

National Estuarine Research Reserve System Research and Monitoring Plan 2012-2017

Introduction

The National Estuarine Research Reserve System (NERRS), established by the Coastal Zone Management Act of 1972, is a network of 28 reserves dedicated for long-term place-based research, monitoring, education, and resource stewardship to address coastal management issues affecting our nation's estuaries. The NERRS operates as a partnership program between the National Oceanic and Atmospheric Administration (NOAA) and the coastal states and territories. NOAA's Estuarine Reserves Division (ERD) provides funding, national guidance, and technical assistance, while the states provide matching funds, personnel, program implementation, and managerial oversight. Each reserve is managed on a daily basis by a lead state agency or university, with input from local partners. The partnership program between NOAA and the coastal states and territories protects more than 1.3 million acres of estuarine land and water that provide essential habitat for wildlife; offer educational opportunities for students, teachers and the public; and serve as living laboratories for research and education.

The NERRS has developed this *2012-2017 Research and Monitoring Plan* (Research and Monitoring Plan or Plan) to provide strategies for ensuring the coordination of the long-term research goals of the NERRS, as identified in the *2011-2016 NERRS Strategic Plan* (NERRS Strategic Plan), with the local and regional priorities of the reserves, as identified in each reserve's Management Plan. The Plan provides a mechanism for addressing coastal management issues through research and monitoring activities that can be directed by a set of key questions and implemented by a set of focused strategies. These key questions and associated strategies build upon existing capacity in the NERRS, while providing opportunities for growth and expansion. This Research and Monitoring Plan is intended for all NERRS sectors and associated communities, but will primarily provide guidance on research and monitoring priorities for individual reserves, NOAA, ERD, and federal, state, and local partners currently working or seeking to work with the NERRS on research and monitoring to support coastal management.

The Plan revises and replaces the *2006 -2011 NERRS Research and Monitoring Plan*. The 2006 - 2011 Plan identified four research goals and associated milestones related to characterization of reserve ecosystems, supporting coastal management decision and fundamental estuarine science, making NERRS data and science products available to users, and increasing use of data and products by the scientific, coastal management and education communities. Virtually all of the milestones associated with the goals have been met (Appendix I), although there is still progress to be made related to habitat mapping at the reserves. The *2012-2017 Research and Monitoring Plan* will build upon these accomplishments.

Several NERRS science plans support this Research and Monitoring Plan and its relevance to the *NERRS Strategic Plan* (Figure 1). The *2011 NERRS System-wide Monitoring Program Plan* (SWMP Plan) provides detailed information about the NERRS' capacity to conduct monitoring, and is

structured around questions that provide a framework for a NERRS monitoring program that is adaptable to a wide variety of coastal management issues. The SWMP Plan also requires that explicit plans for education, outreach, and data translation be incorporated into NERRS research and monitoring activities and these can be compiled as “Application Modules” designed to address specific management issues or to answer specific research questions. Another NERRS internal planning document, the *2010 NERRS Climate Change Initiative*, builds on the NERRS 2008 Climate Change Plan and provides a framework for the NERRS to understand the impacts of climate change, to adapt to climate-induced changes, and to mitigate climate change impacts through greenhouse gas reduction and carbon sequestration. Reserve Management Plans provide detailed information about each reserve’s research programs, and the development of these plans is guided by local and regional issues as well as by system-wide priorities.

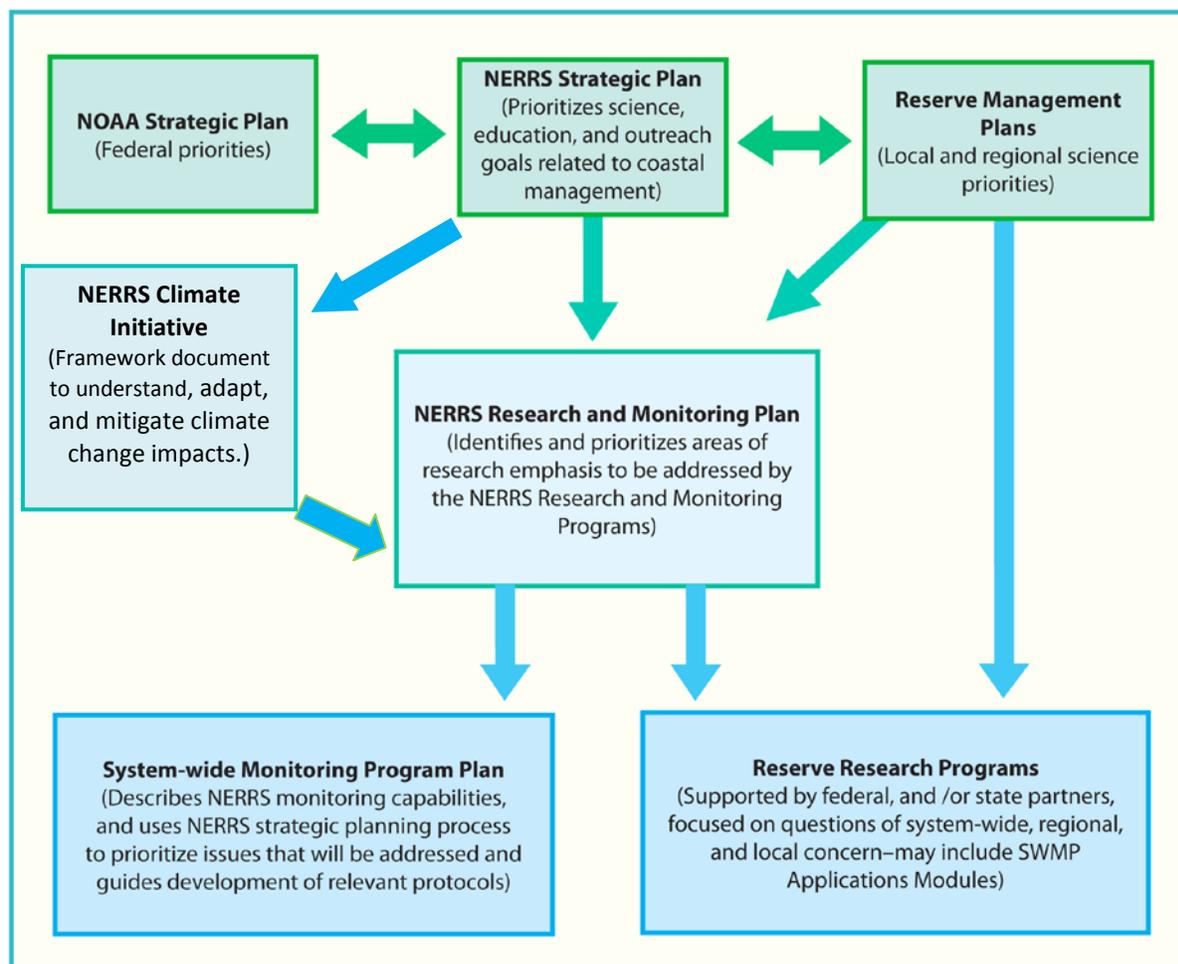


Figure 1. Relationships between the NERRS Research and Monitoring Plan and other NERRS planning documents and science programs.

Background

This Plan has been developed by a working group of NERRS Research, Education, Stewardship, and Coastal Training Program Coordinators, Reserve Managers, and ERD staff. The NERRS

community also provided input. The Plan is based on research and monitoring that are supported by several NERRS programs (Appendix II), including the NERRS Graduate Research Fellowship Program and the NERRS Science Collaborative. Although these and other system-wide programs support NERRS research and monitoring, this Plan was written with the understanding that the supporting programs and their available resources may change as priorities for federal funding and state budgets change. Consequently, the ability to adjust the scope of NERRS research and monitoring efforts is essential to a successful and responsive research and monitoring program, and this Research and Monitoring Plan should be considered a living document that may be refined to reflect evolving national research efforts that are primarily implemented at local to regional scales.

Relationship to the NERRS Strategic Plan

The Research and Monitoring plan complements and supports the NERRS Strategic Plan, which states the following vision and mission:

Vision: Resilient estuaries and coastal watersheds where human and natural communities thrive.

Mission: To practice and promote stewardship of coasts and estuaries through innovative research, education, and training using a place-based system of protected areas.

The *2011- 2016 NERRS Strategic Plan* identifies three strategic areas of focus and investment that are also the priority focus areas of this Research and Monitoring Plan:

- Climate change,
- Water quality, and
- Habitat protection.

The NERRS Strategic Plan also proposes the following Goals:

- Protected Areas: Estuaries and coastal watersheds are better protected and managed by implementing place-based approaches at reserves;
- Science: NERRS scientific investigations improve understanding and inform decisions affecting estuaries and coastal watersheds; and
- People: NERRS education and training increases participants' environmental literacy and ability to make science-based decisions related to estuaries and coastal watersheds.

Although the Goals of the NERRS Strategic Plan are intended to crosscut all NERRS programmatic sectors (Stewardship, Research, Education, and Coastal Training), the Science Goal and its associated objectives provide specific guidance for this Research and Monitoring Plan. The Objectives associated with the Science Goal of the NERRS Strategic Plan are:

1. Expand capacity to monitor changes in water quality and quantity, habitat, and biological indicators in response to land use and climate change drivers.
2. Improve understanding of the effects of climate change and coastal pollution on estuarine and coastal ecology, ecosystem processes, and habitat function.

3. Characterize coastal watersheds and estuary ecosystems and quantify ecosystem services to support ecosystem-based management of natural and built communities.
4. Increase social science research and use of social information to foster coastal stewards that value and protect estuaries.

Priority Issues for the 2012- 2017 Research and Monitoring Plan

Over the next five years, NERRS research and monitoring will build upon the goals and objectives of the *2011- 2016 NERRS Strategic Plan* by increasing capacity across the reserves to understand how climate and other natural and anthropogenic stressors within reserve watersheds affect coastal ecosystems, and how this information can address complex coastal management issues. Specifically, this Research and Monitoring Plan identifies Climate Change, Water Quality, and Habitat Protection as focus areas for NERRS research and monitoring efforts, and to advance the Science Goal and associated Objectives of the NERRS Strategic Plan. The Research and Monitoring Plan is designed to be comprehensive in scope so that it addresses system-wide priorities, but it also allows priorities identified in Reserve Management Plans to be incorporated. Seventy-five percent of the reserves identified some aspect of water quality or habitat protection among their highest research priorities, while sixty percent included some aspect of climate change. Seventy-five percent characterized two of the three focus areas as high priority.

The priorities that structure this Plan will be accomplished by augmenting and developing existing NERRS research and monitoring programs and working to find external support and partners for regional and site-specific research at reserves. There are several NERRS programs that will help accomplish these priorities (Appendix II). For example, the NERRS Science Collaborative will provide foundational information that can be developed and expanded to address related coastal management questions and issues of concern. Additionally, projects undertaken as part of the NERRS Climate Change Initiative will provide insights into the climate and anthropogenic stressors that impact reserves and can be used to inform studies related to ecosystem and habitat protection and water quality degradation. There are also partnership and funding opportunities for conducting research and monitoring within the Reserves that may arise outside of ERD. In NOAA's National Ocean Service (NOS), the National Centers for Coastal Ocean Science (NCCOS) is working to increase partnerships by providing funds for their scientists to work with other NOS offices, including Ocean and Coastal Resource Management (OCRM). The NOAA Climate Program Office (CPO) also supports projects that can be implemented through its regional offices, and NOAA Sea Grant and the NOAA Environmental Cooperative Science Centers are active in creating research and education partnerships in several states. All of these activities support the Objectives that are associated with the Science Goal of the NERRS Strategic Plan.

Social science is a fundamental component of the programs described above, and the implementation strategies developed in this Plan are designed to help build capacity to conduct and use social science to engage the public and to address local coastal management issues. Concerted efforts will be made to incorporate relevant social science disciplines into existing programs and projects such as the NERRS GRF program, as well as when new projects and

programs are being developed. Where appropriate, research and monitoring will be integrated with education, stewardship, and coastal training activities in the NERRS, and will also draw on established partnerships within NOAA (e.g., those with the NOAA CPO, Coastal Services Center (CSC), National Geodetic Service (NGS), Center for Operational Oceanographic Products and Services (CO-OPS), and NCCOS). By working closely with other sectors, Research Coordinators will include relevant estuarine research and data in reserve professional training and education programs. The translation and communication of research and monitoring data and products provides important links to coastal managers, educators, and other stakeholders who ultimately influence decisions about environmental management of coastal resources.

Research and Monitoring Priority Focus Areas: Key Questions and Implementation Strategies

This Research and Monitoring Plan will focus on monitoring and research to investigate Climate Change, Water Quality, and Habitat Protection in the NERRS, which are the three strategic areas of focus and investment that have been identified in the *NERRS 2011 – 2015 Strategic Plan*. Each of these focus areas is supported by a set of key questions that relate directly to the NERRS Strategic Plan Objectives and to research priorities identified in reserve management plans. These key questions were developed through input from the reserve system, and are intentionally broad to allow incorporation of the diverse priorities of NOAA, the NERRS, and the reserves. They provide a framework for Implementation Strategies that: (1) can be connected back to the NERRS Strategic Plan Science Goal, (2) draw on the existing capacity found in NERRS programs and professional expertise, and (3) can be accomplished with existing resources, while allowing additional resources to be pursued through collaboration and partnerships. The anticipated milestones and accomplishments associated with each of the Implementation Strategies are listed below.

Key Questions

Climate Change: How are the dominant physical, ecological, and socio-demographic attributes that characterize reserves and their targeted watersheds affected by climate change?

Water Quality: What is the status of water quality in reserves? What are the natural and anthropogenic drivers that are causing water quality changes? What are the impacts of those changes on reserve ecosystems, including their associated human communities?

Habitat Protection: What is the magnitude and variability of ecosystem change in reserve targeted watersheds and their critical habitats? What are the relative influences of environmental and anthropogenic drivers in initiating and sustaining these changes? How do reserve ecosystems and reserve habitats respond to ecosystem change?

Implementation Strategies

The following five Strategies describe an approach for addressing the focus areas and key questions mentioned above. They take advantage of programmatic infrastructure that is already in place, as well as the existing resources and partnerships that are available to the NERRS (Appendix II). The key questions cannot be addressed in isolation, and addressing them

will require integration of research and monitoring efforts across the five Strategies. In addition, SWMP will be critical to answering the key questions and will serve as the basis for attracting additional research within the reserves. The Strategies will also draw upon the expertise and capacity of other reserve sectors to ensure that outreach, education, and training are integral components of research and monitoring activities from the beginning. Because resource constraints may limit full implementation of the Plan, the Strategies described below are designed so that additional resources can be pursued to fill gaps through collaboration and partnerships. To provide explicit linkages to the *2011-2016 NERRS Strategic Plan*, the most relevant Objectives that support the Science Goal are indicated in parentheses. Relationships to the Protected Places and People goals are also noted in the supporting text.

Strategy 1: Increase the capability and the use of reserves as living laboratories to enhance and expand site specific research, by increasing the quantity, depth, and/or breadth of scientific investigations that improve understanding and inform decisions affecting estuaries and coastal ecosystems (1, 2, 3, 4).

By leveraging resources associated with SWMP (including Sentinel Site, Habitat Mapping, and Biological Monitoring activities), the NERRS GRF Program, and the NERRS Science Collaborative, and by obtaining funding from sources and partnerships outside of NERRS and NOAA, reserves will develop new projects, refine existing projects, and/or pilot common protocols related to major research and monitoring activities. The NERRS GRF Program is a key asset in reaching university and academic audiences for the NERRS, and it provides a valuable training ground for future estuarine scientists and coastal zone management professionals. The GRF program also presents great opportunities for integrating sectors in reserve research and monitoring activities. Reserves will work with ERD and GRF fellows to encourage research projects that are closely tied to reserve management plans and reserve priorities, and that incorporate natural and social science elements.

Reserves will work to update their habitat maps by using protocols described in the *NERRS Habitat Mapping and Change Plan* and associated protocol documents, and, where appropriate, will augment existing vegetation monitoring protocols with protocols for monitoring for ecotones and changes in vegetation boundaries. Other activities that might support this Strategy include developing SWMP modules for understanding impacts of eutrophication, conducting restoration science, and monitoring and mitigating invasive species effects on coastal ecosystems.

Restoration science has been a priority for the NERRS for over twenty years. A 2002 NERRS Restoration Science Strategy articulates an approach for conducting restoration science and long-term monitoring based on stakeholder-driven research needs. The delivery of science to restoration practitioners is also a priority of the NERRS Coastal Training Program. The NERRS will continue to explore opportunities to address science needs of restoration stakeholders by delivering reference site data generated by SWMP, investigating the interaction of climate change on restoration strategies, and monitoring and investigating invasive species trends and associated restoration strategies. The NERRS will focus existing capacity and existing research

and seek outside funding opportunities to address these and other science and training needs identified by restoration stakeholders, and the NERRS Education and Coastal Training Program Coordinators will work closely with the Research and Stewardship Coordinators to transfer and communicate best science practices and research results.

Reserve-specific research activities have been identified in management plans and support for these activities may come from a variety of sources. For example, some reserves have been funded by NOAA ERD to initiate vegetation monitoring for marsh, mangrove, and/or SAV, and some have combined their own resources with those of state, local, and federal partners to augment their work and to delineate and characterize critical habitats within the reserve boundaries using high resolution mapping.

In support of these and other activities that build upon system-wide planning and NERRS initiatives, reserves will continue to expand their research and monitoring programs by working with other reserves, and with federal, state, and local partners to obtain funding and other support for science. For example, research activities such as plankton and marsh bird monitoring have been successfully initiated on a reserve-by-reserve basis through partnerships with NOAA, other reserves, and state and local partners. Research Coordinators will also work with their NERRS colleagues in the Coastal Training Program, and Stewardship sectors to incorporate outreach, and stewardship activities into reserve research and monitoring efforts as new projects are developed and existing project activities are augmented and enhanced.

This strategy supports and helps advance the objectives and strategies under the People and the Protected Places Goals of the NERRS Strategic Plan. In particular, the research and monitoring that takes place at reserves can be incorporated into reserve education programs. This will enhance the capacity and skills of teachers and students to understand and use NERRS data and information for inquiry-based learning. Education research is a field of inquiry aimed at advancing knowledge of education and learning processes and development of the tools and methods necessary to support this endeavor (The American Educational Research Association, <http://www.aera.net>). Although the NERRS does currently not have the resources to support this activity at a system-wide level, education research is an area where the NERRS can make progress toward enhancing the capacity and skills of teachers and students to understand and use NERRS data and information for inquiry-based learning. By incorporating education research into the NERRS K-12 Estuarine Education Program (KEEP), NERRS educators will develop a better understanding of how teachers and students learn about estuarine environments, coastal watersheds, and coastal management issues. This understanding will help the NERRS educators work with NERRS researchers to develop better tools and methods for integrating field-based estuarine science, SWMP data, and technology oriented approaches to education.

Strategy 2: Build upon results and relationships developed by NERRS Science Collaborative projects to continue to connect scientists with intended users to address coastal management issues related to land use change, habitat change and restoration, and management of stormwater and nonpoint source pollution (1,2,4).

NERRS Science Collaborative projects (Appendix III) incorporate collaboration and applied science to address a coastal management problem that has been identified as a priority for a Reserve and the communities that it serves. Projects address the influence of climate change on at least one of the following topics: impacts of land use change, habitat change and restoration, management of stormwater, and nonpoint source pollution. These topics are relevant to each of the key questions, and the portfolio of funded NERRS Science Collaborative projects creates a foundation that can support continued research and management at participating reserves, or by new partners and other reserves, as well as transferability among reserves and their research and management communities. Several projects funded by the NERRS Science Collaborative have social science research components.

In addition to supporting the Science Goal of the NERRS Strategic Plan, the NERRS Science Collaborative project will also support the Protected Places Goal by furthering the development, demonstration, and evaluation of tools and practices that will advance progress on habitat protection, improving water quality, and understanding climate change impacts. This strategy also supports the People Goal by improving the capacity and skills of coastal decision makers to use and apply science-based information in decision-making. Over the next five years, the reserves will build upon the successes of the NERRS Science Collaborative and utilize the products and outcomes of the funded projects to further develop partnerships and to seek support for related activities.

Strategy 3: Use the results of the NERRS Climate Sensitivity Analysis to inform periodic data syntheses, analyses of water quality and habitat change, and other research projects that examine the interactions between climate and non-climate related environmental stressors at local and regional scales and their effects on reserve estuaries, watersheds, and communities (1,2,3,4).

The reserves and ERD are working in partnership with the NERRS Climate Sensitivity Analysis project team (NOAA NCCOS and the University of Wisconsin) to (1) analyze and synthesize the best available information and data that describe the physical, ecological, and socio-demographic attributes of the reserves within their targeted watershed, (2) identify the dominant climate and anthropogenic stressors that impact the reserves, and (3) categorize groups of reserves based on their key attributes and sensitivities to the aforementioned stressors. This climate sensitivity categorization will provide a foundation for future strategic investment in comprehensive place-based studies and vulnerability assessments, and for classifying individual reserves on the basis of their dominant attributes and stressors.

NERRS research activities will use the outcomes of the Climate Sensitivity Analysis to guide future research planning and interpretation of monitoring data and research project results. Research and monitoring will build upon the information provided about fundamental relationships between reserve-specific stressors and SWMP data to develop hypotheses about stressor impacts on reserve habitats and ecosystems and to guide the placement of additional monitoring infrastructure and the focus of new research projects Reserve-specific data analyses

may also provide valuable information about the effects of climate and non-climate stressors on reserve ecosystems. Reserve research programs, along with coastal training, stewardship, and education, will utilize the results of the sensitivity analysis to better understand and communicate how reserve ecosystems and human communities are changing and what adaptation and restoration strategies may be possible. This Strategy also supports the People Goal of the NERRS Strategic Plan by improving the capacity and skills of coastal decision makers to use and apply science-based information and the People Goal by developing tools that advance progress on habitat protection, water quality, and climate change impacts.

Strategy 4: Increase capacity for reserves to contribute to a NERRS Sentinel Sites Network by establishing monitoring and research projects that use reserves as sentinel sites for detecting and understanding the effects of climate change on estuaries (1, 2, 4).

The NERRS will continue to work in partnership with NOAA to support the NOAA Sentinel Site Program, which is presently focused on monitoring and assessing the impacts of changing water levels and altered inundation patterns on coastal ecosystems. As part of this effort, ERD and its partners in NGS and CO-OPS will provide guidance and support for training of staff, installation of infrastructure, and interpretation of data to build-out a NERRS Sentinel Sites Program (NERRS SSP)(Appendix II). This support will be in the form of leveraging existing NOAA resources in training and expertise, and building partnerships with state and regional experts.

The NERRS SSP is initially focused on changes in sea level and effects on marsh and submerged habitats. As resources and funding allow, the NERRS SSP will be expanded by building capacity in reserves where there are existing monitoring capabilities and where the NERRS and NOAA investments can be leveraged most successfully. The NERRS SSP will link SWMP stations and biological monitoring activities to form a network of specialized infrastructure that will allow precise measurements of the impacts of changing coastal water levels on key habitats (i.e., marshes, mangroves, and submerged aquatic vegetation), and to better understand the underlying processes and impacts of changing inundation patterns on coastal ecosystems and coastal communities. In the future, with appropriate resources, the NERRS SSP could be applied to other relevant coastal management issues such as eutrophication, or invasive species.

By linking Sentinel Sites research and monitoring information to climate models relevant to coastal and near shore environments, the NERRS SSP will provide valuable insights into reserve vulnerabilities to climate change. For example, the effects of changing inundation patterns and freshwater input on vegetated communities will be investigated at some reserves by monitoring movement and spatial extent of ecotones and vegetation transition zones. In other reserves, where water levels are not the primary drivers, other factors such as nutrient concentrations and loading, and invasive species may be considered. By including the appropriate strategies for data dissemination, education, and outreach in the early stages of planning, NERRS Sentinel Sites will provide information that can help increase the understanding of coastal communities and coastal managers to climate change impacts and vulnerabilities and will also contribute to the development and demonstration of tools and

practices at reserves that advance progress on habitat protection, water quality, and climate change impacts, which is an Objective of the Protected Places Goal.

Strategy 5: Build NERRS capacity to conduct social science research and to integrate this research with ongoing research and monitoring programs to address coastal management issues. (1,2,3,4)

The NERRS will work to more fully integrate relevant social science disciplines with existing natural science research and monitoring that builds upon the results of ongoing work. For example, it is anticipated that researchers in the behavioral sciences can use the products of NERRS research programs to provide new insights about socio-economic influences on coastal habitats. The NERRS Climate Sensitivity Analysis has a significant socio-demographic component that will explicitly engage researchers in the analysis and synthesis of sociological data that is relevant to the NERRS. The socio-demographic information and analysis developed by the Climate Sensitivity Analysis Project will provide a wealth of foundational information about the sensitivity of reserve communities to climate change, and can inform the development of other social and ecological investigations. The NERRS GRF Program will increase participation in social science research at the reserves by funding graduate research that enhances relationships with inter-disciplinary programs that focus on the interplay of social and ecological issues impacting coastal habitats and communities. The NERRS Science Collaborative will also build the capacity to conduct and integrate social science research by explicitly incorporating social science into its collaborative research approach through the support of Training for the Integration of Decisions and Ecosystems Science (TIDES) students who matriculate through this program and are actively working with reserve staff on projects at the reserves.

Additionally, the NERRS CTP Coordinators utilize tools such as evaluations, program feedback, informal conversations, and collaborative learning frameworks to effectively communicate research outcomes to decision makers which are activities that support the People Goal. The NERRS CTP will be integrally involved in the use of these tools to develop products from the NERRS research and monitoring to inform coastal managers about the types of stressors and environmental drivers that cause changes in reserve watersheds, habitats, and natural communities, which will increase the understanding of climate change impacts and vulnerabilities and will also contribute to the development and demonstration of tools and practices at reserves that advance progress on habitat protection, water quality, and climate change impacts and support the Protected Places Objective of the NERRS Strategic Plan.

In order to better meet the needs of the coastal management community, the NERRS focus areas and research programs need to be expanded. While expansion of the NERRS Research and Monitoring program into new areas and disciplines may not be feasible at this time due to limited resources, the discipline of social science research is a priority for future efforts, and will be pursued as opportunities arise and resources become available.

The Reserve System values social science research as a means to understand, predict, and influence how individuals, municipalities, and states interact with coastal natural resources.

However, the implementation of a social science research program faces two key challenges. These challenges are resource constraints in terms of time, staff, and funding, and the lack of a robust expertise network in the social sciences that uses reserves as platforms for research in their disciplines. To overcome these constraints and build a robust network based on mutual interests and benefit, the NERRS will identify the attributes of reserves and the Reserve System that are attractive to researchers conducting applied work in social science disciplines. This information will be coupled with reserve management priorities to allow the NERRS to be more strategic about building positive relationships with researchers that address coastal management priorities. There have been previous efforts to expand the GRF program to include fellows whose projects specifically address social science issues and employ social science research methodologies and protocols. A pilot social science GRF program was conducted in FY2007, funding five students in partnership with NOAA's CSC and CPO. The current NERRS GRF call for proposals specifically invites social science research topics. When possible, the NERRS will continue to promote social science as a fundamental discipline supported by the GRF Program.

Milestones and products associated with Implementation Strategies (anticipated for 2012-2017).

Strategy 1: Increase the capability and the use of reserves as living laboratories to enhance and expand site specific research, by increasing the quantity, depth, and/or breadth of scientific investigations that improve understanding and inform decisions affecting estuaries and coastal ecosystems

- Milestone: New research and monitoring projects, products, tools, and protocols are developed by NERRS researchers and NERRS partners
 - Product: New research and monitoring products, tools, and protocols
- Milestone: A NERRS Special Journal Issue is published to highlight recent advances in NERRS monitoring and research
 - Product: Published Special Journal Issue
- Milestone: A formative evaluation is conducted to assess NERRS research priorities
 - Product: Report on NERRS research priorities
- Milestone: The 2011 SWMP Plan is revised and updated
 - Product: Revised SWMP Plan
- Milestone: NERRS researchers collaborate with NERRS educators to develop SWMP data, products, tools, and protocols to support the scientific, coastal management, and education communities, as well as the general public.
 - Product: New monitoring data supported educational tools and products are developed and used by NERRS educators

Strategy 2: Build upon results and relationships developed by NERRS Science Collaborative projects to continue to connect scientists with intended users to address coastal management issues related to land use change, habitat change and restoration, and management of stormwater and nonpoint source pollution

- Milestone: Results and outcomes of NERRS Science Collaborative Projects are summarized.
 - Product: NERRS Science Collaborative Synthesis and Report
- Milestone: Partnerships and outcomes from NERRS Science Collaborative projects are part of new collaborations.
 - Product: New projects that connect scientists with intended users and use key results from NERRS Science Collaborative projects.

Strategy 3: Use the results of the NERRS Climate Sensitivity Analysis to generate periodic data syntheses, analyses of water quality and habitat change, and other research projects that examine the interactions between climate and non-climate related environmental stressors at local and regional scales and their effects on reserve estuaries, watersheds and communities

- Milestone: Reserve-specific analyses of climate sensitivity are developed
 - Product: Peer reviewed publications
 - Product: Reserve-specific reports
 - Product: Synthesis document
 - Product: Web-enabled GIS -based sensitivity maps of reserves
- Milestone: Reserve research programs, along with coastal training, stewardship, and education programs, utilize the results of the NERRS Climate Sensitivity Analysis
 - Product: Climate sensitivity and vulnerability training or K-12 education modules based on products from NERRS Climate Sensitivity Analysis.
 - Product: Place-based research projects that support graduate student research focused on understanding climate impacts on coastal ecosystems and communities

Strategy 4: Increase capacity for reserves to contribute to a NERRS Sentinel Sites Network by establishing monitoring and research projects that use reserves as sentinel sites for detecting and understanding the effects of climate change on estuaries.

- Milestone: Reserves participate in NOAA Sentinel Sites Cooperatives
 - Product: NOAA SS Cooperative Implementation Plans involving partnerships with four or more reserves
- Milestone: Reserves develop and implement NERRS Sentinel Sites Program Plans
 - Product: Four NERRS Sentinel Site Program Plans produced by reserves
 - Product: Climate training and/or education modules based on information produced by NERRS Sentinel Sites
- Milestone: Reserves increase operational capacity to function as NERRS Sentinel Sites, according to guidance developed in the 2012 NERRS Sentinel Sites Guidance document.
 - Product: A full complement of sentinel sites monitoring infrastructure, installed at three reserves

Strategy 5: Build NERRS capacity to conduct social science research and integrate social science research with ongoing research and monitoring to address coastal management issues

- Milestone: New social science projects are begun at reserves

- Product: Social science projects that utilize and build upon NERRS research and monitoring activities (e.g., NERRS Sentinel Sites, NERRS Climate Sensitivity Analysis, Biological Monitoring).
- Product: Social science projects that use reserves as research platforms
- Milestone: Social science is integrated into NERRS research to support coastal management at reserves.
 - Product: Research data and information that is effectively communicated and used by relevant coastal communities and audiences

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Appendix I. Key milestones from 2006-2011 NERRS Research and Monitoring Plan

Research Goal	Milestones	Products	Accomplished?
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	2 site profiles remaining
	Revise SAV/Emergent Biomonitoring protocol	Updated protocol	Yes
	Summarize initial SAV/Emergent Biomonitoring projects	Synthesis document	Yes
	Implement NERRS Habitat Classification System	At least 3 sites employ/year	In progress
	Develop a NERRS Remote Sensing Strategy	NERRS remote sensing guidance document	No
	Integrate NERRS monitoring data with national and regional IOOS efforts	Partners use NERRS real-time and archived data	Yes
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	Yes
	Revise NERRS Research Database that archives and tracks research projects with the NERRS	Functional NERRS Research Database	Yes
	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	Yes
	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	Yes
	Complete a regional and/or national assessment of NERRS environmental conditions	A NERRS "Report Card" document	In progress
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	Yes
	NERRS Research Database is available for public access online	Searchable database of research projects is available online for public access/information	In progress
	A NERRS Special Journal Issue is published to highlight biological monitoring and research in the field	Published Special Journal Issue	Yes
	A NERRS Special Journal Issue is published to highlight NERRS Habitat mapping/Land use change monitoring and remote sensing research	Published Special Journal Issue	No
	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	In progress
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	Yes
	Revise and update SWMP Plan	Revised SWMP Plan	Yes
	Conduct a SWMP External Review	Evaluated program to guide future development	Yes

Appendix II: Supporting Programs and Ongoing Activities

The programs listed below are foundation programs of the NERRS and will provide the resources and capacity to support the NERRS Research Strategies described above.

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 biological, physical, and geochemical conditions. The NERRS SWMP Plan was revised in 2011, and reflects an integrated approach that provides a strategy for focusing NERRS monitoring efforts on management issues that have are identified in the NERRS Strategic Plan, and this 2011-2016 Research and Monitoring Plan.

Research and monitoring are integrally linked in the NERRS, and the operational infrastructure and extensive sets of ecological data and information that the SWMP provides is critical to the NERRS ability to provide a robust, long term, and versatile research program, with the capacity to address a comprehensive suite of coastal management issues. There are three fundamental questions that SWMP is designed to address:

- How do environmental conditions vary through space and time within the network of NERRS sites?
- How does ecosystem function vary through space and time within critical NERRS habitats?
- To what extent are changes in estuarine ecosystems represented by the NERRS attributable to natural variability versus anthropogenic activity?

The reserves are currently funded to conduct water quality and meteorological monitoring and a majority of the reserves have received funds to lay the foundations for long term monitoring of submerged and emergent vegetation communities. Land-use and habitat change mapping is being implemented at most reserves, with the goal of building out the program through partnerships and leveraging existing resources. These activities are currently supporting the NERRS Sentinel Sites Program, and are fundamental building blocks for other programs in the NERRS that require long-term and consistent data for understanding anthropogenic impacts on reserve ecosystems.

Providing information to improve environmental literacy and serving as a resource for coastal managers are also primary goals of SWMP because they provide a means of improving understanding and informing decisions. Therefore SWMP is also focused on:

- Synthesizing and interpreting data,
- Translating and disseminating information that it is useful to coastal decision makers, and

- Training and educating teachers, students, community members, and other stakeholders in the use of SWMP data and data products.

NERRS Graduate Research Fellowship Program (1997 - 2012)

The NERRS Graduate Research Fellowship (GRF) program provided M.S. and Ph.D. candidates with an opportunity to conduct research of local and national significance that is focused on enhancing coastal zone management. The five research focus areas for the GRF program were: 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. The GRF program provided a means to build partnerships with University scientists, and increased research capacity of the NERRS and the reserves. It provided much needed exposure for the reserves to the scientific community and provided a launching point and a training ground for future professionals in estuarine science and decision making.

The NERRS Science Collaborative

The National Estuarine Research Reserve System Science Collaborative is designed to put NERRS-based science to work in coastal communities. Administered by the University of New Hampshire, this program uses a competitive process to identify, fund, and foster science to address local coastal management problems with broader relevance. Projects selected through annual requests for proposals ensure that researchers and intended users of the science work together to describe science and technology needs related to specific problems, define research questions, design and implement projects using appropriate approaches and methodology, and apply the results.

NERRS Reserve-specific Research Programs

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. 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.

NERRS Climate Sensitivity Assessment (2012)

The National Estuarine Research Reserve System (NERRS) initiated a project to understand how sensitive estuaries around the nation are to climate change. This project was supported by funding from NOAA's Climate Program Office, who was a partner in its development and implementation. Scientists from NOAA's National Centers for Coastal Ocean Science and the University of Wisconsin worked to analyze and synthesize the best available information and

data from Reserves and their watersheds to identify their key physical, ecological, and socio-demographic attributes. These key attributes were used to categorize the Reserves' sensitivity to climate change impacts and human-induced stresses. This study was one of the first of its kind to synthesize both biophysical and socio-demographic information, with the goal of categorizing the susceptibility of U.S. coastal areas to climate change impacts. The work will provide the foundation for future strategic investment in comprehensive place-based studies, vulnerability assessments, and adaptation planning in the NERRS.

NERRS Sentinel Sites Program

The NERRS Sentinel Sites Program combines the monitoring, outreach and training capacity at each reserve into networks that address questions of impacts of climate change and anthropogenic stressors on estuarine ecosystems and coastal communities. The current focus of the NERR Sentinel Sites is to assess the impacts of sea level change and inundation on tidal wetlands, submerged aquatic vegetation (SAV), and mangroves to inform coastal management. By linking NERRS ecosystem monitoring to geospatial infrastructure of the National Spatial Reference System (NSRS) and National Water Level Observation Network, reserves can inform and develop robust tools such as inundation maps, integrated ecosystem models, and vulnerability assessments to assist coastal managers in adapting to climate change. The NERR Sentinel Sites are a foundational element of the larger NOAA Sentinel Sites Program, which is a partnership between NOAA and other Federal, local and regional partners focused on leveraging networks of environmental observations to address coastal management issues of local and regional concern.

Appendix III: List of project funded by NERRS Science Collaborative through 2012.

Land use change projects (links will be provided)

- *Bracing for climate change in San Francisco Bay --- (project homepage) (progress reports)*
- *Planning for sea level rise on the Florida coast --- (project homepage) (progress reports)*
- *Balancing freshwater needs in a changing Texas landscape --- (project homepage) (progress reports)*
- *Balancing land use decisions in Southern Maine --- (project homepage) (progress reports)*
- *Promoting sustainable shorelines along New York's Hudson River --- (project homepage) (progress reports)*
- *Planning the future with an eye to the past along Mississippi's Grand Bay --- (project homepage) (progress reports)*
- *Planning for a changing landscape in Alaska's Kachemak Bay --- (project homepage) (progress reports)*
- *Community management of shared water resources --- For more information contact **Janel Vasallo**, Rookery Bay NERR coastal training specialist.*

Habitat change & restoration projects

- *Bringing wetlands to market in Massachusetts -- (project homepage) (progress reports)*
- *California oyster restoration in the face of climate change --- (project homepage) (progress reports)*
- *Bringing the "Oly" oyster back to Oregon's Coos Bay --- (project homepage) (progress reports)*

Management of stormwater & nonpoint source pollution projects

- *Stormwater solutions in Ohio -- (project homepage) (progress reports)*
- *Managing nonpoint nitrogen pollution in New Hampshire's Great Bay --- (project homepage) (progress reports)*
- *Assessing the impacts of stormwater swashes on coastal water quality in South Carolina --- (project homepage)(progress reports)*