



*Photo Credit: Vance Miller*



*Photo Credit: David Cessna*



# Increasing the Use of Living Shorelines to Protect and Restore Coastal Wetland Habitat in North Carolina

*Coastal Habitat Protection Plan  
Wetland Workshops: Coastal  
Wetland Restoration and  
Living Shorelines*

*August 26, 2020*

*Lexia M. Weaver, Ph.D.,  
Coastal Scientist and  
Central Regional Manager*



North Carolina  
Coastal Federation  
*Working Together for a Healthy Coast*

# North Carolina Coastal Federation

## *Working Together for a Healthy Coast*

- Collaborate and engage people from all walks of life to protect and restore coastal water quality and habitat throughout the North Carolina coast
- Member supported organization founded in 1982
- 30 staff and 30 board members
- Cover North Carolina's 20 coastal counties
- Offices in Wanchese, Ocean and Wrightsville Beach, NC



# North Carolina Coastal Federation

## *What We Work For – Our Goals*

- **Clean coastal waters** that support fishing and swimming
- **Living shorelines** that reduce soundside erosion and provide habitat
- **Thriving oysters** that support the coastal environment and economy
- **Effective coastal management** that protects our coast
- A coast that is **free of marine debris**



# Living Shorelines



# Wetland Restoration through Living Shoreline Implementation



# Wetland Restoration through Living Shoreline Implementation

*Before Planting*



*After 1 Year*



# Wetland Restoration through Living Shoreline Implementation



*Before Planting*



*After 3 years*



*After 6 years*

# Wetland Restoration through Living Shoreline Implementation

*Before Planting*

*After*





# Wetland Restoration through Living Shoreline Implementation

Bogue Sound, Pine Knoll Shores, NC



*Before (2007)*



*After 9 Years (2016)*



# Wetland Restoration through Living Shoreline Implementation

## Bogue Sound, Pine Knoll Shores



*Before (2007)*



*After 9 Years (2016)*



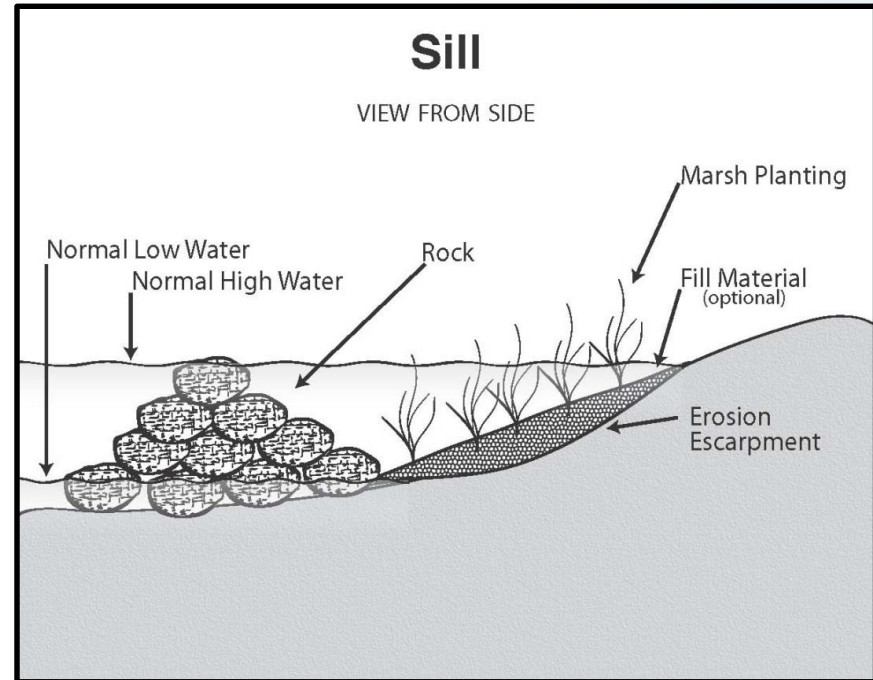
# Benefits of Living Shorelines

- Natural alternative to the traditionally used hard shoreline stabilization methods
- Attenuate waves and reduce shoreline erosion
- Restore and protect valuable fishery habitat (coastal wetland marsh and oyster reefs)
- Improve water quality
- Resilient and outperform bulkheads through storms
- Increase property value
- Less expensive than bulkheads



# Living Shoreline Design Considerations

- Wave energy
- Fetch
- Predominant wind direction
- Water depths
- Proximity to navigation channels
- Shoreline orientation
- Extent of erosion
- Slope
- Natural abundance of oysters
- Cost
- Property owner preference



# Living Shoreline Materials

## Oyster Shell Bags



## Granite/Concrete/Marl



## Oyster Domes/Reef Balls



## Oyster Catcher™



## Atlantic ReefMaker EcoSystems



## Oyster Castles



Photo Credit: David Cessna

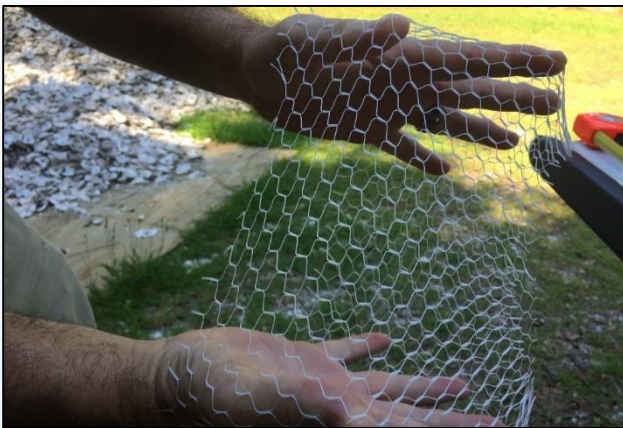


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# Living Shoreline Materials

## Testing Alternatives to Traditional Mesh Bags



# Storm Resiliency of Living Shorelines

Ocean & Coastal Management 102 (2014) 94–102

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**Ocean & Coastal Management**

journal homepage: [www.elsevier.com/locate/ococoaman](http://www.elsevier.com/locate/ococoaman)

**Marshes with and without sills protect estuarine shorelines from erosion better than bulkheads during a Category 1 hurricane**

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**ABSTRACT**

Acting on the perception that they perform better for longer, most property owners in the United States choose hard engineered structures, such as bulkheads or riprap revetments, to protect estuarine shorelines from erosion. Less intrusive alternatives, specifically marsh plantings with and without sills, have the potential to better sustain marsh habitat and support its ecosystem services, yet their shoreline protection capabilities during storms have not been evaluated. In this study, the performances of alternative shoreline protection approaches during Hurricane Irene (Category 1 storm) were compared by 1) classifying resultant damage to shorelines with different types of shoreline protection in three NC coastal regions after Irene; and 2) quantifying shoreline erosion at marshes with and without sills in one NC region by using repeated measurements of marsh surface elevation and marsh vegetation stem density before and after Irene. In the central Outer Banks, NC, where the strongest sustained winds blew across the longest fetch; Irene damaged 76% of bulkheads surveyed, while no damage to other shoreline protection options was detected. Across marsh sites within 25 km of its landfall, Hurricane Irene had no effect on marsh surface elevations behind sills or along marsh shorelines without sills. Although Irene temporarily reduced marsh vegetation density at sites with and without sills, vegetation recovered to pre-hurricane levels within a year. Storm responses suggest that marshes with and without sills are more durable and may protect shorelines from erosion better than the bulkheads in a Category 1 storm. This study is the first to provide data on the shoreline protection capabilities of marshes with and without sills relative to bulkheads during a substantial storm event, and to articulate a research framework to assist in the development of comprehensive policies for climate change adaptation and sustainable management of estuarine shorelines and resources in U.S. and globally.

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One year before

One day after



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# Living Shoreline Maintenance

- Bulkheads often require costly repairs and replacement
- Living shorelines require minimal to no maintenance
  - Salt marsh is restored in 1-3 years
- Fared extremely well after Hurricane Florence
  - Salt marsh plants and rock sills were not affected by the storm
  - Oyster shell bags also remained in place



*Post-Hurricane Florence*





# Promoting and Increasing Living Shoreline Use through Implementation

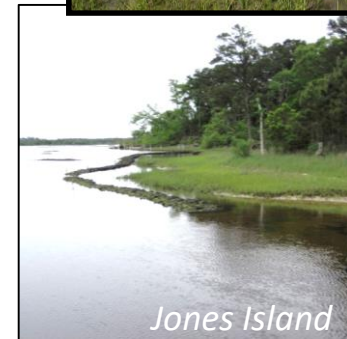
## Private Property



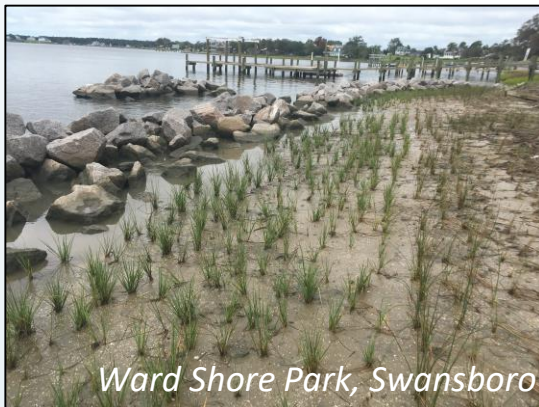
## Community



## State



## Local Government



## County



# Promoting and Increasing Living Shoreline Use through Implementation

National and International Case Study:  
US-Netherlands Infrastructure Resilience Collaboration



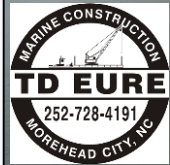
# Promoting and Increasing Living Shoreline Use through Community Engagement



*Hands on Education and Restoration*

*Living Shoreline Open Houses*

# Promoting and Increasing Living Shoreline Use through Engineers and Contractor Training



garygreene-engineers.com



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# Promoting and Increasing Living Shoreline Use through Partnerships

- Students
- Community
- Waterfront Property Owners
- Businesses
- Marine Contractors
- Engineers
- Developers
- Universities and Colleges
- Local, State and Federal Agencies
- Other Non-profit Organizations



# Promoting and Increasing Living Shoreline Use through Funding

- N.C. Division of Soil and Water Conservation's Community Conservation Assistance Program
- N.C. Clean Water Management Trust Fund
- N.C. Division of Water Resources
- National Oceanic and Atmospheric Administration
- National Fish and Wildlife Foundation
- USDA Natural Resources Conservation Service
- Southeast Aquatic Resources Partnership
- Atlantic Coastal Fish Habitat Partnership
- Grady White Boats
- TogetherGreen



# Living Shoreline Permitting

- Salt marsh planting alone: no permit required
- Marsh sill and marsh-toe revetment: Coastal Area Management Act (CAMA) General Permit
  - \$200 fee
  - Project location map and designs
  - Adjacent property owner signatures
  - Valid for 120 days
- CAMA Major Development Permit
  - \$400 fee
  - Additional application materials
  - Reviewed by 13 state and federal agencies
  - Valid for 3 years





# Needs for Increasing the Use of Living Shorelines in the Future

- Strong promotion of living shorelines by regulatory and resource agencies
- Projects should be expected to conduct an alternative's analysis to identify most effective shoreline stabilization method
- Financial incentive programs
- Grant opportunities for communities
- Short-term construction insurance
- Awareness and adoption of living shorelines by the public and marine contractors
- Business programs for marine contractors

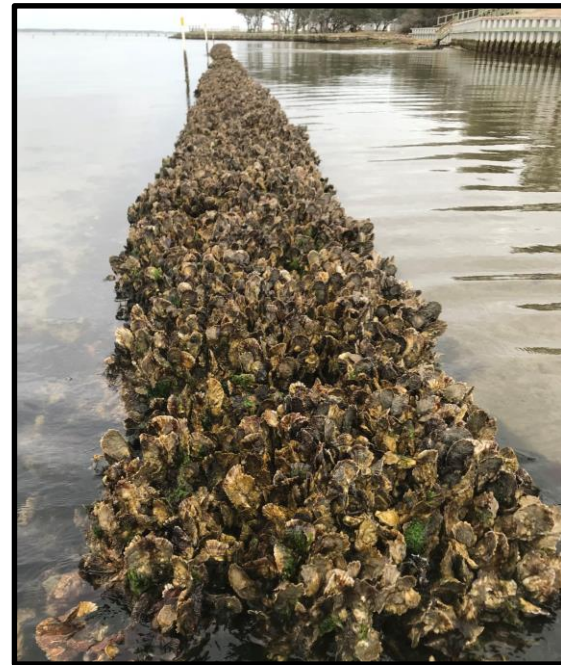


# Living Shoreline Strategy

*Draft Actions and Benchmarks for the  
2021-2025 Oyster Blueprint Update*



*1 Year After Construction*



*2 Years After Construction*

# Living Shoreline Strategy

## Workgroup Members

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# Living Shoreline Strategy

## Overarching Goal

- Expand the use of living shorelines to become the most commonly used stabilization method in estuaries to support **wetland and** oyster habitats.



# Action 1: Collaborate through the Living Shoreline Steering Committee

- Identify and bring together the multiple efforts focused on promoting the use of living shorelines.
- Provide the leadership necessary to reach the goal for living shorelines within this blueprint (**and elsewhere**).



The screenshot shows the website for the Albemarle-Pamlico National Estuary Partnership. The header includes the organization's name and logo, a search bar, and a navigation menu with links for Home, About APNEP, Our Estuary, Our Work, and News And Events. Below the navigation is a breadcrumb trail: APNEP > About APNEP > Committees and Teams > Action Teams > Living Shorelines Team. The main heading is "Living Shorelines Team" with a green underline. Below the heading is a photograph of a living shoreline, which is a narrow strip of land between the water and the marsh, composed of rocks and plants. The text "Overview" is visible below the photo. At the bottom of the page, there is a paragraph of text: "The Living Shorelines Action Team (Living Shorelines Steering Committee) is facilitated by both APNEP and the N.C. Coastal Federation. This action team consists of scientists, federal and state agency personnel, and NGOs working together to coordinate education, implementation, research, and monitoring of living shorelines in North Carolina. The [Living Shoreline Working Strategy](#) provides guidance to the Action Team."



## Action 2: Implement living shorelines to continue to demonstrate their benefits to **wetlands**, oysters and soundfront property owners.

- Build at least three miles of living shorelines on public and private lands where **wetlands and** oysters grow by 2025.
- Continue to site and design living shorelines based on research to date and lessons learned from decades of intertidal **wetland and** oyster restoration in North Carolina and elsewhere to promote **wetland and** oyster growth and development, as well as support other ecosystem functions and services.
- Devise and implement a communication and education strategy around each project to publicize benefits to gain more public and agency demand for these projects.
- Engage volunteers and contractors in building living shorelines to help increase public awareness of their benefits.
- Document the success of living shoreline projects each year (new and old) including their **wetland enhancement** and oyster recruitment potential, cost-benefits and resilience compared to other types of shoreline stabilization.

# Action 3: Increase the use of living shorelines instead of bulkheads.

- Quantify the extent of living shorelines implemented to date that also serve as **wetland and** oyster habitat.
- Increase the percentage of living shorelines permitted for shoreline stabilization along shorelines that support **wetland and** oyster growth by 15 percent a year. The more living shorelines, the more **wetlands** and oysters in the water.
- Track the number and type of shoreline stabilization projects authorized each year.
- Educate marine contractors, engineers, consultants and regulators through technical trainings to encourage the use of living shorelines. Conduct three regional 2-day trainings for marine contractors, consultants, engineers, agency staff, beginning in Wilmington in February 2021.
- Conduct living shoreline consultations with five marine contractors per year.



Action 4: Create and promote consumer demand for living shorelines by property owners with a special focus on shorelines that support **wetland and** oyster growth.

- Educate waterfront property owners, realtors, homeowners associations (Community Association Management Services), local governments and the general public on the value and benefits of living shorelines.
- Develop educational outreach materials (electronic and printed) to be distributed to these audiences.
- Conduct one on one living shoreline consultations with 50 waterfront property owners per year.
- Market the use of living shorelines by property managers and owners at three outreach events in three regions of the coast.





# Action 5: Protect regulated and permitted living shorelines that grow harvestable oysters.

- Explore the protection of oyster shell bag and Oyster Catcher™ living shorelines in the next update to the N.C. Coastal Habitat Protection Plan (CHPP).
- Experiment with the use of stronger bags or other sill materials that would not be damaged if oysters are harvested from them.



## Action 6: Test alternative living shoreline construction materials and methods that increase **wetland habitat and** oyster recruitment.

- Test non-plastic, alternative materials for living shoreline construction at five demonstration project sites.
- Monitor and report the performance of alternative materials.



# Action 7: Summarize living shoreline research accomplishments and major findings to date related to **wetlands and oysters**.

- Provide information on how to site and design living shorelines to promote **wetlands and oysters** based on research to date.

Table 1. Summary information on number of unique reefs, total initial population size, and average initial size structure by reef derived from the North Carolina Division of Marine Fisheries Shoreline Mapping Program. Average initial size structure is based on explicit oyster densities  $m^{-2}$  by reef area. Average initial size structure is based on explicit oyster densities  $m^{-2}$  by reef area. Average initial size structure is based on explicit oyster densities  $m^{-2}$  by reef area.

Reef Type	Number of Unique Reefs	Total Reef Area (ha)	Average Reef Area (ha)	Average Initial Size Structure
Subtidal Natural Reefs	301	934.27	3.12	
Subtidal Culch Reefs	53	15.32	0.29	
Subtidal Sanctuary Reefs	14	66.02	4.72	
Hardened Shoreline Reefs	149	2.69	0.10	
Intertidal Natural Reefs (Pamlico Sound)	57	10.43	0.28	
Intertidal Natural Reefs (Core Sound)				

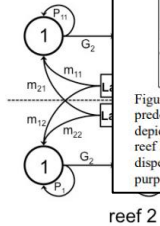


Figure 3: A simplified life cycle graph (adapted from Puckett and Eggleston 2016) depicting the spatially explicit, size-structured matrix metapopulation model used in this study. Two subpopulations (separated by dotted line) and three size classes (circles) are shown. The model used in the present study consisted of 646 reefs and three size classes. Model parameters are as follows:  $P_i$  is the probability of surviving and remaining in size class  $i$ ;  $G_j$  is the probability of surviving and growing into size class  $j$ ;  $F_i$  is the per capita fecundity of size class  $i$ , and  $m_{jk}$  is the proportion of larvae spawned in reef  $j$  that settle in reef  $k$ .

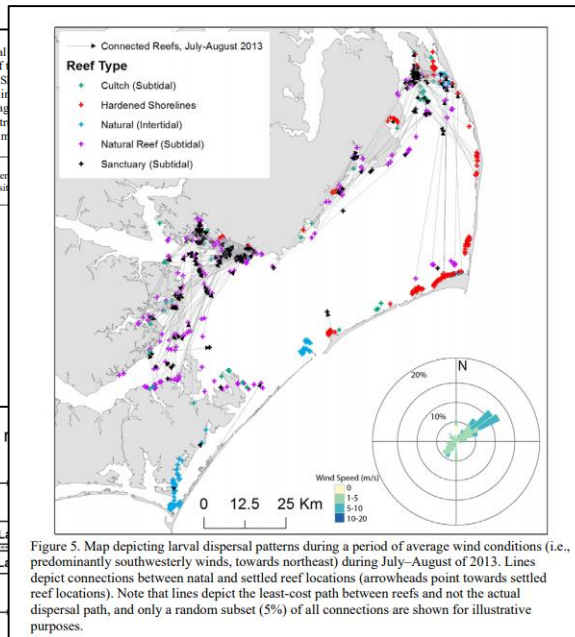


Figure 5. Map depicting larval dispersal patterns during a period of average wind conditions (i.e., predominantly southwesterly winds, towards northeast) during July–August of 2013. Lines depict connections between natal and settled reef locations (arrowheads point towards settled reef locations). Note that lines depict the least-cost path between reefs and not the actual dispersal path, and only a random subset (5%) of all connections are shown for illustrative purposes.

reef 2

Article | Open Access | Published: 07 October 2015

### Maximizing oyster-reef growth supports green infrastructure with accelerating sea-level rise

Justin T. Ridge, Antonio B. Rodriguez, F. Joel Fodrie, Niels L. Lindquist, Michelle C. Brodeur, Sara E. Coleman, Jonathan H. Grabowski & Ethan J. Theuerkauf

Scientific Reports 5, Article number: 14785 (2015) | Cite this article

### The Potential for Created Oyster Shell Reefs as a Sustainable Shoreline Protection Strategy in Louisiana

August 2005 · Restoration Ecology, 13(3):499 - 506  
DOI: 10.1111/j.1526-100X.2005.00062.x

Bryan P. Piazza · Patrick D. Banks · Megan K. La Peyre

Published: 29 August 2016

### Wave Exposure Structures Oyster Distribution on Natural Intertidal Reefs, But Not on Hardened Shorelines

Seth J. Theuerkauf · David B. Eggleston · Brandon J. Puckett & Kathrynlynn W. Theuerkauf

Estuaries and Coasts 40, 376–386(2017) | Cite this article

1 April 2017

### Oyster Density and Demographic Rates on Natural Intertidal Reefs and Hardened Shoreline Structures

Seth J. Theuerkauf · David B. Eggleston · Kathrynlynn W. Theuerkauf · Brandon J. Puckett

Author Affiliations +

J. of Shellfish Research 36(1):87-100 (2017), https://doi.org/10.2983/035.036.0111

nature climate change LETTERS

PUBLISHED ONLINE: 28 APRIL 2014 | DOI: 10.1038/NCLIMATE2216

### Oyster reefs can outpace sea-level rise

Antonio B. Rodriguez<sup>1\*</sup>, F. Joel Fodrie<sup>1</sup>, Justin T. Ridge<sup>1</sup>, Niels L. Lindquist<sup>1</sup>, Ethan J. Theuerkauf<sup>1</sup>, Sara E. Coleman<sup>1</sup>, Jonathan H. Grabowski<sup>2</sup>, Michelle C. Brodeur<sup>1</sup>, Rachel K. Gittman<sup>1</sup>, Danielle A. Keller<sup>1</sup> and Matthew D. Kenworthy<sup>1</sup>



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## Action 8: Identify and answer living shoreline research questions and gaps as they pertain to **wetlands and** oysters.

- Continue quantifying the role of living shorelines in supporting **wetlands and** oyster populations.
- Document the degree to which living shorelines using **wetlands and** oysters can adjust to sea level rise.
- Research the nutrient (nitrogen, phosphorus) reduction benefits provided by living shorelines and use that information to provide incentives for living shoreline projects if warranted.
- Determine why is oyster recruitment on living shoreline materials more abundant on the seaward edge of the sill. How can they be designed differently to increase oyster recruitment?
- On average, how many oysters per ft. can be generated from a living shoreline? On average, how much water can be filtered by oysters on a living shoreline per ft. or other unit?



# Action 9: Qualify living shorelines for mitigation credits.

- Determine if living shoreline projects can be built to qualify for salt marsh (\$560,000 an acre value) or nutrient mitigation credits.
- Issue formal policy recommendations.
- Inform mitigation bankers about this opportunity.

Statewide Stream & Wetland ILF Program Rates for Standard Service Areas

Service Area	Mitigation Type	DMS Rate Per Credit (Effective through 6/30/2020)
Statewide Standard	Stream	\$525.65
Statewide Standard	Freshwater Wetlands (Riparian and Non Riparian)	\$52,273.99
Statewide Standard	Coastal Wetlands	\$560,000.00



(<https://deq.nc.gov/about/divisions/mitigation-services/dms-customers/fee-schedules>)



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# North Carolina Coastal Federation

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