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COLLABORATIVE RESEARCH TO ADVANCE THE USE OF LIVING SHORELINES

Coastal communities and their shorelines are increasingly vulnerable to the impacts of climate change. A variety of living shoreline techniques have been shown to reduce erosion and stabilize shorelines while protecting habitat. However, these nature-based shoreline approaches are not adopted as widely as they could be. A number of researchers working closely with National Estuarine Research Reserve System (NERRS) have been helping address key information needs identified by landowners, regulators, and contractors, including questions about living shoreline placement, design, and long-term performance. This management brief highlights the work of four teams, supported in part by the NERRS Science Collaborative, that have been working on living shoreline issues in New York, South Carolina, eastern Florida, and the Alabama Gulf Coast, demonstrating the impact of the reserves and their partners.

About the NERRS

The National Estuarine Research Reserve System (NERRS) is a network of 29 coastal reserves located in 22 states and Puerto Rico. Each site includes programs focused on land stewardship, research and scientific monitoring, training programs for the public and local officials, and education.

About the NERRS Science Collaborative

The NERRS Science Collaborative is a NOAA-funded program that provides grants and other support for user-driven collaborative research, assessment, and transfer activities that address critical coastal management needs identified by the reserves.

Surveying a bald cypress swamp that is now protected by an offshore breakwall in Bon Secour Bay, AL.
Photo credit: Just Cebrian, University of South Alabama

About this document

Representatives from the projects featured in this brief will be participating in a panel webinar on April 11, 2019 to discuss lessons learned and next steps, opportunities, and needs for living shorelines management and research. This brief is a DRAFT document that will be finalized once content from the panel discussion has been incorporated.

This document was prepared by NERRS Science Collaborative staff, with input from Christine Angelini, Stuart Findlay, Jennifer Raulin, Denise Sanger, and Eric Sparks, and their project partners.

National Estuarine Research Reserve System Science Collaborative

SHORELINES ARE VULNERABLE

Poised at the transition between land and water, coastal areas are inherently dynamic. Coastal communities face the unique challenge of protecting homes, businesses, and infrastructure against rising sea levels and increasing storm intensity. These same forces are also altering already stressed coastal habitats, such as marshes and oyster reefs. Traditional stabilization techniques such as bulkheads, revetments, and hardened shorelines are frequently used to stabilize shorelines and stop horizontal erosion, but not without tradeoffs. Armoring the shoreline against erosion can mean increased bottom scour and a loss of ecosystem services and the beneficial functions that natural shorelines provide.

LIVING SHORELINES CAN PROTECT AND ENHANCE COASTS

Nature-based, ecologically enhanced, soft, or living shoreline techniques are increasingly being used to stabilize shorelines. These alternative techniques have the potential to provide greater resilience to physical forces and maintain and enhance important ecological services, while being cost-competitive with traditional, hardened, approaches.

Using crab pots to promote oyster growth and protect an eroding marsh near ACE Basin, SC.
Photo credit: Ben Stone, South Carolina Department of Natural Resources

Living shorelines incorporate features of the natural environment in order to preserve coastal integrity. In addition to absorbing wave energy and slowing erosion, they provide ecological benefits such as increasing habitat diversity, reducing water pollution via captured runoff, providing habitat and migratory routes for a variety of coastal and estuarine organisms, enabling pathways for wetland migration, and offering natural buffers against storm surge and sea level rise.

Living shoreline designs are shaped by both the desired ecosystem services and the unique geophysical nature of a given site. Design choices are made deliberately, taking into account site-specific attributes, such as habitat type, climate, wave energy, slope, tidal range, and sediment. Different materials, including oyster structures, rocks, or logs, and strategies, such as adding submerged sills, are used to reduce wave energy and erosion, allowing wetland plants to persist along the shoreline.

BUT LIVING SHORELINES ARE UNDERUTILIZED

Despite their potential, living shorelines are not applied as broadly as might be expected. While many factors ultimately inform a decision about which shoreline stabilization technique is used at a site, there is a tendency to depend on the traditional, hardened techniques that contractors have been using and regulatory agencies have been permitting for decades. At play is a combination of factors, including the level of awareness, or lack thereof, of living shorelines and their potential benefits, as well as varying confidence in their ability to perform locally and over time.

Sometimes the informational needs or regulatory hurdles associated with living shorelines deter the use of these alternative approaches. Living shoreline techniques will not be appropriate for every site but, in order for these techniques to be used more widely and their benefits realized, they have to be considered alongside traditional options as a viable alternative.

A number of researchers partnering closely with National Estuarine Research Reserves (NERRs) have been working to identify and meet informational and practical needs of landowners, regulators, and contractors related to living

shorelines and even the playing field when it comes to shoreline stabilization options. This includes addressing questions about living shoreline placement, design, and long-term performance, as well as developing tools, such as guidance for site assessments and post-installation monitoring, to ease the burden of getting living shorelines into practice. This management brief highlights the work of four teams, supported in part by the NERRS Science Collaborative, that have been working on living shoreline issues in New York, South Carolina, eastern Florida and the Alabama Gulf Coast.

INCREASING CONFIDENCE IN LIVING SHORELINES

Awareness of and confidence in living shorelines vary widely across the country and across different types of landowners and managers. While there are a number of reasons for this variability, it's clear that understanding diverse perspectives and meeting information needs are critical steps toward increased application of these techniques. As a first step, landowners, land managers, contractors, and permitters must be aware of and appreciate the potential benefits of living shorelines. Second, they must feel confident that specific living shoreline techniques can work in their region and achieve the desired outcomes, including performing over time and through major storm events. To help meet these needs, Science Collaborative project teams are increasing awareness of living shorelines and their benefits, installing pilot and demonstration projects, and documenting performance in different settings around the country.

In New York, a **sustainable shorelines group** - led by researchers from the Cary Institute of Ecosystem Studies and the Stevens Institute of Technology, staff from the Hudson River NERR, and collaboration facilitators from the Consensus Building Institute - has spent the past decade addressing living shoreline informational needs and enhancing confidence in ecologically appropriate shoreline options that prevent erosion along the Hudson River while providing ecosystem service benefits. Through the development of a network of living shoreline installments along the Hudson River, the group has helped to elucidate what living shorelines can look like in the region. The team has also worked to enhance regional understanding and confidence in the performance of living shorelines over time by developing living

Reserve staff and volunteers forming a chain to unload and place materials for a living shoreline experiment at GTM NERR, FL.
Photo credit: Bob and Dorothy Wickline, GTM volunteers

Testing a monitoring protocol at a living shoreline project in Hudson River Valley, NY.
Photo credit: Sarah Lipuma, Huron River Sustainable Shorelines Project

shoreline assessment guidance and training land stewards in the protocol. Previous work also included conducting **forensic analyses** of living shoreline installments following major storm events. Both the guidance and forensic analyses have proven valuable in understanding what works well, and not so well, when it comes to installing living shorelines in New York.

In South Carolina, oyster-based living shorelines have been created adjacent to public lands dating back to 2001. Although interest in these approaches is growing, state coastal managers want to better understand the long-term performance of oyster structures and other strategies in South Carolina before recommending a particular technique for private landowners. Since 2015, a team - led by researchers from the South Carolina Department of Natural Resources (SCDNR), Ashepoo, Combahee and Edisto (ACE) Basin NERR, and the North Inlet-Winyah Bay NERR - has been tracking the ecological benefits of 60 of these living shorelines and 16 newly created experimental installations. Through comprehensive monitoring approaches, the team has observed that oyster-based shoreline stabilization techniques work particularly well along more protected coastlines with a gentle slope. Oyster habitat structures begin reducing erosion soon after installation and, over subsequent years, promote the expansion of marsh grasses behind the living shoreline. Equally important, the new structures can become self-sustaining reefs where coastal waters have sufficient natural oyster populations to colonize them, requiring little follow-up maintenance. This project's unique long term data set is helping agency partners and private landowners trust that living shoreline techniques can work in South Carolina, and that projects will continue to provide important ecological benefits over many years.

In Mississippi and Alabama, a project team - led by the Mississippi State University Extension Service, Mississippi-Alabama Sea Grant Consortium, and the Weeks Bay NERR - is working to increase awareness of living shorelines among private landowners and contractors. They've found that landowners in the region are increasingly interested in living shoreline approaches, but need more information and assistance with site assessments to determine whether living shorelines are appropriate for their properties. By developing new workshops and resource guides geared specifically toward landowners and contractors, the project team has met some of these informational needs, resulting in an increased interest in living shorelines. This same team is also evaluating the effectiveness of different living shoreline techniques to better understand which approaches work well in Mobile Bay, Alabama. More specifically, they are assessing the performance of various living shoreline strategies, including planting vegetation and comparing growth under different strategies - with and without offshore oyster breakwaters - to help inform more strategic decisions about placement and types of living shorelines in the region.

In Florida's busy intracoastal waterway, land managers are eager to reduce the rapid loss of marsh and oyster habitat observed over recent decades, but have

found that typical living shoreline techniques can't withstand the high energy wakes created by passing ships and boats; this has affected confidence in living shorelines as an effective shoreline stabilization technique and stymied their use in this region. A team - led by researchers from the University of Florida, University of New Hampshire, and the Guana Tolomato Matanzas (GTM) NERR - has been testing a new hybrid design that has worked well in the Netherlands. In 2016, they installed an experimental living shoreline that uses two lines of defense - porous wooden breakwalls placed in front of reef structures consisting of caged oyster shells - to reduce coastal erosion. Local restoration practitioners were invited to visit the projects, and saw evidence of how the marsh edge began expanding just a year after installation. The project serves as a local demonstration that some living shoreline designs can work in high energy environments, prompting project partners from the Florida Wildlife and Conservation Commission to replicate the new hybrid design in a nearby estuary, even before the project's final results were available.

DEVELOPING TOOLS, EXPANDING EXPERTISE

As is the case when installing traditional shoreline stabilization measures, living shoreline installments require site assessment and technical expertise to develop a plan that will achieve the goals for a particular site. Without an understanding of different living shoreline approaches, or appropriate tools or training in their use, landowners, land stewards, and contractors are unlikely to pursue softer approaches over traditional shoreline stabilization techniques. Science Collaborative project teams have been addressing this challenge by evaluating a range of living shoreline techniques, engaging landowners and restoration practitioners in their research, conducting outreach, and providing training and tools.

An aerial view of the Swift Tract living shoreline project in Bon Secour Bay, AL.
Photo credit: Eric Sparks, Mississippi State University and Mississippi-Alabama Sea Grant

Through project conceptualization, design, and implementation, the Mississippi and Alabama team engaged an advisory group of restoration practitioners from federal, state, academic, and nonprofit institutions as well as the private sector. As a result, the work zeros in on and answers practical questions about how to apply living shorelines in the region. So far, the monitoring has demonstrated an increase in growth of pre-existing marsh areas behind breakwaters, but it's small and it took some time - six years since installation. Marsh areas planted by the project team showed no differences between breakwater and no-breakwater areas. And, because of their close engagement and familiarity with the project findings, advisory group members have already begun applying lessons learned in this study alongside other restoration efforts in the region, including more

RESERVES IN ACTION

In 2008, the State of Maryland passed the Living Shorelines Protection Act, which states:

"Improvements to protect a person's property against erosion shall consist of non-structural shoreline stabilization measures (i.e. living shorelines) except where the person can demonstrate such measures are not feasible, or where mapping indicates areas that have been deemed appropriate for structural shoreline stabilization measures."

Essentially, this law makes living shorelines the preferred option in evaluating shoreline erosion control measures. However, Maryland still struggles with perception issues, especially cost, maintenance and long-term efficacy of the practice.

Continued communication and information-sharing are key. Chesapeake Bay-MD NERR offers living shoreline trainings through its Coastal Training Program, and has supported information-sharing opportunities such as the 2013 Mid-Atlantic Living Shorelines Summit with Restore America's Estuaries. More recently, the reserve has been involved with developing the monitoring protocols for the state's Resiliency through Restoration program which will put more projects, including living shorelines, on the ground.

strategic placement of living shoreline installations, setting realistic expectations of project success, and using that knowledge to evaluate the tradeoffs associated with different restoration project types.

To help put the relevant expertise into the hands of those in the field - the people actively making decisions about which shoreline approaches are used - the Mississippi and Alabama team has developed a living shorelines workshop and training materials that target marine contractors, landscapers, and consultants. The workshop is designed to introduce the concept of living shorelines and describe the necessary considerations for site selection, suitability, design, and permitting; provide cost estimates; and direct participants to assistance programs and resources. The team has also developed a low-cost wave gauge which measures wave energy - an important step in site assessment for determining living shoreline suitability and/or design.

The project in New York developed a living shorelines Rapid Assessment Protocol Manual with land stewards and shoreline designers in mind. It provides guidance for assessing both the physical and ecological performance of nature-based engineered shoreline structures. The manual uses a series of worksheets that provide step-by-step instructions for performing preliminary site analyses, establishing baseline reference points, and collecting observational data. Although written in the context of the Hudson River, the guidance in the manual can be applied to other sites by users familiar with the relevant field techniques or with the Rapid Assessment Protocol process.

There is a myriad of living shoreline techniques, and subtle differences in installation can influence performance. To help inform restoration practitioners, the South Carolina team has been evaluating the effectiveness of different shoreline stabilization approaches. Their diverse study sites included four systems to restore intertidal oysters and three natural fiber treatment systems. They found that natural fibers are a stabilization option for low-salinity areas where oysters cannot grow, but the fiber treatments did not hold up well over time. The treatment systems promoting oyster growth generally remained intact over time and some techniques, such as bagged oyster shells, worked best on firmer sediments while others, such as re-purposed crab pots coated in concrete, could perform well at sites with softer sediments. The team is using such findings to develop a decision tree and guidance for the South Carolina Department of Health and Environmental Control's Office of Ocean and Coastal Resource Management for use in building a regulatory strategy. Ultimately, NERR staff will develop resources for private landowners and coastal contractors to assess whether a living shoreline would be appropriate to help protect a particular marsh and, if so, which approach to pursue.

In response to interest from local restoration practitioners, the Florida team has developed a number of tools to help other practitioners learn about their new hybrid living shoreline design. The team produced a video about their installation process and developed A Manual for Re-Engineering Living Shorelines to Halt Erosion and Restore Coastal Habitat in High-Energy Environments. The manual provides guidance about site assessment, installation, maintenance and monitoring.

Practitioners have toured the projects and several workshops have engaged different segments of the public and a broader coastal management community.

MAKING ROOM IN THE REGULATORY ENVIRONMENT

A major factor impeding the greater use of living shoreline approaches has less to do with a lack of understanding of the related science, or general support for the techniques, and more with the current regulatory environment. Simply put, in many states, it's easier to permit a hardened shoreline option than a living shoreline. Many coastal states are increasingly interested in nature-based options for protecting shorelines, but they often lack permitting pathways and locally-tailored guidance documents for applicants and permitters.

Pilot shoreline projects serve as local demonstrations of new techniques and also illuminate relevant permitting requirements. For example, the Florida team was able to successfully permit a unique hybrid shoreline design, and their experience navigating the permitting process can help others do the same. The engineering manual the team developed includes recommendations to help secure permits, including suggestions about setting up a pre-application meeting with permitting agencies to identify any initial concerns and design attributes to emphasize.

Carrying a cage of oyster shells that will provide oyster habitat as part of a living shoreline experiment at GTM NERR, FL.
Photo credit: GTM Research Reserve

The Rapid Assessment Protocol manual developed in New York is designed to clarify assessment procedures, which is valuable to both permit seekers and permitters. Having clear, established protocols for assessing a site expedites the initial site assessment stage and provides a format for consistent approaches that can be applied when evaluating project designs and locations. Regulators can then point permit seekers and their engineers to these protocols for monitoring performance. Because the sustainable shorelines group engaged land managers, contractors, and state regulators from the beginning -- asking them what information and tools are necessary and consulting them in project and tool design -- their products are in the hands of those who can apply them and are already proving useful. The indicators and detailed protocols the project developed will be referenced as protocols for a statewide, nature-based shoreline framework in New York. In addition, the project team developed a database that will inform the development of the statewide framework database.

In South Carolina, intertidal living shoreline projects have typically been installed by restoration practitioners along shorelines adjacent to public lands. To date, there hasn't been a straightforward permitting pathway for private property owners to proactively address shoreline erosion issues and protect habitat adjacent to their own properties. The state permitting agency approached the SCDNR and ACE Basin NERR and solicited their help in assessing existing living shoreline projects to inform anticipated regulatory changes. Close collaboration between researchers and agency partners has helped shape the research design and the structure of final products to best address critical information gaps. Specifically, the state is using the

team's research findings to develop guidance documents for permitting officers and applicants about which coastal areas are suitable for living shorelines and which techniques perform best in South Carolina. These guidance documents are expected to facilitate living shoreline permitting on private lands under current rules and also inform the drafting of new regulations specific to living shorelines, which should further streamline permitting processes for coastal landowners.

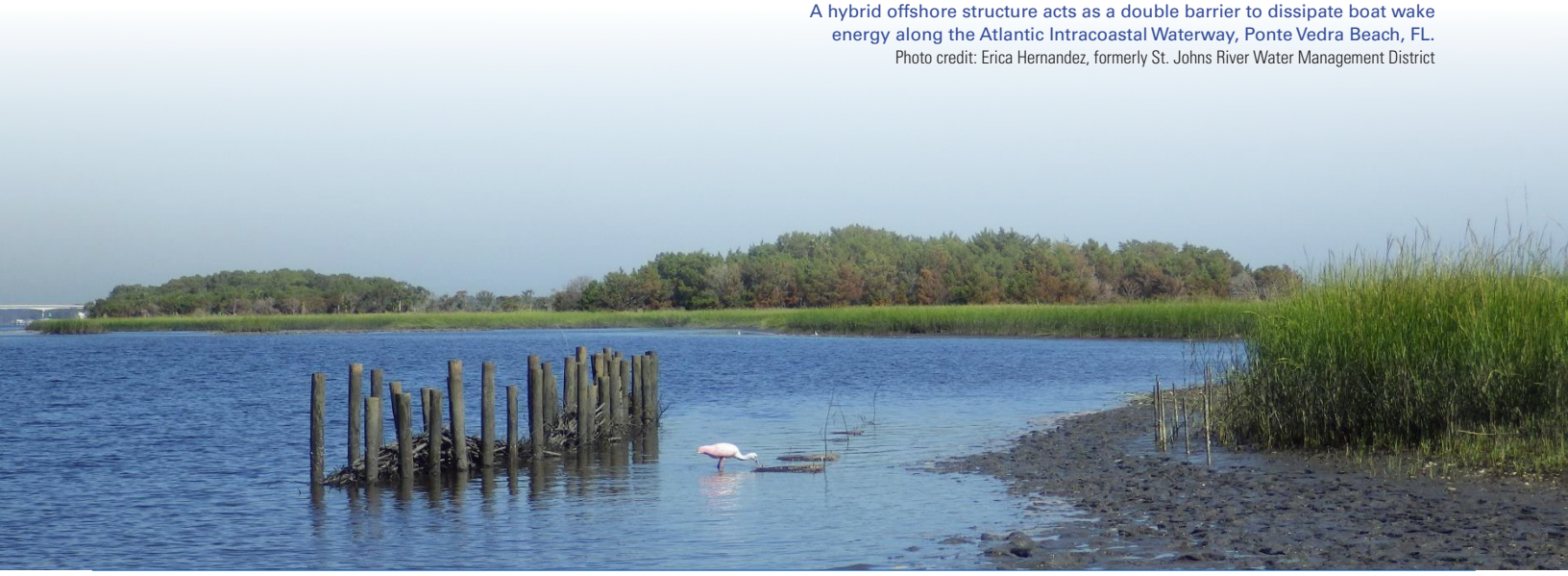
NEXT STEPS AND OPPORTUNITIES FOR ADVANCING LIVING SHORELINES

*Representatives from the projects featured in this brief will be participating in a **panel webinar on April 11, 2019** to discuss lessons learned and next steps, opportunities, and needs for living shorelines management and research. This section will be developed after the webinar and based on the panel discussion.*

HIGHLIGHTED PROJECTS

This management brief spotlights the work of four project teams that were funded by the NERRS Science Collaborative in 2015.

PROJECT TITLE	PROJECT LEAD	RESERVE(S), STATE
Re-engineering living shorelines for high-energy coastal environments	Christine Angelini, University of Florida (c.angelini@ufl.edu)	Guana Tolomato Matanzas, Florida
Assessing ecological and physical performance of sustainable shoreline structures	Stuart Findlay, Cary Institute of Ecosystem Studies (findlays@caryinstitute.org)	Hudson River, New York
Evaluating living shorelines to inform regulatory decision-making in South Carolina	Denise Sanger, ACE Basin NERR (sangerd@dnr.sc.gov)	ACE Basin and North Inlet-Winyah Bay, South Carolina
End-user derived research to improve the effectiveness, sustainability, and prevalence of coastal restoration projects	Eric Sparks, Mississippi State University (eric.sparks@msstate.edu)	Weeks Bay, Alabama



A hybrid offshore structure acts as a double barrier to dissipate boat wake energy along the Atlantic Intracoastal Waterway, Ponte Vedra Beach, FL.
Photo credit: Erica Hernandez, formerly St. Johns River Water Management District