Weighing Your Options

How to Protect Your Property from Shoreline Erosion:

A handbook for estuarine property owners in North Carolina

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Updates are made by the N.C. Division of Coastal Management – North Carolina Coastal Reserve & National Estuarine Research Reserve (NCNERR).

INTRODUCTION

Welcome to *Weighing Your Options: How to Protect Your Property from Shoreline Erosion*. If you own property on one of North Carolina's estuaries, you can use this guide as a tool to learn about the choices you have to control your shoreline erosion and help decide which approach may be right for you. In North Carolina, we make a distinction between waterfront property that is located on the estuary, referred to as *estuarine*, *shoreline*, *soundfront* or *riverside* property, and waterfront property located directly on the ocean, referred to as *oceanfront*. Why? State laws and regulations addressing estuarine and oceanfront property and the available erosion control methods are quite different.

Exploring the estuary, Rachel Carson Reserve, N.C.

This guide focuses on estuarine property. We will introduce you to the main erosion control options in use in North Carolina and give you information about the out-of-pocket costs and tangible benefits of each option. We'll also give you information about "hidden" costs and benefits that you may want to factor into your decision-making.

Kite-boarding, Cape Hatteras, N.C.

If you own a piece of estuarine shoreline property and you've noticed some shoreline erosion lately, you're probably a little concerned. But there are ready solutions. Let's start with some preliminary steps to get a "big picture" overview before diving into the details.

STEP 1: CONSIDER WHAT YOUR ESTUARY DOES FOR YOU

North Carolina has one of the longest estuarine coastlines in the nation – over 12,000 miles, in fact. The N.C. Division of Coastal Management (DCM) recently created the first-ever continuous digital map of the estuarine shoreline for all 20 coastal counties in North Carolina. Information about the project and characterization of the shoreline can be found here: http://portal.ncdenr.org/web/cm/estuarine-shoreline-mapping-project.

Besides providing a source of transportation and beautiful real estate, our estuaries supply jobs, purify water, help temper the effects of hurricanes, and provide recreation for fishermen, sailors, kite-boarders, hunters, swimmers and bird watchers.

Bird watching, Bird Shoal, N.C.

Additionally, healthy estuaries serve as nursery and foraging habitat for juvenile fish, offer a home and feeding ground to birds, and feed and house innumerable shellfish, dolphins, otters, turtles and other marine life.

Egret chicks, Rachel Carson Reserve, N.C.

Together, these characteristics make up the estuarine ecosystem. The functioning of estuarine ecosystems is largely dependent on how people use the adjacent coastal land, and while you may not think your individual shoreline stabilization protection project will have much effect on the surrounding ecosystem, the cumulative effect of all the shoreline alterations in your area can alter the balance of ecosystems in the near-shore environment.

STEP 2: LOOK AT ALL THE OPTIONS

Main Erosion Control Methods for Shorelines in North Carolina Estuaries

- **Vegetation**
- **Oyster Reefs**
- **Marsh Sills**
- **Riprap**
- **Breakwaters**
- **Bulkheads**

Some of the methods used to protect against shoreline erosion may be familiar to you, and some less so. Each method has its advantages and disadvantages, depending on location and exposure, like the direction your property faces, the amount and power of the wind and waves it receives, geography, and shore type. We'll discuss each alternative, using photos and drawings to explain each approach and how it works to control erosion. We'll also list property characteristics favorable to each option, note installation costs, and talk about other costs and benefits associated with each option that affect the beauty and ecological health of the estuaries and sounds that make coastal North Carolina so special.

STEP 3: NARROW YOUR OPTIONS

Six may seem like an over-whelming number of choices, and that's before we count the combinations. Oysters and vegetation alone combine with all the other options. But chances are good that you can narrow the number down pretty quickly. You'll find a list of questions in the back of this booklet. We suggest taking a look at the questions and answering them as best you can while you read through the guide to help inform your answers.

Naturally growing salt marsh and oyster reef, Back Sound, N.C.

The Importance of Shoreline Type

The first question asks, "What is your type of shoreline?" In North Carolina, the shoreline bordering an estuary can be, broadly, a swamp forest, a marsh, an oyster reef, or a sediment bank (see photos on the right).

Certain protection methods are better suited to certain types of shoreline. For example, a low sediment bank, which has a continuous gentle slope below and above the water line, can be protected well by a marsh sill, whereas a high sediment bank, with a steep slope, can't. A swamp forest works well with certain vegetation (*i.e.*, cypress trees), but since there is no bank to stabilize, a bulkhead would not be a good match. We'll point out the good matches throughout the document.

Right column: Shoreline Types (top to bottom): swamp forest, marsh, oyster reef, low sediment bank, high sediment bank.

You'll notice that two shoreline types, marshes and oyster reefs, are also included in our list of erosion control methods. That's because they have the ability to stabilize the shoreline on their own. If your property includes a marsh that is partly underwater at high tide or during a wind tide, the marsh vegetation traps the sediment washed in by the tides, and their dense root system holds it in place. Marsh vegetation dies back and roots become incorporated into the sediment, further building the foundation for sustaining marsh growth. Together, these self-perpetuating processes counter erosion by dissipating waves and adding sediment.

Natural salt marsh, Masonboro Island, N.C.

If you have an oyster reef, it accumulates shell material and traps sediment landward of the reef, adding fill and maintaining the shoreline.

STEP 4: UNDERSTAND THE PERMIT PROCESS

Your State Representative

While it may seem complicated, the permitting process is actually streamlined and efficient, and can be finished within two weeks. The representatives from DCM who come to look at your property can be very helpful. They are a part of the Department of Environmental Quality (DEQ) and have permitting responsibilities under the Coastal Area Management Act (CAMA). The permit reps have the same goals you have: to keep you and your property safe and the estuary healthy.

Surveying, Wilmington, N.C

Types of Permits and Costs

Marsh sills, riprap revetments, and *bulkheads* can require a general or a major permit; *oyster reefs* require a major permit; *breakwaters* require a major or general permit, and *vegetation* can require a major, minor, or general permit, or none at all. **General permits** are used for projects that have relatively small impacts on the environment, and the process usually involves contact with only DCM. A **major permit** is used for large projects and those requiring review and permits from other state or federal agencies.

If your project requires a major permit DCM reps will be there to assist you from start to finish. Depending on the scope of your project, your location, and the permits required, you (or your contractor, engineer, or consultant) may need to interact with as few as one or as many as 14 federal and state agencies, such as USACE (United States Army Corps of Engineers), North Carolina DMF (Division of Marine Fisheries), or North Carolina DWR (Division of Water Resources). A list of all 14 agencies and links to their websites appear at the end of this guide, along with a brief explanation of their purpose.

DCM permits cost between $100 and $400, and additional charges may be encumbered depending on the permit requirements of the agencies involved.

Doing It Yourself vs. Bringing in the Professionals – or Both

Two erosion control alternatives, vegetation and oyster reefs, lend themselves to being Do It Yourself (DIY) projects. Consider your personal situation: do you have more time than money? If so, then pay particular attention to the vegetation and oyster sections to see if they fit your project goals.

The other options – riprap revetments, marsh sills, bulkheads, and breakwaters – will probably require the services of a contractor or coastal engineer. These options can be supplemented by planting vegetation or adding hard material that supports oyster growth, such as oyster cultch

(shell material), limestone or granite, so you can include some DIY involvement if you choose.

Bulkhead with marsh, Beaufort, N.C.

If you think you'll need a contractor but haven't hired one yet, read through this guide, note the kinds of experience and skills you're looking for, and then call DCM. Ask your rep for a list of local contractors, then ask your neighbors, friends, and real estate agent for their recommendations.

Contractors tend to specialize in one stabilization type based on their experience and the equipment they own or can readily access. Not surprisingly, that will be the method they recommend, and they may not take into account all the specifics regarding your property and the impact you choose to have on the estuary.

Reading through this book will help you decide on the stabilization method that best meets your needs and make you a more informed client, as well as add to your appreciation of your local ecosystem.

If you're already working with a contractor, keep in mind that experts agree that to preserve the existing shoreline type and ecosystem, the location of the erosion control method on your property is more important than the actual method. So if you're installing a bulkhead or riprap revetment, the more landward it can be placed, the better. Again, your DCM rep can size up your and provide options to support your preferences.

Bulkhead under construction, Radio Island, N.C.

Being a Good Neighbor

Under CAMA **permitting guidelines**, you must demonstrate to DCM that you have contacted all adjacent property owners and notified them about your plans. This can be done in two ways: submit 1) signed letters of no objection; or 2) a certified mail return receipt form. Your neighbor will have 10 days upon receipt of your letter to submit comments to DCM on your planned work. If your neighbor fails to submit a response, this is interpreted as "no objection."

Neighboring properties with different erosion protection approaches

Where to Find a DCM Rep

Whatever your situation, you'll be doing yourself a favor to get DCM involved from the start. Local offices and phone numbers are listed below.

Contact Information for DCM

- **Elizabeth City:** 252-264-3901
- **Morehead City:** 252-808-2808
- **Washington:** 252-946-6481
- **Wilmington:** 910-796-7215

For More Information

DCM contact information and in-depth information about the permitting process can be found at nccoastalmanagement.net.

STEP 5: KNOW YOUR TIDES

Estuarine water levels are extremely variable, due to storm and wind events, seasonal changes, and astronomical cycles. For example, in North Carolina's estuaries, the normal water level is seven inches higher in September than in January. The "normal" high tide line indicates where the high tides reach about half the time, which means the other half of

the time tides are higher than the normal high tide line. Add this variability to the current trend of rising sea level, and it's a good idea to install shoreline stabilization structures such as bulkheads and riprap as high on the shoreline as possible. This will add to their longevity and help protect the natural resources seaward of your property.

Now, let's look at potential erosion control options that work for you.

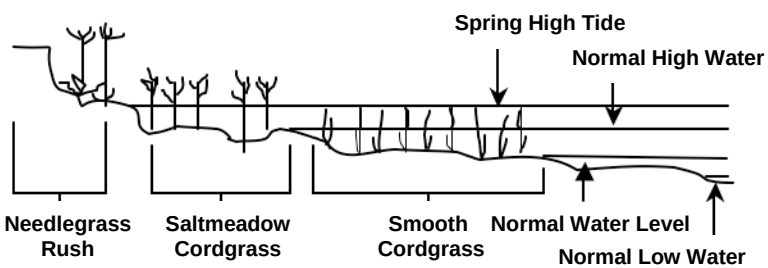
Oyster reef, Middle Marsh, N.C.

VEGETATION

What is it and how does it work?

Salt tolerant plants, such as smooth cordgrass, saltmeadow cordgrass, and needlegrass rush, are planted along the shoreline in 10 to 40-foot-wide patches, forming a marsh fringe. Once the marsh is established, it is very effective at blocking wave energy. A 15-foot-wide marsh can reduce the incoming wave energy by over 50 percent. The roots of the vegetation can extend a foot or more below the surface and further stabilize the shoreline.

Vegetation



Best property for that…

- has low-energy shoreline
- has little boat wake traffic
- has a gentle, wide slope (low sediment bank)
- faces a fetch (the distance over water that the wind blows) of less than 3 miles or, if fetch is more than 3 miles, is protected from waves by sandbars or shallow mudflats
- if fetch exceeds 1 mile, an oyster reef, coir log, riprap, or sill may help stabilize the plants (see photos at top of next page)

Vegetation

Vegetation with coir logs

Vegetation with oysters

Vegetation with rocks

Out-of-pocket costs & considerations

Factors in determining cost:

- cost of labor
- number of plants
- need for replanting
- fill and grading
- shipping
- landscaping feeds
- cost of coir logs, marsh toe or sill (if recommended)

For current pricing estimates go to the Estuarine Shorelines page on the DCM website: http://portal.ncdenr.org/web/cm/estuarine-shorelines

Consider: Vegetation planting lends itself to a DIY project. Plants are sold by the "plug," and average measurements are 4" x ½" or 2" x ½". Depending on the size of the plug, you'll need at least one or two cordgrass plants for every four square feet of property you want to plant, and one to three saltmeadow plants for every two square feet. A motivated person can plant 1,000 plugs in a day; another tactic is to enlist a few friends and encourage them to plant 3,000 plants in about five hours; yet another approach is to hire local labor. Planting between March and June will give the plugs time to stabilize before the winter storms and increase the likelihood of success. However, if you require coir logs, a landscaper must install those and a major permit is required. A coir log is interwoven fibers bound together with biodegradable netting. The log stabilizes a site while vegetation becomes established. They cost about $100–$150 each for a 12" x 10' log, and installation is approximately $50. If you need to add riprap to the marsh toe, you'll need a contractor to install that structure.

Maintenance: Vegetation planting may require weed control in low salinity areas, replacement of dead and missing plants, and post-storm inspection.

Longevity: Planted salt marshes can last for decades, although storm events or changes in site water movement and wave energy may shorten their lifespan. However, if plants are lost as a result of a storm event, as long as the sediment bank remains relatively unchanged, a replant can be done at fairly low cost. Also, vegetation can often recover on its own. Results will vary depending on a variety of site-specific factors, including storm events, local rates of relative sea level rise and sediment availability. Coir logs have a 6-12 year lifespan.

Permits: No permit is necessary for vegetation planting unless you need to fill or grade your property before planting. A minor permit is needed for fill or grading above the normal water level, and a major permit is required for fill or grading below the normal water level. Coir logs require a major permit and marsh toes require a general permit. A minor permit will cost $100 and a major permit will cost $400.

Ecosystem costs & considerations

= Good, benefits the ecosystem = Fair, may be tradeoffs

= Poor, reduction or loss in service

Ecosystem Service	Effect of Vegetation Planting on Ecosystem Value	
Reduce erosion		marshes dissipate wave energy, provide stability, and trap sediments
Water quality		marsh systems filter runoff and improve water quality
Animal habitat		salt marshes provide food and protection for finfish, shellfish, mammals, and shorebirds
Fish production		marshes provide protection and habitat for juvenile fish
		adult fish prowl the edges of salt marshes seeking prey
Ecosystem diversity		vegetated habitats in the intertidal zone increase plant and animal species diversity
Carbon storage		marshes trap sediment and bury belowground carbon, removing CO_2 and storing carbon for centuries
Recreation		planting a salt marsh will replace beach area
		if you want a pier, it must be 3 feet above the substrate

Sample project costs

Specifications	Project 1: Full Service Landscaper	Project 2: DIY
Region	Pamlico Sound	Swansboro
Shoreline exposure	long fetch (5 miles)	short fetch (1/2 mile)
Length of property	500 feet	100 feet
Width of proposed marsh fringe	40 feet	20 feet
Cordgrass/saltmeadow/ needlegrass	20 x 10 x 10 feet	13 x 7 x 0 feet
Fill required	1 ton	none
Permit	major	none
In-water stabilization	coir logs	none
Estimated cost	$25,000	$750

Possible combinations

- Vegetation landward of oyster reefs and breakwaters
- Vegetation seaward of bulkheads and riprap
- Marsh sills

Did you know?

Planting vegetation is the cheapest and most environmentally sound stabilization method available.

Low salinity marsh, Kitty Hawk Bay, N.C.

In 2014, N.C. commercial fisherman landed more than 50 million pounds of finfish and shellfish, resulting in an industry valued at nearly $80 million per year (NCDMF Harvest Statistics)

Fishing for red drum, Newport River, N.C.

OYSTERS

(also called oyster reefs, sills, beds, patches and toes)

What are they and how do they work?

Oyster reefs form natural breakwaters and protect shoreline property from erosion and storm damage. They are often used in conjunction with one of the other shoreline control types discussed in this guide and may be added to a pre-existing shoreline erosion project. Reefs are built by adding material to the water, such as small bags of oyster shells, loose oyster or clam shells, riprap, marl, or other suitable substances. The material attracts oyster larvae, which settles and creates a live reef. Permitting representatives will visit your site and help you determine the type of stabilization method and materials that will be needed based on site-specific characteristics.

Generally, if you live in the northern part of the state, a subtidal oyster reef may be appropriate; if you live in the central or southern region, an intertidal reef is another option to consider.

Oyster reef, New River, N.C.

Barge dispersing cultch, Pivers Island N.C.

Best for property that...

- is on water with known oyster productivity

Out-of-pocket costs & considerations

Factors in determining cost:

- access to water
- whether the location of the reef is subtidal or intertidal
- cost of reef material (concrete, marl, or granite)
- availability and cost of oyster cultch (shells produced by living organisms designed to provide points of attachment for oysters)
- cost of transporting material to site
- rental of barge and dispersal of loose cultch or bags
- rental of barge and dispersal of loose cultch or bags
- labor to carry bags or other structures into water
- labor to fill bags

For current pricing estimates go to the Estuarine Shorelines page on the DCM website: http://portal.ncdenr.org/web/cm/estuarine-shorelines

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Consider: The design of your oyster reef and the material used need to be appropriate for your property type. For example, light material in a high-energy area will be scattered, and heavy material on a site with deep, soft mud will sink until enough material is deployed to stabilize the site which can be very expensive. Rock and marl can be used for lower layers and capped with cultch to help minimize costs. Remember to factor in the cost of transporting material. Also, in some situations it will make sense to hire a barge and dispersal unit and approach the project area from the water. If there is easy access to the site from your property for large equipment, a trailer would be the better choice.

Maintenance: Assuming your site and environmental conditions are suitable, oysters may take up to a year to cement into a living reef. Before they do, shells may be lost or shift following a storm, and they can be buried with normal wave action. If this occurs they will need to be replaced. Once the reef is established it can become self-sustaining.

Longevity: Once established, oyster reefs are extremely durable and may last for 50 years or longer.

Permits: Contact DCM when planning your oyster structure. You will need DCM, USACE, DMF, and DWR guidance and approval for any oyster project that involves deployment of material into North Carolina coastal waters. These projects typically will require a major permit which costs $400.

Possible combinations

- Oyster reef with landward marsh
- Oyster toe on bulkheads
- Oyster cultch added to intertidal riprap and breakwaters

Oyster reef with landward marsh, Gallants Channel, Beaufort, N.C.

Ecosystem costs & considerations

Ecosystem Service	Effect of Oysters on Ecosystem Value	
Reduce erosion		oyster reefs dissipate wave action, trap sediment and add shell material to living reef to maintain elevation relative to sea level rise
Water quality		oysters filter runoff and improve water quality
Animal habitat		reefs provide habitat for shrimp, crabs, clams, snails and worms, as well as many finfish
Oyster production		if you live in an "approved" harvest area, as specified by DEQ based on input from the FDA, oysters can be harvested from the reefs or areas nearby during the open season, usually Oct. 5 – May 15. If you deploy oyster cultch and oysters successfully grow on your reef, the general public is entitled to harvest those oysters.
		growing areas can be permanently or temporarily closed to harvest due to poor water quality and public health concerns
Fish production		reefs provide additional habitat for fish
Ecosystem diversity		oyster reef structure increases animal species diversity at the shoreline

Carbon storage		oysters remove carbon through the process of filtering and feeding, but produce carbon during shell formation
Recreation		cleaner water results in increased recreational use
		oyster shells are sharp under foot, reducing beach access

Oyster reef with marsh, Middle Marsh, N.C.

Sample project costs

Specifications	Project 1	Project 2
Region	Albemarle Sound	Bogue Sound
Shoreline exposure	long fetch	low wave energy
Length of property	208 feet	150 feet
Number of mounds	20 mounds, 20 feet each, placed in checker-board pattern	n/a
Distance from shoreline	50 feet	20 feet
Construction material	concrete, marl and loose shells	bags of cultch
Professional help	marine contractor and barge operator	labor to fill bags; barge operator to disperse bags
Estimated costs	$25,000 + permits	$3,700 + permits

Did you know?

Oyster reef, Core Sound, N.C.

A single adult oyster is capable of filtering up to 50 gallons of water per day.

Oysters support the production of commercially viable species, such as blue crabs and finish, valued at 62 million annually (nccoast.org).

DMF provides drop off sites to the public for recycling oyster shells. A list of drop off sites can be found here:

http://portal.ncdenr.org/web/mf/public-oyster-shell-recycling-locations

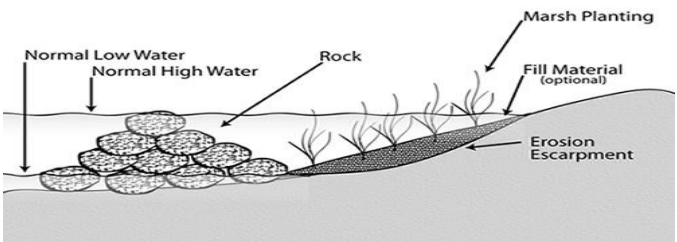
MARSH SILLS

What are they and how do they work?

A marsh sill is a combination of a protective barrier placed in the water parallel to the shoreline and a 10 to 30-foot-wide strip of vegetation planted (or pre-existing) on shore. The sill - constructed of sloping stone, oyster shell, or wood - acts as a barrier by breaking wave energy and allowing the marsh to grow and the marsh further absorbs wave energy and prevents erosion. Most sills have a low profile, usually rising only six inches above the water at high tide; this allows waves to pass over and through it, providing nutrient-rich sediment to the marsh. The sill's intermittent openings allow fish to swim into the marsh and feed.

Marsh Sill

VIEW FROM SIDE



Best for property that...

- has shoreline facing a fetch of 1 to 10+ miles
- has relatively shallow water
- has a low sediment bank or existing marsh
- is in an area experiencing moderate boat traffic and boat wake effects

Out-of-pocket costs & considerations

Factors in determining cost:

- equipment access
- stone work
- site work (bottom preparation, land fill)
- access to water
- material (wood, stone, concrete riprap, marl)
- labor for planting
- cost of transporting materials to site
- cost and type of plants

For current pricing estimates go to the Estuarine Shorelines page on the DCM website: http://portal.ncdenr.org/web/cm/estuarine-shorelines

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Consider: Depending on the county, the North Carolina Community Conservation Assistance Program (CCAP) may provide assistance for marsh sill projects and reimburse landowners up to 75% of their costs up to a maximum of $5,000. Applications are submitted through local soil and water conservation districts. For more information, visit http://www.ncagr.gov/SWC/costshareprograms/CCAP/index.html

Maintenance: Depending on material used, a marsh sill may require repair following a storm. Plants may have to be replanted until the marsh is well-established, even if no storms occur.

Longevity: The planted marsh associated with a sill can last for decades and can be replanted if needed. Granite structures are extremely durable and may persist for 50 years or longer. Results will vary depending on a variety of site-specific factors, including storm events, local rates of relative sea level rise and sediment availability.

Permits: A marsh sill can require either a major or a general permit depending on the scale of the project. A general permit will cost $200 and a major permit will cost $400.

Marsh sill, N.C.

Ecosystem costs & considerations

Ecosystem Service	Effect of Marsh Sills on Ecosystem Value	
Reduce erosion		marsh sills absorb and dissipate wave energy, and marsh vegetation traps sediments, which counters sea level rise
		sills can sometimes reflect wave energy, causing erosion issues in adjacent locations
Water quality		marsh systems filter runoff and improve water quality
Animal habitat		a sill acts as a condominium for aquatic species, often colonized by oysters
		installing a sill may cover habitat of species occupying shallow tidal flats
Fish production		marshes provide protection and habitat for juvenile fish
Ecosystem diversity		If built on a sandy beach, the addition of marsh and shallow habitat may attract new bird and fish species
		a marsh maintains the land-sea connection for animal access
Carbon storage		marshes trap sediment and bury belowground carbon, removing CO_2 and storing carbon for centuries
Recreation		marshes attract fish and wildlife, increasing bird watching and fishing opportunities
		beach habitat is replaced by a marsh sill system
		may increase length of dock required to reach open water

Sample project costs

Specifications	Project 1	Project 2
Region	Pamlico Sound	Grapevine Bay
Shoreline exposure	long fetch	low wave energy
Length of property	150 feet	500 feet
Base width of sill	9 feet	15 feet
Distance from shoreline	20 feet	75 feet
Construction material	wood	limestone
Width of marsh	20 feet	40 feet
Area of planned marsh	3,000 square feet	48,000 square feet
Permit	general	major
Estimated cost	$3700 + permits	$25,000 + permits

Possible combinations

- Marsh sill and oyster reef

A life oyster reef grows seaward of the marsh, Pivers Island, N.C.

Did you know?

Salt marsh soils and grasses protect the shoreline by buffering waves, absorbing excess water, and slowing down storm surges.

Zeke's Island Reserve, N.C.

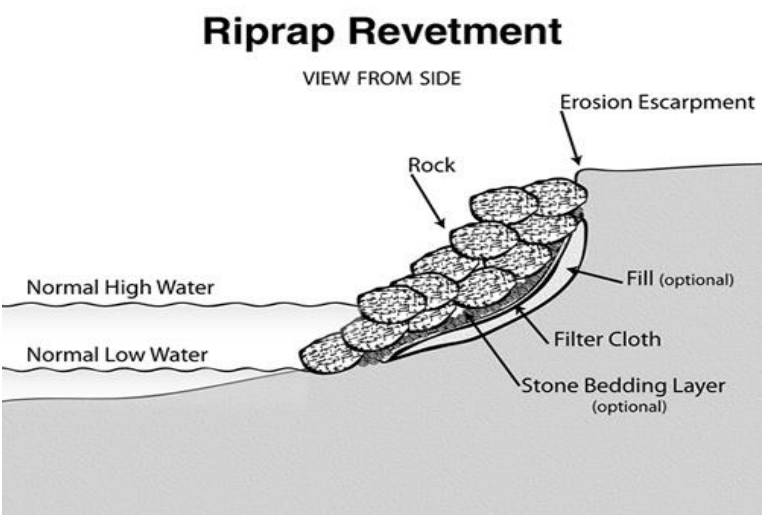
Two-thirds of the fish and shellfish caught in the U.S. depend on estuaries for their survival. (nerra.org)

RIPRAP REVETMENT

(also called a revetment, sloping revetment and shoreline hardening)

What is it and how does it work?

Riprap forms a protective, sloping barrier between the water and land. Usually constructed of heavy stone and lined with a permeable sheet, riprap breaks wave energy and prevents soil from eroding. The angle of the riprap is determined by expected wave height, but is commonly 3:1 to 1.5:1 (horizontal: vertical). The larger the expected waves, the flatter the riprap and the heavier the stones need to be.



Best for property that...

- faces moderate to high wave energy

Out-of-pocket costs & considerations

Factors in determining cost:

- access to shoreline
- material: broken concrete; marl, granite
- depth of water
- source of stone and delivery distance
- size of stone
- fill
- bedding layer
- height
- distance riprap extends from shoreline

For current pricing estimates go to the Estuarine Shorelines page on the DCM website: http://portal.ncdenr.org/web/cm/estuarine-shoreline

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Consider: Broken concrete that is free of rebar is a cheaper type of material that can be used as a base and then "dressed up" with granite. Granite weighs four times as much as limestone, but can cost twice as much. If you are in a high wave energy location, granite may be necessary due to its increased weight.

Maintenance: Stones or rocks will settle and readjust with storms or waves and occasionally will need replacing. Limestone will be displaced much more easily than granite.

Longevity: Riprap is durable and installations can last for several decades, although storm events may shorten the lifespan of riprap installations. Granite is more durable than marl.

Permits: Riprap can require either a general or a major permit depending on the scale of the project. A general permit will cost $200 and a major permit will cost $400.

Riprap revetment with grasses and lawn, N.C.

Ecosystem costs & considerations

Ecosystem Service	Effect of Riprap on Ecosystem Value	
Reduce erosion		if properly built, riprap revetments provide protection from wave energy
		reflected waves may cause scour or erosion of adjacent property
Water quality		riprap revetments can protect existing vegetation, which helps improve WQ but reduces the expansion of vegetation seaward of the ripap
Animal habitat		can add to habitat complexity by introducing new surface material (*e.g.*, barnacles and oysters)
		a sloping surface causes a wider footprint that extends further waterward, covering shallow water habitats
Fish production		alteration of habitat may cause a reduction in fish population
Ecosystem diversity		riprap alters the bottom habitat, replacing soft bottom with hard, reducing plant and animal diversity and abundance
		reduces diversity and abundance of birds and shellfish, among other species
Recreation		can be used adjacent to deep water for easy boat access
		may reduce beach area

Sample project costs

Specifications	Project 1	Project 2
Region	Pamlico Sound	Wilmington area
Shoreline exposure	5 mile fetch	low wave energy
Length of riprap	150 feet	500 feet
Depth of water at high tide	4 feet	10 feet
Height of riprap	2 feet	5 feet
Construction material	broken concrete; marl	granite
Permit	general	major
Estimated cost	$13,500	$75,000

Possible combinations

- Riprap and marsh
- Riprap and oyster reef
- Riprap and bulkhead

Did you know?

The coast of North Carolina is composed of roughly 7,400 miles of marsh habitat (2012 Estuarine Shoreline Mapping Analysis Report).

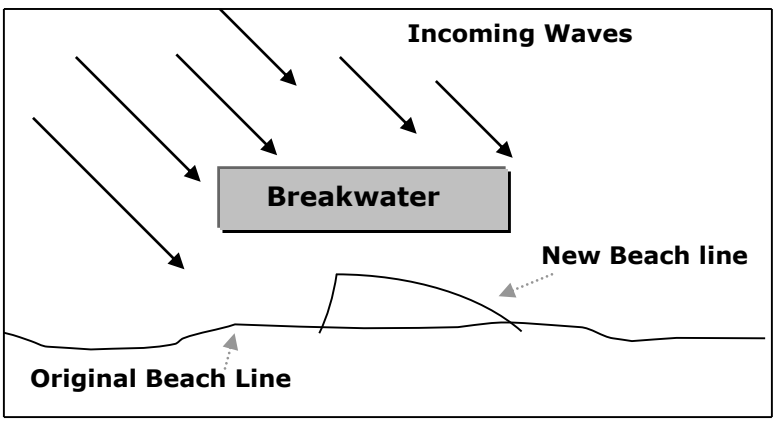
Natural salt marsh, New River, N.C.

BREAKWATERS

(also called a wave break, wave fence, or hardened structure)

What are they and how do they work?

A breakwater is a stone structure placed in the water parallel to the shoreline. As the name implies, it "breaks" the strength of the incoming waves, resulting in a weaker wave reaching land, lessening erosion. For a longer stretch of shoreline, a series of breakwaters can be set up side by side at regular intervals, with the gap between them equal to the length of one breakwater. Sand often fills that gap, creating a small beach between the breakwater and the land.



Best for property that...

- experiences moderate to high wave action
- experiences boat wake traffic *and* sand moving down the shore

Out-of-pocket costs & considerations

Factors in determining cost:

- depth of water
- access to the water
- length and number of structures
- depth of water
- equipment necessary
- material (granite, wood, or concrete)

For current pricing estimates go to the Estuarine Shorelines page on the DCM website: http://portal.ncdenr.org/web/cm/estuarine-shorelines

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Consider: Breakwaters can require either a major or minor permit, and costs will include services provided by an environmental consultants and engineer to design the structure. They are generally more expensive than other hardened structures, such as a bulkhead or riprap, because of the volume of stone and the cost of installing the breakwater in open water.

Maintenance: Water can move rock, especially in Albemarle Sound. Inspection after a storm is recommended.

Longevity: If appropriately weighted rock is used, a breakwater can last for over 40 years.

Breakwaters, Bogue Sound, N.C.

Permits: A breakwater will require either a general permit or a major permit depending on the scale of the project. A general permit will cost $200. A major permit will cost $250 with no fill and $400 with fill.

Ecosystem costs & considerations

Ecosystem Service	Effect of Breakwater on Ecosystem Value	
Reduce erosion		effectively dissipates wave energy
		sand that accumulates and forms a beach landward of a breakwater is often "stolen" from shorelines down drift of the property.
		waves reflected from breakwaters may cause scour or erosion of adjacent shorelines,
Water quality		no significant effect
Animal habitat		the beach and rock replace valuable shallow-water fish habitat, but introducing new surface material can increase habitat complexity (e.g., barnacles and oysters)
Fish production		reduction in habitat causes reduction in fish population
Ecosystem diversity		breakwater material alters the bottom habitat, replacing soft bottom with hard, reducing plant and animal diversity and abundance
Recreation		a new beach is formed although the breakwater reduces access

Sample project costs

Specifications	Project 1	Project 2
Region	Albemarle Sound	Cedar Island
Shoreline exposure	long fetch	low wave energy
Length of breakwater	150 feet	2 x 10 feet
Depth of water at high tide	4 feet	4 feet
Height of breakwater above high tide level	2 feet	1 foot
Construction material	stone	stone
Permit	major	major
Estimated cost	$25,000	$5,000

Did you know?

The heathier the shoreline is in North Carolina, the more likely there will be positive impacts to the tourism and recreation industry in the state (NCCF).

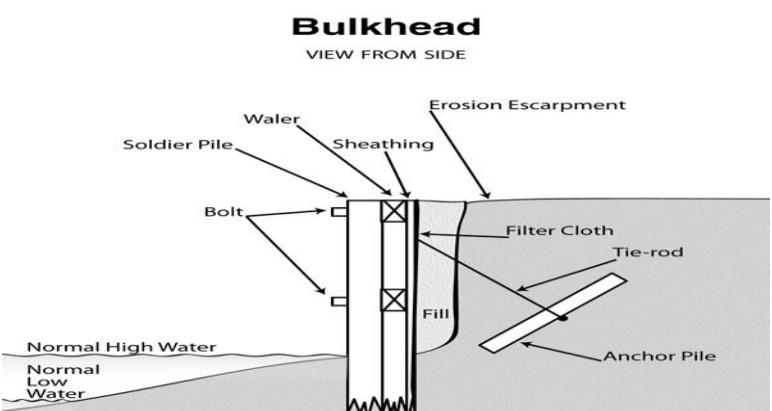
Canoeing in the Newport River, N.C.

BULKHEADS

(also called shoreline hardening, armoring, and seawall)

What are they and how do they work?

A bulkhead is a vertical structure, much like a solid fence, built on the water-side of an eroding shoreline and anchored into the eroding bank. Once erected, the gap between the bulkhead and a nearby highpoint on the property is filled in with soil. The bulkhead holds the soil in place by acting as a barrier between the waves and the property. It can be built of wood, vinyl, steel, concrete or fiberglass.



Best for property that...

- is exposed to high wave energy
- has significant, existing erosion

Out-of-pocket costs & considerations

Factors in determining cost:

- access to the water
- equipment necessary
- shoreline conditions
- length of bulkhead
- contractor workload
- minimizing impacts on existing seagrass, oysters, or marsh
- amount of backfill required
- material (wood, concrete, steel, fiberglass, or vinyl)
- number and complexity of tiebacks necessary
- height of wall
- if required, adding riprap in front of bulkhead

For current pricing estimates go to the Estuarine Shorelines page on the DCM website: http://portal.ncdenr.org/web/cm/estuarine-shoreline

Consider: As expected from the number of factors to consider in building a bulkhead, the range in price is huge: $100–$1,200 per linear foot, with residential prices about $135 / foot. The taller the bulkhead needs to be, the more expensive it will be.

Maintenance: Backfill must be retained for the bulkhead to function. Cracks or holes in the bulkhead allow soil to escape, which weakens support and could lead to possible collapse. Periodic inspections are recommended. Wood is the most difficult material to repair.

Longevity: Longevity depends on type of construction and local site conditions, particularly storm events. The usual lifespan for bulkheads can range from 10 to 40 years, with wood falling at the lower end of the range, concrete in the middle, and vinyl/fiberglass at the upper end.

Permits: A bulkhead can require a general or major permit depending on the scale of the project. A general permit will cost $400 and a major permit will cost $400.

Ecosystem costs & considerations

Ecosystem Service	Effect of Bulkheads on Ecosystem Value	
Reduce erosion		if properly built bulkheads provide protection from wave energy
		wave energy is reflected rather than absorbed and reflected waves may cause bottom scour and loss of vegetation
		*if vegetation is removed*: natural buffer to ease waves and stabilize sediments is eliminated
Water quality		if bulkhead base is in the intertidal zone, there is an opportunity to plant vegetation that can provide effective filtering and improve water quality
		*if vegetation is removed*: loss of marsh filtering capacity and reflected wave energy may increase re-suspension of sediments into water column
Animal habitat		block the land-sea connection between terrestrial and aquatic habitat
		loss of shallow water habitat
Fish production		barnacles and oysters often settle on bulkheads, providing food for fish
Ecosystem diversity		stops the natural creation of wetlands
		Bulkheads reflect incoming wave energy and may cause scouring of the bottom of the structure which stops vegetation from becoming well-established and reduces diversity
Recreation		provides easy access to deep water

Bulkhead constructed using vinyl, Pivers Island, N.C.

Sample project costs

Specifications	Project 1	Project 2
Region	Wrightsville	Ocracoke
Shoreline exposure	high wave energy	long fetch
Length of bulkhead	150 feet	50 feet
Depth of water at high tide	6 feet	4 feet
Height of bulkhead above high tide level	5 feet	2 feet
Construction material	fiberglass	wood
Permit	major	general
Estimated cost	$90,000	$7,000

Possible combinations

- Bulkhead and waterward marsh
- Bulkhead and riprap
- Bulkhead and oyster toe

Did you know?

Estuaries provide habitat for more than 75 percent of America's commercial fish catch and 80 to 90 percent of recreational fish catch (U.S. EPA).

Vinyl bulkhead with waterward marsh, N.C.

PUTTING IT ALL TOGETHER

Choosing the best shoreline erosion control option for your property is an important decision. In addition to reducing property loss, erosion control methods have ecological consequences, cost factors, and aesthetic implications. This booklet has been designed to provide you with an overview of your alternatives so that you can make informed decisions about your choices.

Now that you've read the handbook, you have a solid foundation of information. You can speak with representatives from the North Carolina Division of Coastal Management and/or your contractor about issues of concern and work with them to select the most appropriate erosion control method for your property.

By taking an interest in your shoreline, you are helping to protect and preserve the exceptional beauty of North Carolina's estuaries for generations to come.

Potential state and federal agencies that may be involved with your erosion control construction and area of oversight

North Carolina

- Department of Administration, State Property Office **(NCDOA – SPO)** administers the acquisition and disposition of all state-owned land or any interest by deed, lease, easement, or allocation; manage the state's submerged lands; and maintain an accurate inventory of state lands and buildings.
  http://www.doa.state.nc.us/spo/
- Department of Natural and Cultural Resources, Division of Archives and History (**NCDNCR – Archives & History**) collects, preserves, and utilizes the state's historic resources so that present and future residents may better understand their history.
  www.history.ncdcr.gov/
- Department of Commerce, Division of Community Assistance (**NC Commerce – DCA**) provides a variety of resources and services for economic prosperity, growth management, and customized community development assistance.
- Department of Transportation, Division of Highways (**NCDOT**) protects state wetlands and waterways through the Highway Stormwater Program and the Division of Mitigation Services.
  ncdot.gov/doh/
- Department of Environmental Quality (**DEQ**) serves as the lead stewardship agency for the protection of North Carolina's environmental quality.
  ncdenr.gov/web/guest/home

Divisions within DEQ include:

- Division of Coastal Management (**DCM**) works to protect, conserve and manage North Carolina's coastal resources in the 20 coastal counties, through an integrated program of planning, permitting, education and research. DCM regulates development, helps plan for future growth, and manages the state's coastal reserves.
  nccoastalmanagement.net
- Division of Marine Fisheries Shellfish Sanitation Section ensures the safety of consumers of molluscan shellfish by monitoring harvesting waters and ensuring the proper handling of shellfish sold to the public.
  http://portal.ncdenr.org/web/mf/shellfish-sanitation-and-recreational-water-quality
- Division of Water Resources (**DWR**) ensures safe drinking water in accordance with federal requirements, issues pollution control permits, monitors permit compliance, evaluates environmental water quality and quantity, and carries out enforcement actions for violations of environmental regulations.
  http://portal.ncdenr.org/web/wq/dwr-home-page
- Division of Energy, Mineral, and Land Resources seeks to promote the wise use and protection of North Carolina's land and geologic resources.
  http://portal.ncdenr.org/web/lr/
- Division of Marine Fisheries (**DMF**) is dedicated to ensuring sustainable marine and estuarine fisheries and habitats for the benefit and health of the people of North Carolina.
  http://portal.ncdenr.org/web/mf/
- Wildlife Resources Commission (**WRC**) conserves North Carolina's wildlife resources and their habitats and provides

programs and opportunities that allow hunters, anglers, boaters, and other outdoor enthusiasts to enjoy wildlife-associated recreation.
http://www.ncwildlife.org/

United States

- Environmental Protection Agency (**EPA**) protects human health and the environment.
  http://www.epa.gov/
- Fish and Wildlife Service (**USFWS**) works to conserve, protect and enhance fish, wildlife, and plants and their habitats for the continuing benefit of the American people.
  http://www.fws.gov/
- National Marine Fisheries Service (**NMFS**) is responsible for the stewardship of the nation's ocean resources and their habitat.
  http://www.nmfs.noaa.gov/index.html
- Army Corps of Engineers (**USACE; ACE; the Corps**) delivers vital public and military engineering services; partnering in peace and war to strengthen our Nation’s security, energize the economy and reduce risks from disasters.
  http://www.usace.army.mil/

Worksheet

Answer these questions as best you can. Identifying certain characteristics that make it better suited to specific erosion control options will help you learn a lot about your property. As you're reading through the guide, you can compare the information about your property with the suitability of each alternative.

1. What is your shoreline type? (refer to photos on page 4)

a) Swamp Forest (are there cypress gum trees?) _____

b) Marsh (are there salt water-tolerant plants?) _____

c) Oyster reef (do you have oyster reefs?) _____

d) Sediment Banks (is there no vegetation?) _____

1. Low sediment bank (is there a gentle slope above the water line, less than 3 feet over 5 yards?) _____
2. High sediment bank (is there a steep slope above the water line, more than 3 feet over 5 yards?) _____

e) Combination (*e.g.*, swamp is upland from a marsh; marsh is landward of an oyster reef) _____

2. Do you know what is causing the erosion?

Yes____ No ____

If **yes**, what is the cause?

a) boat wake____ b) storms____ c) wind tides ____

d) gradual effects ____ e) other (please describe) _____

3. What direction(s) does your shoreline face?

N ____	S ____
NE ____	SW ____
E ____	W ____
SE ____	NW ____

Note: In eastern North Carolina, the direction of strong winds is fairly predictable. *If you marked N, SW, NE, W, or S as your answer to 3, pay attention to question 4.* The combination of exposure to strong wind and high fetch can direct you to certain erosion control alternatives.

4. How much fetch does the property face?
(i.e., how much water does the wind blow over before it reaches your property?)

a) less than ½ mile (low fetch) ____

b) more than ½ mile but less than 2 miles (medium fetch) ____

c) more than 2 miles (high fetch) ____

5. How much wave energy is hitting the shoreline?
(i.e., how high do the waves come up the shoreline above the normal high tide mark?)

a) from boat traffic _____ feet

occasionally? _____ frequently? _____

b) during a storm _____ feet

occasionally? _____ frequently? _____

Note: Properties with long fetch and deep water will usually experience high wave energy; properties with a long fetch but shallow water,

vegetation, or sandbars directly in front of the shoreline usually experience moderate wave energy.

6. What is the length of the shoreline that needs protecting?

Feet _____

7. What are your neighbors doing?

a) to the left _____

b) to the right _____

8. What body of water does your property touch?

_____

9. What is the slope of your property?

a) gentle _____

b) steep _____

10. Which of the following activities are important to you?

a) fishing ____

b) hunting ____

c) bird watching ____

d) boating ____

e) enjoying nature ____

f) swimming __

11. Which of the following ecosystem services are most important to you?

a) pollution control ____

b) wildlife habitat ____

c) water quality ____

d) surge and flood protection ____

12. How long do you plan to be at this property?

_____

Notes

For more information, visit the following websites:

N.C. DCM: *nccoastalmanagement.net*
North Carolina Coastal Reserve & National Estuarine Research Reserve (NCNERR): *nccoastalreserve.net*
NOAA Center for Coastal Fisheries and Habitat Research: *http://coastalscience.noaa.gov/about/centers/ccfhr*

Photo credits:
Page 11 - *vegetation with coir log*: Photo c/o the Partnership for the Delaware Estuary, *vegetation with rocks*: Photo c/o Rachel Gittman
All other photos courtesy of DEQ and NOAA

References:
N.C. Department of Environmental Quality Division of Marine Fisheries - Harvest Statistics. (n.d.). Retrieved November 10, 2015, from http://portal.ncdenr.org/web/mf/marine-fisheries-catch-statistics

Living Shorelines | N.C. Coastal Federation. (n.d.). Retrieved November 10, 2015, from http://www.nccoast.org/how-we-work/restore-preserve/living-shorelines/

N.C. Department of Environmental Quality Division of Coastal Management - Estuarine Shoreline Mapping Project. (2012). Retrieved November 10, 2015, from http://portal.ncdenr.org/web/cm/estuarine-shoreline-mapping-project

N.C. Coastal Federation, *Coastal Restoration And Community Economic Development In North Carolina.* RTI International, 2015. Web. 10 Nov. 2015.

National Estuary Program Coastal Condition Report - NEP CCR Factsheet. (n.d.). Retrieved November 10, 2015, from http://water. epa.gov/type/oceb/nep/nepccr-factsheet.cfm

Thank you to all the North Carolina contractors, marine engineers, real estate agents, landscapers, barge operators, state and federal government employees, scientists, coastal consultants, economists, developers, insurance agents and estuarine property owners who contributed their time, knowledge and experience to this guide. Any errors or misrepresentations of our communications are the sole responsibility of the authors.