify a 50% loss in marsh vegetation in the past 150 years (Van Dyke and Wasson 2005).

Phase 2 of SWMP focuses on characterizing biotic diversity in reserve estuarine ecosystems by assessing community composition and species abundance and distributions. Reserve projects will explore patterns of inter-annual variability and spatial distribution of estuarine communities, including emergent and submerged vegetation, invasive species, benthic, plankton and nekton communities, as well as targeted monitoring for the occurrence and distribution of invasive species. Since 2004, biomonitoring demonstration projects at 16 reserves have focused on developing baseline information on submerged and emergent vegetation distribution for use in future land use change research, determining changes in the health and distribution of these communities

with long-term changes in water quality and quantity, and quantifying changes in estuarine habitat types. Rigorous protocols were established to ensure a national strategy for implementing this biomonitoring initiative, while retaining local flexibility as appropriate for individual reserves (Moore and Bulthuis 2003). There are currently plans for a special journal edition focusing on local, regional, and national application of this biological monitoring information.

Phase 3 of SWMP is well-aligned with phase 2, as both of these efforts utilize remote sensing imagery and ground truthing. The central objective focuses on tracking and evaluating changes over time in coastal and estuarine

habitat and land use in the watershed. Reserve staff have developed a common classification system to provide the system with consistent, and thus nationally comparable, habitat and watershed mapping efforts (Kutcher et. al. 2005). The use of a common classification system will enable the NERRS to assess habitat change at local, regional, and national scales and identify the status of coastal habitats (i.e., degrading, improving, or maintaining). In addition, system-wide use of this classification system will provide a baseline of information that can be applied to management and restoration activities and guide conservation and protection of these important habitats. Currently, five reserves have piloted this classification system and the protocol was refined in the fall of 2005. It is anticipated that this classification system will be adopted by the reserves in 2006. Phases 2 and 3 will be implemented as resources become available.

Further details regarding parameters measured, data acquisition, data dissemination, deployment protocols, developing phases of SWMP, and applications of NERRS SWMP data within research, coastal decision making and education communities are available in the NERRS SWMP Plan (NOAA, 2002; Appendix A) and the NERRS SWMP 10th Anniversary Report (Owen and White, 2005). To ensure the collection of accurate, high quality SWMP data, the reserve system established a Centralized Data Management Office (CDMO; <http://cdmo.baruch.sc.edu>) in 1995. Quality assurance/quality control protocols have been established for the collection of all monitoring parameters and for the metadata (FGDC content compliant) associated with the time-series datasets.

A number of publications use and synthesize SWMP data. A recent special issue of the Journal of Coastal Research highlights a number of reserve research efforts (Kennish and Finkle 2004), and past syntheses have produced additional information regarding patterns within the reserve system (Wenner et. al., 1998 and 2000).

NERRS Graduate Research Fellowships

The NERRS Graduate Research Fellowship (GRF) program provides master's degree students and Ph.D. candidates with an opportunity to conduct research of local and national significance focusing on enhancing coastal zone management. Since its inception in 1997, the program has funded more than 160 fellows from 56 universities across the country. The five research focus areas for the GRF program are: eutrophication, effects of non-point source pollution and/or nutrient dynamics; habitat conservation and/or restoration; biodiversity and/or the effects of invasive species; mechanisms for sustaining resources within estuarine ecosystems; and economic, sociological, and/or anthropological research applicable to estuarine ecosystem management (Figure 1).

Reserve Site-Specific Research

The National Estuarine Research Reserves serve as living laboratories for on-site staff, visiting scientists and graduate students. Since its inception, a primary goal of the program has been to ensure a stable environment for research through long-term protection of reserve resources and ecosystems. Reserve management plans include site-based research

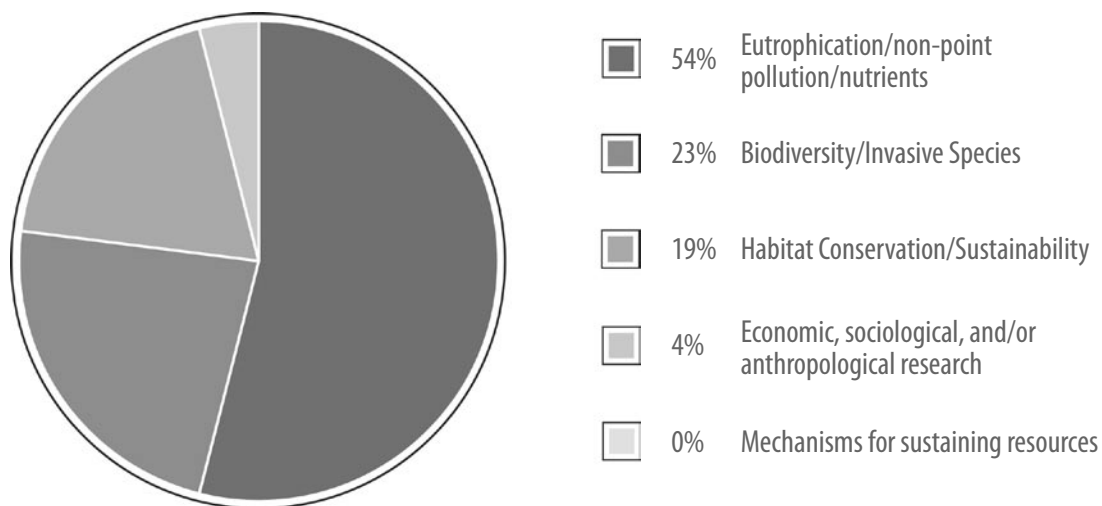


Figure 1. Snapshot of NERR Graduate Research Fellowship research project focus areas for 2005.

and monitoring priorities. Research activities within the reserve system occur in a number of ways. Each reserve has a research coordinator who is primarily responsible for coordinating research and monitoring efforts that occur within the reserve. As a group, the research coordinators' scientific expertise encompasses a wide range of subjects including nutrient biogeochemistry, population, community and ecosystem ecology, and physical oceanography. The breadth of knowledge and expertise that is shared among research coordinators constantly improves and pushes the reserve system toward new and successful research opportunities focused on improving coastal management decisions at individual reserves and nationally. In addition, scientists from a variety of backgrounds (e.g. academic, non-governmental, state and federal governments) conduct research within each reserve in coordination

with reserve research staff. This also broadens the scientific knowledge base for the NERRS.

Research and Monitoring Partnerships

Additional research and monitoring efforts within the reserves are supported by a series of partnerships within NOAA and other programs. Examples of these partnerships include:

- The Cooperative Institute for Coastal and Estuarine Environmental Technology (CICEET) is supported through a partnership between NOAA and the University of New Hampshire (<http://www.ciceet.unh.edu>). Research projects funded by CICEET occur within reserve boundaries or the adjacent watershed and focus on a variety of environmental issues from habitat restoration research to developing and piloting new technologies to monitor water quality and contaminants.

- NOAA's Chesapeake Bay Office (NCBO) and the NERRS support specific research and monitoring programs that focus on understanding and restoring Chesapeake Bay communities.
- NOAA's Coastal Services Center (CSC) has supported remote sensing and geographical information system (GIS) tools, training, and development programs within the reserve system.
- NOAA's Center for Operational Oceanographic Products and Services (CO-OPS) has partnered with reserve sites to demonstrate the effectiveness of collaboration to produce an improved, more effective product that will be used by coastal managers and others for improved decision making. CO-OPS National Water Level Observation Network (NWLON) is expanding to include reserve sites in an effort to link SWMP data with more detailed tide, water level, and weather information within the Reserve.
- NOAA's National Weather Service (NWS) and National Environmental Satellite, Information, and Data Service (NESDIS) have partnered with the NERRS to deliver newly telemetered, real-time, SWMP weather and water data through NOAA's Geostationary Operational Environmental Satellites (GOES) and the NWS's Hydrometeorological Automated Data System (HADS) to the NERRS Centralized Data Management Office.
- NOAA's Sea Grant Programs, Coastal Zone Management Programs, and National Marine Sanctuary Programs support research projects that address priority research needs within or adjacent to reserve sites.
- The National Atmospheric Deposition Program (NADP)/National Trends Network (NTN) and United States Geological Survey (USGS) have established atmospheric deposition monitoring programs within and close to reserve boundaries.
- The Environmental Protection Agency's National Estuary Program (NEP) and the NERRS collaborate at local scales to accomplish research that is relevant for both programs and at national scales to improve science information exchange between programs.
- The Smithsonian's Environmental Research Center (SERC) and the NERRS have ongoing collaborations that focus on monitoring and forecasting expansion and distribution of invasive species within the reserve system.
- NOAA's National Centers for Coastal Ocean Science (NCCOS) collaborates with the reserve system to investigate long-term trends in eutrophication and contaminants in estuarine systems across the nation. The reserves continue to be involved in NCCOS's national estuarine eutrophication assessments and the Mussel Watch Program.
- NOAA's Educational Partnership Program (EPP) established the Environmental Cooperative Science Center (ECSC) in October 2000 with Florida A&M University in collaboration with Delaware State University, Jackson State University, Morgan State University, South Caro-

lina State University, and the University of Miami Rosenstiel School. The ECSC addresses ecological and management issues through studies and collaboration with several NERR sites and the Florida Keys National Marine Sanctuary. The ECSC NERR partners include: Apalachicola, FL NERR; Grand Bay, MS NERR; ACE Basin, SC NERR; Delaware NERR; and Chesapeake Bay, MD NERR.

- The National Science Foundation's coastal Long-term Ecological Research (LTER) sites offer the NERRS additional research and collaborative opportunities. Sapelo Island NERR is located within the Georgia Coastal Ecosystems LTER site.

Research Plan Framework and Development

The research plan for the NERRS has been developed to address topic areas and technological needs identified at national, regional, and local levels. Considerable challenges must be overcome to develop a coherent national research plan for the reserve system that can simultaneously incorporate and accommodate the flexibility in approaches and design that are necessary to meet local and regional coastal research and management needs, while also addressing nationally significant coastal issues. Scaling research priorities up from a local and regional perspective to address nationally relevant coastal issues requires the reserves to constantly evaluate how individual reserve research can support broader national estuarine information and application needs.

Development of this plan has been coordinated by NOAA's Estuarine Reserves Division with primary input from the individual reserves and NOAA's Office of Coastal Resource Management. Reserve research coordinators and managers contributed directly to the formulation of this plan by identifying the primary research needs and coastal management issues within reserve sites (Appendix B). The plan incorporates information contained in several documents produced by the reserve system including the NERRS Strategic Plan for 2005-2010 (Appendix C), the NERR System-Wide Monitoring Plan, NERR

management plans, site profile documents (Appendix D), and local needs assessments conducted by the NERR Coastal Training Programs. Additional research needs and coastal management issues were identified through the findings of several recent compilations including: (a) the CICEET survey of coastal management needs for new and improved technology (2004); (b) the Coastal States Organization (CSO) census of national and regional priorities to improve links between science and coastal management needs (2004); (c) the CSO survey of state coastal observational and monitoring needs (2004); (d) research needs for coastal resource management identified by the Estuarine Research Federation (ERF, 2005); (e) the National Research Council priorities for coastal ecosystem science (1994); (f) the PEW Ocean Commission Report; and (g) findings from the U.S. Commission on Ocean Policy (2004). As an example of the range of coastal management priorities identified, Table 1 presents CSO's results for both national research needs and needs identified by NERRS Manager's as well as key estuarine threats identified by the PEW Ocean Commission. Information provided by these sources has been used to identify a series of reserve research priorities that are both nationally relevant and tailored to meet the regional and site specific needs of individual reserve sites.

Table 1. *Coastal management research needs and threats identified from surveys conducted by the Coastal States Organization and PEW Ocean Commission.*

The Coastal States Organization top ranked research needs:

<u>Top National Level Research Needs</u>	<u>Top NERR Research Priorities</u>
Cumulative Effects	Cumulative impact assessment
Source identification and tracking	Ecosystem indicators
Trends/change analysis	Source identification and tracking
Remote Sensing	Improved models
Improved Models	Rapid detection and monitoring of invasive species
	Risk and vulnerability assessments
	Restoration prioritization
	Ecological characterizations

The PEW Ocean Commission identified the following key estuarine threats and pressures:

- Coastal development
- Nutrient runoff into coastal rivers and bays
- Unsustainable fishing activities impacting nearshore/estuarine systems
- Invasive species introductions
- Global climate change impacts

The framework for the NERR Research Plan provides a pathway for integration and support of site-based research projects to meet local, regional, and national coastal and estuarine management needs (Figure 2). Science investigations and research projects undertaken at individual NERR sites are supported by state, NOAA, and other sources, and are typically conducted by NERR scientists, graduate students, visiting investigators, contractors, and volunteers to meet the needs identified by local and regional coastal resource managers. Taken collectively, the research effort undertaken within the network of NERR sites contributes in a “bottom-up” manner to the goals and objec-

tives of the NERR Research Plan. Conversely, the NERR Research Plan serves a “top-down” role to provide guidance, coordination, and the national context to support site-based research within the NERRS network. Financial support for the site-based research activities is typically derived from the states, federal agencies, regional programs, non-governmental organizations, and/or other sources depending on the topic and focus of the research problem. As the focal point for coordination of NERRS science activities, the NERR Research Plan serves as an integral element of the NERR Strategic Plan for 2005-2010. The NERR Strategic Plan functions to coordinate the research and monitoring

activities with other elements of the NERRS (e.g., education/outreach, coastal training, resource stewardship, and management). This in turn serves to facilitate investigations undertaken by multiple reserves, and to leverage support for NERRS research internally in cooperation with other NOAA science programs and externally in partnership with outside groups. Science activities completed under the guidance of the NERR Strategic Plan and NERR Research Plan contribute to the objectives of the NOAA-wide Research Plan (2005), and they address the cross-cutting issues identified by the Ecosystem Goal for Coastal and Marine Resources. Collective integration of NERRS science at many levels (e.g., NERRS sites, NERR Research Plan, NERR Strategic Plan, NOAA Research Plan) will help meet a sub-set of the national priorities for coastal and estuarine ecosystem science.

Priority Coastal Management and Research Issues

The U.S. Commission on Ocean Policy recommended that NOAA adopt an ecosystem-based approach to the development of coastal and ocean policy that is based on the best available science for marine and estuarine ecosystems. NOAA's focus on protecting, restoring, and managing the use of coastal and ocean resources through an ecosystem approach is closely aligned with the specific

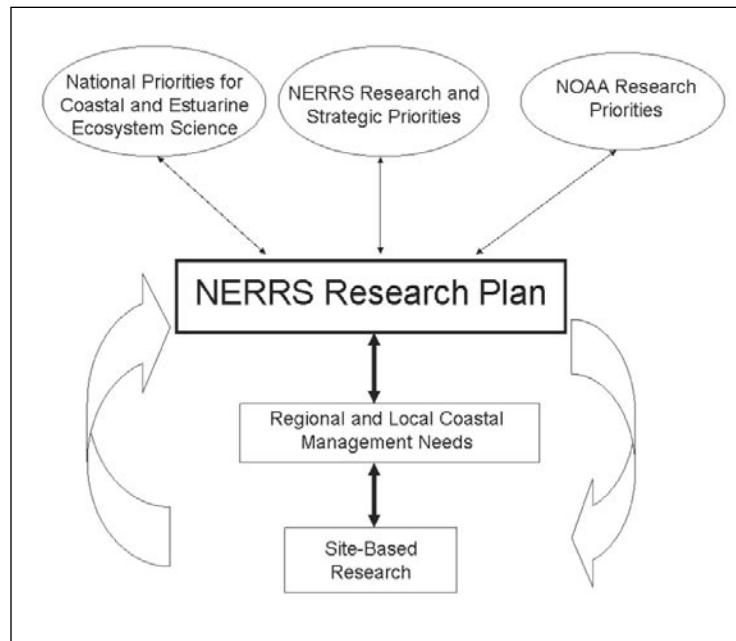


Figure 2. *The development components and anticipated science contributions associated with the NERRS Research and Monitoring Plan at local, regional, and national scales.*

research activities undertaken within the reserve system. The NERR Research Plan nests within the broader, NOAA 5-Year Research Plan, while simultaneously addressing the regional and local needs of the reserves.

The highest priority U.S. coastal management issues identified at both the national and regional levels focus on assessments of impacts due to changing shoreline and watershed land use and coastal habitat change (Table 1). It is clear that nationally and regionally, coastal managers are concerned about increased development pressures in coastal and estuarine areas, and are supportive of research and monitoring efforts that will address the growing need for information to document impacts on the coastal environment. Environmental contamination, habitat

degradation, eutrophication, invasive species, declines in fish species, freshwater diversions, sea level changes, and sediment problems are significant stressors to coastal and estuarine ecosystems. Consequently, it is not surprising that the top-ranked research needs for coastal managers are: (a) new approaches to address the cumulative effects of multiple environmental stressors, and (b) source identification and tracking for coastal environmental pollutants. Priority information needs identified by the U.S. coastal management community include quantitative data to describe temporal trends and changes in land use, coastal habitats, and habitat quality, and the priority needs for new technology focus on development of useful products from remote sensing imagery and improved conceptual and numerical models to predict the consequences of stressors on environmental change.

The priority research needs identified by the estuarine research community (e.g., academia, agencies, NGOs, and private-sector scientists; ERF, 2005) are highly complementary to those identified by the U.S. coastal management community. The highest priority research needs are: (a) investigations of anthropogenic impacts on estuarine ecosystem functions; (b) documentation of linkages among coastal land use activities and estua-

rine habitats; (c) increased understanding of environmental variability, sensitivity, and resilience; and (d) new infrastructure to link estuarine science, management, and policy (ERF, 2005). These priority estuarine research issues are consistent with the priorities for coastal ecosystem science identified by the National Research Council (i.e., integrated monitoring of coastal habitats; watershed hydrology and ecosystem processes; water quality and aquatic ecosystem functions; ecological restoration and rehabilitation; development of observational and predictive systems). In combination, the priority research needs identified by the U.S. coastal management and research communities clearly articulate a suite of pressing science-management issues that can be addressed by the network of representative reserve sites and the NERRS Research Plan. For example, within individual reserves, program priorities are broadly focused on research regarding habitat change/land use, cumulative impact assessments, tracking of pollutants, development of indicators that link land use with ecosystem impacts, estuarine ecosystem functions, invasive species, land use change analysis, the success of restoration efforts, habitat use by fish and shellfish, integrated monitoring, and improved models that predict and/or simulate changing environmental conditions.

National Estuarine Research Reserve System Research Plan

The NERRS Strategic Plan outlines four priority coastal management issues; land use and population growth, habitat loss and alteration, water quality degradation, and changes in biological communities. The five main NERRS research priority areas clearly address these identified estuarine threats and the supporting research questions, goals and strategies described below will enable the NERRS to better understand estuarine processes, provide scientific data that can be applied and thus improve coastal management decisions and the protection of estuarine habitats (Figure 3).

The five main NERR research priority areas were identified as a result of information compiled from within the NERRS, NOAA and external sources as outlined previously. NERR research priority areas include:

- Habitat and Ecosystem Coastal Processes
- Anthropogenic Influences on Estuaries
- Habitat Conservation and Restoration
- Species Management
- Social Science and Economics

Research projects that are designed to tackle NERRS research priority areas will clearly address the four priority coastal management issues identified within the NERRS Strategic Plan and thus support improved coastal decision making and a greater understanding

of estuarine systems. The research categories are interrelated on one or more levels. In addition, research can include natural or social science research. For example, social science and economic research can be used as a tool to address natural science issues. In the true ecological sense, this is a web of research topics with threads leading from topic to topic. NERRS-specific research questions are focused on coastal management issues related to these five priority areas.

Key Questions for each priority area might include:

Habitat and Ecosystem Coastal Processes

- What are the natural scales of variability in coastal and estuarine ecosystem processes?
- How do short-term climatic events (e.g., tropical storms and hurricanes), and large-scale events (e.g., El Nino, North Atlantic Oscillation, global climate change) impact estuarine water quality parameters and estuarine habitats?
- How do variable watershed inputs and oceanic physical forcing drive changes in estuarine ecosystems (including nutrient cycling, sediment transport, larval transport, etc.)?

Anthropogenic Influences on Estuaries

- How do human activities impact estuarine water quality, living resources (e.g.,

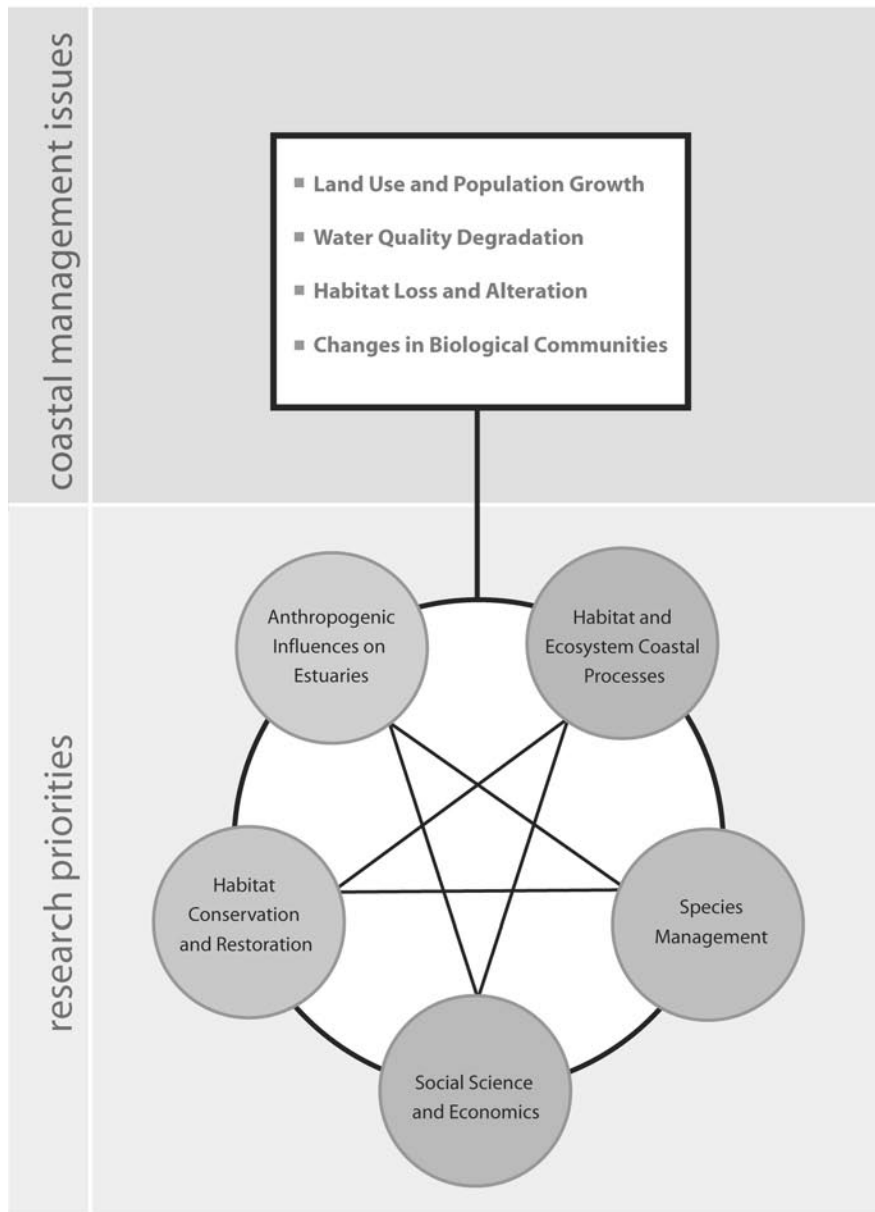


Figure 3. *The 5 NERRS Research Priorities, anthropogenic influences on estuaries, habitat and ecosystem coastal processes, habitat conservation and restoration, species management and social science and economics address key coastal management issues.*

submerged aquatic vegetation, benthic communities, habitat fragmentation), and ecosystem function (or “services”)?

- Are current watershed and coastal nutrient management measures effective in minimizing impact to estuarine ecosystems and resources?
- What is the magnitude and impact of atmospheric deposition on estuaries?

Habitat Conservation and Restoration

- What impacts does climate change have on habitat integrity and restoration success?
- How does the restoration of tidal hydrology impact estuarine communities (e.g. colonization of invasive species, resiliency of native species, etc.).
- What are the linkages between adjacent upland habitats and tidal wetlands and how critical are those links to the recovery of wetland function?
- What invasive species control methods are effective?
- How can reserves serve as reference sites for restoration efforts?

Species Management

- How do invasive species affect native species and communities?

- What tools can be developed and used to detect invasive species, respond rapidly and appropriately to these events, and monitor for additional impacts?
- Can natural variations in the distribution and density of organisms be distinguished from human impacts on these populations?
- How do estuarine and coastal communities and individual species populations change under varying environmental conditions?
- How are estuarine species and communities affected by landscape or watershed scale changes (e.g., habitat proximity, subtidal-intertidal linkages, connectivity)?

Social Science and Economics

- How are coastal populations demographics changing and how does this/will this impact natural resource protection and management?
- What are the economic tradeoffs/effects of increasing development and urbanization in the coastal zone on traditional commercial enterprises such as seafood harvesting, etc.?
- How do human perceptions of health risks influence coastal decision making and natural resource protection?
- What are the cumulative impacts of multiple human recreational and economic activities on the coastal environment?

Implementation Strategy

Research Goals

The reserve research and monitoring plan includes a number of priority goals for the system (a few of which are outlined below) to support national and regional efforts toward improving the protection of coastal and estuarine natural resources by conducting research that supports sound coastal decision making. These goals are not meant to be an exhaustive list as by definition this research plan is designed to be supportive of regional and local research initiatives that address reserve system and NOAA research needs. The goals listed below provide a basic foundation on which reserve science efforts can build. It is fully anticipated that these strategies will be modified appropriately over time as the Reserve system continually assesses the quality and impact of research results and products in order to continue to improve and sustain coastal environments (Appendix E). The desired ecosystem approach to management is an iterative process, where results from previous actions and research are used to refine and improve future efforts in research and management decisions. Implementation of some strategies depends on the availability of sufficient resources.

Research Goal 1: Biological, chemical, physical, and ecological conditions of reserves are characterized and monitored to describe reference conditions and to quantify change.

Objectives:

1. Water and weather parameters, biodiversity, and habitats located within the reserve and nearby watershed areas are sufficiently characterized, both spatially and temporally, to support trend analysis efforts.
2. Biological monitoring data collected by the reserve system are incorporated into an accessible database for use.
3. Biological monitoring efforts within the NERRS are synthesized regularly as appropriate at national, regional and local scales.

Strategies:

- Complete site profiles.
- Continue system-wide measurements of the short-term variability and long-term changes in estuarine water quality and meteorological parameters, consider expanding suite of standard water quality parameters tracked (e.g. addition of chlorophyll a to fixed station sampling) as possible.
- Collect system-wide measurements of the short-term variability and long-term changes in submerged aquatic vegetation and emergent vegetation.
- Collect additional appropriate biological monitoring information on important

habitats, species, and ecological functioning within reserves.

- Link system-wide measurements of chemical and physical parameters with biological monitoring information.
- Implement a system-wide habitat classification system that allows for site specific and system-wide analysis.
- Synthesize biological monitoring pilot project data and revise protocol to reflect lessons learned and move toward system-wide operational status.
- Develop a system-wide remote-sensing strategy that supports and enhances ongoing biological monitoring and habitat classification efforts.
- Partner with appropriate university, state agency, federal agency, local government and private entities to bring monitoring of sediment quality, benthic communities, nekton populations and shoreline change into reserves.
- Integrate NERRS monitoring data into the national IOOS program.

Research Goal 2: Scientists conduct estuarine research at reserves that is relevant to coastal management needs and increases basic understanding of estuarine processes.

Objectives:

1. Research efforts focus on understanding the response of estuarine and coastal processes to specific natural and anthropogenic impacts.
2. Research efforts focus on estuarine habitat and species management and the restoration of critical ecosystem function.
3. Research efforts incorporate an ecosystem-based approach to management that involves multiple stakeholders.
4. Scientists from multiple agencies (ie. academic, governmental, NGO's, etc.) utilize reserves as a platform for research.

Strategies:

- Attract CICEET, GRF, and external researchers to reserves to work on priority research topics: habitat and ecosystem coastal processes, anthropogenic influences on estuaries, habitat conservation and restoration, species management, and social science and economics.
- Revisit GRF priority research areas to update them as appropriate to reflect NERRS coastal management needs.
- Utilize SWMP data to drive hypothesis driven research within reserves and adjoining watersheds.

- Support ecosystem-based approaches to coastal research and management projects that incorporate adaptive management strategies to improve research efforts and applications.
- Design and regularly update a database that archives and tracks research projects within the NERRS that are supported by non-Section 315 NERRS funding (i.e. other NOAA monies, academic, NGO, external funding sources, etc.) and address priority coastal management and estuarine research needs.
- Improve current partnerships and explore new opportunities to leverage resources that support reserve priority research efforts.
- Facilitate research efforts between and across NERRS, both regionally and nationally, to address important coastal issues.
- Design a regional or national assessment of the NERRS that integrate research results from the reserves to determine if NERRS environmental conditions are improving or declining and why (i.e. a “report card” for the NERRS).

Research Goal 3: Scientists, educators, and coastal managers have access to NERRS datasets, science products and results.

Objectives:

1. Scientists are aware of available NERRS datasets and research products.
2. Biological monitoring data is available for academic scientists, coastal managers, and educators to use.

3. Data visualization products are available.

Strategies:

- Develop a useful and informative database for accessing past and current research projects, data, and resulting publications and products.
- Establish a data management strategy and database to support biological monitoring and land use/habitat information.
- Disseminate science through publications, outreach and technology transfer.
- Develop and implement appropriate communication tools to increase awareness of science conducted, data application, and data availability within the NERRS.
- Assess CDMO capabilities and needs in relation to expanding NERRS research and monitoring, data accessibility, and data visualization efforts.

Research 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.

Objectives:

1. Researchers and coastal managers identify priority resource needs that will improve research activities at the local, regional, and national scales.
2. Enhance the use of NERRS scientific data in coastal training, stewardship, and education programs within the NERRS.

3. The NERRS are increasingly recognized as a primary source of information about estuaries and coastal areas.

Strategies:

- Re-evaluate priority research needs biennially.
- Revise and update SWMP Plan based on NERRS research and monitoring needs.
- Conduct a SWMP External Review.
- Coordinate with education and outreach professionals early in the formation of research activities, where feasible, to target educational product development and dissemination from research activities.
- Provide science based information and training to individuals and organizations that make decisions about coastal resources on a regular basis in a professional or volunteer capacity.

- Improve the ability of restoration practitioners to restore and protect coastal ecosystems.
- Provide science based information to assist in the production and dissemination of educational materials and web based products that use science generated at the reserve.
- Provide science based information and training to citizens so that they can make informed decisions about protecting coastal resources through their own actions.

Appendices:

- A. NERRS SWMP Plan Executive Summary
- B. Regional NERRS research priority issues
- C. NERRS Strategic Plan (2005-2010)
- D. NERRS Site Profile Status
- E. Key milestones anticipated for achieving NERRS research goals

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Appendices

Appendix A: NERRS System wide Monitoring Program Plan Executive Summary

THE NATIONAL ESTUARINE RESEARCH RESERVE'S SYSTEM-WIDE MONITORING PROGRAM (SWMP): A SCIENTIFIC FRAMEWORK AND PLAN FOR DETECTION OF SHORT-TERM VARIABILITY AND LONG-TERM CHANGE IN ESTUARIES AND COASTAL HABITATS OF THE UNITED STATES

(Updated Spring 2006)

Executive Summary

Estuaries are among the most dynamic and productive environments known. They are transitional places where salt and fresh water mix and serve as nursery areas for numerous commercial fish and shellfish species. These habitats also act as rest stops for migratory birds, filters for pollution and buffers against coastal erosion. The high value that society places on estuaries for living, working and recreation has made these habitats among the most densely populated in the United States.

An increased awareness of estuarine degradation resulted in the passage of legislation aimed at protecting estuarine ecosystems. A landmark piece of legislation enacted by Congress was the Coastal Zone Management Act (CZMA) of 1972, which was the beginning of what became the National Estuarine Research Reserve System (NERRS). Currently, 27 reserves in 22 states and territories protect over 1.3 million acres of estuarine waters, wetlands and uplands. The NERRS was built on a foundation of partnerships among state

and federal agencies and community groups. The reserves have a management framework in place that links stewardship, public education and scientific research and thus provide an ideal vehicle to establish a nationally coordinated monitoring program.

In 1992, the reserve system proposed the establishment of a coordinated monitoring program that would attempt to identify and track short term variability and long term changes in the integrity and biodiversity of representative estuarine ecosystems and coastal watersheds for the purposes of contributing to effective coastal management. The initial phase of the NERR System wide Monitoring Program, known by its acronym SWMP (pronounced "swamp"), began in 1995. The initial focus was on monitoring a suite of water quality and atmospheric variables over a range of spatial and temporal scales. Water quality parameters measured include pH, salinity, conductivity, temperature, dissolved oxygen, turbidity and nitrate,

ammonia, ortho-phosphate, and chlorophyll a. Atmospheric parameters measured include temperature, wind speed and direction, relative humidity, barometric pressure, rainfall, and photosynthetic active radiation.

The purpose of the updated SWMP document is to lay out a revised scientific framework and plan for the NERR SWMP that will assist in guiding the program with the perspective gained over the past 10 years, for the next 10 years. It is not a static document, especially regarding costs and implementation details, but it portrays priority activities for ongoing and future SWMP efforts. This document describes a conceptual framework for NERR SWMP laying out the steps that will assist in addressing coastal management problems. Updates, including steps taken to expand abiotic monitoring within the reserves and initiate the second and third phases (e.g. biological monitoring and watershed and land use classifications) are included. In addition, the SWMP plan contains some general areas for future targeted monitoring including additional expansions of abiotic, biological and watershed/land use components (e.g., contaminant monitoring, monitoring of invasive species, conducting benthic/subtidal mapping, etc.).

The advantages of the NERRS monitoring program are that it:

- Provides an ecosystem-based network for understanding the temporal and spatial

variability of ecosystem components and their interactions.

- Provides a long-term database for the estuarine reserves' protected area network.
- Establishes a baseline for measuring changes in environmental conditions and ecological processes.
- Provides a research framework for evaluating ecosystem conditions and interpreting and predicting responses to change.
- Provides the basis for an ecosystem-based approach to managing coastal resources.

The scientific value of NERR SWMP data increases over time because it is through the collection of long-term data that subtle changes in environmental conditions are identified. This established monitoring program continues to be an opportunity to increase our understanding of how various environmental factors influence estuarine processes by collecting high-quality, long-term data.

By understanding how estuaries function and change over time, we can begin to predict how these systems respond to changes in climate and human-induced perturbations. Research is critical to the interpretation of monitoring results and for testing hypotheses generated by monitoring. Whereas monitoring determines whether and how

much the environment has changed from its reference state, research helps establish causal relationships. The reserve system's monitoring program, coupled with NERR-supported

research programs, provides a foundation for developing solutions to coastal management problems by answering how estuarine ecosystems change and why.

Appendix B. Regional NERRS Research Priority Issues

	REGIONS								
		NW Pacific	California	Caribbean	Northeast	Mid-Atlantic	Southeast Atlantic	Gulf of Mexico	Great Lakes
	Total Count (Rank Order)	Region Total (N = 3 sites)	Region Total (N = 3 sites)	Region Total (N = 1 site)	Region Total (N = 5 sites)	Region Total (N = 4 sites)	Region Total (N = 5 sites)	Region Total (N = 4 sites)	Region Total (N = 1 site)
Non-point source pollution	15	2	3	1	3	1	3	2	0
Hydrology	12	0	2	1	2	2	2	2	1
Nutrient studies	11	1	0	0	3	2	3	1	1
Restoration	11	1	3	1	2	1	2	1	0
Contaminants	10	1	1	0	2	1	3	1	1
Invasive Species	10	1	3	1	1	1	2	1	0
Sediment Transport / Processes	10	1	0	1	3	1	2	1	1
Physical Oceanography	9	2	0	1	2	1	2	1	0
Land Use (change/planning)	8	0	2	0	2	2	1	1	0
Other	8	0	0	0	3	2	0	3	0
Water Quality	7	1	3	0	2	0	1	0	0
Climate Change	6	0	0	0	3	1	1	0	1
Biodiversity	6	0	0	1	2	0	1	2	0
Energy Flow	4	0	0	0	1	1	1	0	1
Habitat Conservation	4	0	2	1	0	1	0	0	0
Plant/Animal Growth	4	2	0	0	1	1	0	0	0
Indicator Species	3	0	0	0	2	0	0	1	0
Cultural Resources	3	0	0	0	0	1	1	1	0
Human Impacts	3	0	0	0	1	1	0	1	0
Methodology Development	2	0	2	0	0	0	0	0	0
Plant/Animal Interactions	2	0	0	0	0	1	1	0	0
Management of Special Status Species	2	0	2	0	0	0	0	0	0
Storm Impacts	2	0	0	0	0	0	1	0	1
Sustaining Resources	2	0	0	1	0	0	1	0	0
Larval Transport	2	1	0	0	1	0	0	0	0
Community/Population Dynamics	1	0	0	0	1	0	0	0	0
Biological Oceanography	1	1	0	0	0	0	0	0	0

Appendix C: NERRS Strategic Plan (2005-2010)



vision | Healthy estuaries and coastal watersheds where coastal communities and ecosystems thrive.

mission | To practice and promote coastal and estuarine stewardship through innovative research and education, using a system of protected areas.

goals |

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.

Introduction

For thousands of years, coastal and estuarine environments have provided people with food, safe harbors, transportation access, flood control, and a place to play and relax. The pressures on the nation's coast are enormous and the impacts on economies and ecosystems are becoming increasingly evident. Severe storms, climate

change, pollution, habitat alteration and rapid population growth threaten the ecological functions that have supported coastal communities throughout history. As a network of 26 (soon to be 27) protected areas established for long-term research, education and stewardship, the National Estuarine Research Reserve

System has a unique role to play in keeping coastal ecosystems healthy and productive.

The reserve system is a partnership program between the National Oceanic and Atmospheric Administration and coastal states that has protected more than one million acres of coastal and estuarine habitat since the program was established by the Coastal Zone Management Act in 1972. NOAA provides funding, national guidance and technical assistance. Each reserve is managed on a daily basis by a lead state agency, non-profit organization or university with input from local partners. Through careful stewardship, innovative science and education, and relevant training programs, the reserves encourage careful management and protection of local estuarine and coastal resources.

The Coastal Zone Management Act created the reserve system to protect estuarine areas, provide educational opportunities, promote and conduct estuarine research and monitoring, and transfer relevant information to coastal managers. For the next five years, core reserve programs will focus on four priority topics:

- Impacts of land use and population growth;
- Habitat loss and alteration;
- Water quality degradation;
- Changes in biological communities.

The National Estuarine Research Reserve System's 2005-2010 Strategic Plan articulates how the strengths of the reserve system will be applied to address the major challenges of coastal management.

Priority Coastal Management Issues:

1. Land Use and Population Growth

The United States' exploding coastal population results in competing demands for clean water, beaches, recreational and commercial space, infrastructure and housing. In 2003, an estimated 153 million people lived in coastal counties, which is approximately 53% of the total US population. Pressure to develop land in coastal areas is escalating at more than twice the rate of population growth. Land use changes can significantly impact coastal and estuarine species and habitat. The Pew Ocean Commission reports that when more than 10% of a watershed is covered in impervious surface such as roads, roofs and parking lots, aquatic resources begin to degrade.¹

Coastal population and land use demands are not only increasing, they also are changing. Demographic and socio-economic trends show that the backgrounds and interests of people who are moving to the coast may be different from those of traditional fishing, commerce, or beach communities. The way people value and understand their relationship to the coast is reflected in the personal, political and professional choices they make. To make wise coastal resource management decisions, we need to understand the relationships among estuarine ecosystems and changing landscapes and attitudes. National Estuarine Research Reserves encourage the development and use of science based knowledge and tools in local land use planning, community development, and stewardship of public and private property.

2. Habitat Loss and Alteration

More than half of the nation's coastal wetlands have vanished since European settlement.² Estuarine and coastal environments continue to be altered and eliminated due to dredging, dams, recreational and commercial uses, flood and hazard mitigation, residential and infrastructure development, commercial port activities, and agriculture. Many of these activities disturb the physical, biological and chemical attributes of the estuary and therefore degrade the plants and animals that depend on the habitat to survive. Seagrass beds, marshes, shellfish, bird and fish populations can be affected by sedimentation, erosion, and hydrological, chemical or physical alteration of the habitat. Estuarine ecosystems also are vulnerable to coastal storms and sensitive to changes in climate and sea level. Coastal managers want to know more about how their choices influence coastal habitat and the species that live there. Better information will ensure that alternatives are considered for permitting, as well as planning and implementing successful restoration and mitigation efforts.³

Reserve research and monitoring programs increase the fundamental understanding of estuarine dynamics and add new information about the causes and consequences of changes in habitat quantity and quality. Research and stewardship programs at the NERRs also develop, implement and evaluate new techniques to restore and protect estuarine resources. Training programs and advisory services make this information available to professionals. Through education programs conducted at the reserves, students and citizens learn why these habitats are important and what they can do to keep them healthy.

3. Water Quality Degradation

Improving the condition of coastal water quality is a goal of the Coastal Zone Management Act and an ongoing struggle for all coastal regulatory agencies. Despite continuing local, state and federal investments, more than 20,000 beach closures were enforced in 2004 and more than 60% of estuarine waters were classified by the EPA as having degraded water in 2005.⁵ Excess nutrients and chemical and biological contamination can cause human health problems and threaten aquatic life.

The Reserve System has been collecting water quality data for ten years to quantify short term variability and long term changes in estuarine waters. Through monitoring and studying changes in water quality, the reserves investigate how human activity, weather patterns, and estuarine characteristics contribute to changes in water quality that affect ecological processes and, consequently, human health. Reserves apply the knowledge generated through research and monitoring to improve water quality through habitat protection, restoration, and training and outreach programs.

4. Changes in Biological Communities

Biological communities are changing as a result of invasive species, over-harvest, climate changes, pollution, and habitat destruction. Invasive species out-compete or consume native organisms; habitat alteration and destruction displace some species and create opportunities for others; and changes in parameters such as temperature and salinity can shift the distribution of plants and animals. Chemical contamination and nutrient enrichment damage habitat and can alter the structure of floral

and faunal communities. Over-harvesting biological resources also can change community structure and threaten valuable species. These problems impact natural interactions and linkages and lead to cascading indirect effects throughout the ecosystems.

Reserve research, stewardship, education, and training programs focus on understanding how changes in biological communities affect the way estuaries function. To minimize the negative impact of these changes, reserves investigate and communicate how to balance public needs with the protection of increasingly susceptible natural resources.

A Local Approach to National Priorities

Land use and population growth, water quality degradation, habitat loss and alteration, and changes in biological communities are not the only topics that reserves work on, but these four have risen to the top as deserving of adequate and strategic investment for the national system. These four topics are high priority science and training needs for coastal managers.³ Reserve scientists, educators and land

managers have identified these topics as locally and nationally important and appropriate to the mission of the National Estuarine Research Reserve System. Increased understanding about these topics will improve the reserve system's ability to protect and restore coastal watersheds and estuaries and empower individuals to make informed decisions. The nation's coasts and estuaries need to be managed, understood and appreciated at multiple scales. Through a network of locally oriented programs around the country, the reserve system provides insight into common information and management needs as well as data for use by local, regional and federal scientists and decision makers. Working at both the site level and as a national system, reserves have a greater impact than could be achieved through community efforts alone.

The goals, objectives and strategies outlined in this strategic plan will guide and support the National Estuarine Research Reserve System in its nation-wide efforts to improve coastal management, advance estuarine research, and educate current and future generations of coastal stewards.

Guiding Principles

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

Goal One:

Strengthen the protection and management of representative estuarine ecosystems to advance estuarine conservation, research and education.

Objectives:

1. Biogeographically and typologically representative estuarine ecosystems are protected through the designation of new reserves.
 2. Biological, chemical, physical, and community conditions of reserves are characterized and monitored to describe reference conditions and to quantify change.
 3. Reserve ecosystems are conserved through land acquisition, natural resource management and restoration.
- Collect baseline information about the biological, physical, chemical, and socio-economic parameters of reserve biological and human communities.
 - Integrate NERRS monitoring, data management, education and training capabilities in regional ocean observing systems.
 - Implement land acquisition plans to enhance the long term integrity and diversity of reserve habitats.

Strategies:

- Identify and designate new reserves consistent with system-wide policy and available resources.
- Collect system-wide measurements of the short-term variability and long-term changes in the water quality, biotic communities and diversity, land-use and land cover characteristics of estuarine ecosystems to support effective coastal zone management.
- Restore and actively manage reserves' natural resources to meet local habitat and human use goals.
- Work collaboratively with other programs to evaluate and apply advanced technologies and tools to support effective coastal management.
- Provide facilities and support to manage the natural resources within reserve boundaries.

Goal Two:

Increase the use of reserve science and sites to address priority coastal management issues.

Objectives:

1. Scientists conduct estuarine research at reserves that is relevant to coastal management needs.
 2. Scientists have access to NERRS datasets, science products and results.
 3. The scientific community uses data, tools and techniques generated at the NERRS.
- Disseminate reserve science through publications, outreach and technology transfer.
 - Generate time-series data and empirical studies to describe the ecological condition of reserve habitats.
 - Promote reserve science products through web sites, communication materials, and other avenues to meet the needs of diverse stakeholders.

Strategies:

- Understand coastal decision maker science and training needs through needs assessments, coastal management science needs surveys, etc.
- Work collaboratively with other programs to conduct research on priority management issues in the reserves.
- Offer Graduate Research Fellowships to master's and doctoral students to conduct science that is relevant to coastal management and to train students in estuarine science.
- Deliver monitoring and observation data to the scientific community.
- Increase visibility and reinforce the credibility of NERRS science through communication efforts about NERRS research and monitoring.
- Attract scientists and practitioners to use reserves as reference sites.
- Conduct and facilitate relevant research in reserve watersheds.
- Synthesize reserve data into information for use in decision making.
- Conduct and facilitate research into education effectiveness and behavior change.
- Ensure that reserves have facilities and research support to meet the needs of visiting scientists and staff.

Scientist:

A person who uses principles and procedures for the systematic pursuit of knowledge involving the recognition and formulation of a problem, the collection of data through observation and experiment, and the formulation and testing of hypotheses.

Goal Three:

Enhance people's ability and willingness to make informed decisions and take responsible actions that affect coastal communities and ecosystems.

Objectives:

1. People are aware of the ecological, economic, historical, and cultural importance of estuarine resources.
2. People understand how human choices and natural disturbances impact social, economic, and estuarine ecological systems.
3. People apply science-based information when making decisions that could impact coastal and estuarine resources.

Strategies:

- Provide educational opportunities that increase students' understanding of estuarine science and technology.
- Implement and participate in public programs and events to raise awareness and understanding about estuaries and the NERRS.
- Produce and distribute educational materials and web-based products that raise public awareness about estuaries, the NERRS, and NERRS education products.
- Train teachers to educate students about coastal watersheds and estuaries.
- Deliver monitoring and observing data to diverse user groups in a useful format.
- Improve the willingness and ability of communities to restore and protect coastal ecosystems.
- Provide science-based information and training to individuals and organizations.
- Assist restoration practitioners in developing and applying effective restoration techniques.
- Implement volunteer programs to engage local citizens in advancing the goals of the reserves.
- Conduct programs to encourage people to make personal choices that reduce their impact on coastal resources.
- Evaluate programs to determine how people apply information and knowledge.
- Build and maintain educational facilities and interpretive displays.

Appendix D. NERRS Site Profile Status

Sites completed profile		Sites planning profile	
	<i>Year published</i>		<i>Anticipated publication year</i>
ACE Basin, SC	2001	Apalachicola Bay, FL	2006
Delaware	1999	Chesapeake Bay, MD	2008
Elkhorn Slough, CA	2002	Chesapeake Bay, VA	2007
Great Bay, NH	1992	Grand Bay, MS	2006
Jobos Bay, PR	2002	Guana-Tolomato-Matanzas, FL	2006
Kachemak Bay, AK	2003	Jacques Cousteau, NJ	2007
Old Woman Creek, OH	2004	Narragansett Bay, RI	2007
Rookery Bay, FL	2003	North Carolina	2006
Sapelo Island, GA	1997	North Inlet-Winyah Bay, SC	2006
Tijuana River, CA	1992	Padilla Bay, OR	2007
Waquoit Bay, MA	1996	San Francisco Bay, CA	2007
Weeks Bay, AL	1996	South Slough, OR	2006
Hudson River, NY	2006	Texas-Mission Aransas	2009
		Wells, MA	2006

Appendix E. Key milestones anticipated for achieving NERRS research goals

Research Goal	Milestones*	Products*	Y1	Y2	Y3	Y4	Y5
1. Biological, chemical, physical, and ecological conditions of reserves are characterized and monitored to describe reference conditions and to quantify change.	Site Profiles completed	3 site profiles/year	x	x	x	x	x
	Revise SAV/Emergent Biomonitoring protocol	Updated protocol	x				
	Summarize initial SAV/Emergent Biomonitoring projects	Synthesis document	x	x			
	Implement NERRS Habitat Classification System	At least 3 sites employ/year	x	x	x	x	x
	Develop a NERRS Remote Sensing Strategy	NERRS remote sensing guidance document	x	x			
	Integrate NERRS monitoring data with national and regional IOOS efforts	Partners use NERRS real-time and archived data	x	x	x	x	x
2. Scientists conduct estuarine research at reserves that is relevant to coastal management needs and increases basic understanding of estuarine processes.	Revise Graduate Research Fellowship (GRF) priority research areas	Updated GRF focal areas	x	x			
	Revise NERRS Research Database that archives and tracks research projects with the NERRS	Functional NERRS Research Database	x				
	Populate NERRS Research Database with research projects that are occurring or have occurred in the recent past (5 years) at reserves	Current, ongoing, and past research projects with NERRS are archived	x	x	x	x	x
	NERRS works with CICEET to improve coordination and delivery of relevant science	NERRS research products are accessible, CTP workshops deliver information to broad user audiences	x	x	x	x	x
	Complete a regional and/or national assessment of NERRS environmental conditions	A NERRS "Report Card" document			x	x	
3. Scientists have access to NERRS datasets, science products and results.	CDMO capabilities are assessed in relation to expanding NERRS data collection and delivery needs	CDMO and ERD identify options to manage increasing data loads and data visualization needs	x	x	x		
	NERRS Research Database is available for public access online	Searchable database of research projects is available online for public access/information	x	x			
	A NERRS Special Journal Issue is published to highlight biological monitoring and research in the field	Published Special Journal Issue		x			
	A NERRS Special Journal Issue is published to highlight NERRS Habitat mapping/Land use change monitoring and remote sensing research	Published Special Journal Issue					x
	Develop a method to deliver biological monitoring and habitat mapping information to the public through CDMO	Biomonitoring information and habitat maps are made available to the public	x	x	x		
4. The scientific, coastal management and education communities, as well as the general public, use data, products, tools, and techniques generated at the NERRS.	Regularly evaluate NERRS Research priority needs	Up-to-date NERRS research priorities		x		x	
	Revise and update SWMP Plan	Revised SWMP Plan	x	x			
	Conduct a SWMP External Review	Evaluated program to guide future development	x	x			

* Some milestones and products will require additional resources.

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