Program Title: Exploring Erosion Processes

Figure 1 Wind driven waves lapping an estuarine shore.

Program Abstract: The focus of this program is the over 12,000 miles of estuarine shoreline found in North Carolina. Estuaries provide a number of ecosystem services of value to humans. Vegetation found within the estuaries provide protection against storm surge and increased wave action, in addition to being home to numerous species of invertebrates, birds, frogs, turtles, and commercially significant fish and crab populations. Through this program we will investigate the role vegetation plays in mitigating the effects of storm surge and wave action, as well as providing a sanctuary to a host of organisms. Through field activities and classroom experimentation students will explore sediment erosion due to wind-driven wave energy and document the different shorelines found in coastal North Carolina.

Program Length: 1.5 hours

Grades: 6-12

NCDPI Standards: 6.E.2.4, 8.E.1.4, 8.L.3.1, 8.L.3.2, 8.L.3.3, EEn.2.1.3, EEn.2.2.1, EEn.2.3.1

Background: Erosion in our Estuaries

For class: UNC Coastal Studies Institute: Estuaries video:
https://vimeo.com/22518290

For the teacher: UNC CSI Science on the Sound Lecture:
https://www.youtube.com/watch?v=p5tvOYG5hy8&list=PLX09KgwgnTc7wIirstw3l_kN9yYh3UogG&index=9

Supplies Needed: Paint tray (1 per 2 students and 4 for the teacher to demonstrate the 4 types of sand, soil, stone, and marsh, 12x1" piece of astro-turf 1 per student and 1 for the teacher, container of sand, container of soil, container of gravel per team, pitcher for water, measuring cup (1 per team), wave generator (tupperware top), measuring tool in cm and stop watch

Prep: Collect mud, sand, and gravel samples, setup supplies

Framework:

Introduction: 15-minute presentation and video on shoreline types and erosion
Exploring Shorelines on the grounds of CSI: 15 minutes
Shoreline creation experiments: 15 min
Shoreline development competition: 45 min.

Slide 1: Introduction – Welcome to UNC CSI. We are a research and education institution that is part of the UNC system.

Slide 2: Today we will be talking about the different estuary types, the ecological services that estuaries provide, and identifying estuarine shoreline types. We will then head across the grounds to the Marine Operations Building (MOB). On our way we will look at and discuss the different shorelines right here at the facility. At the MOB we will see how shorelines stand up to wave action and discuss observations about the different shorelines. Lastly, you will be given a chance to construct your own shoreline and see how it stands up to erosion.

Slide 3: The coast of North Carolina has 325 miles of ocean shoreline. These are the beaches that make the Outer Banks famous, but they not the only shoreline on the coast. This is nearly 40x more estuarine shoreline than ocean, covering an area of 12,000 miles. Scientists from UNC CSI partnered with a state agency to map the intricate shoreline of our estuaries. You will see a video about this process in a few minutes.

Slide 4: It is important to note that there are three types of estuaries in North Carolina and that each type is unique in the habitats they provide and the ecological diversity of their make up. Some of the organisms found in these estuaries begin life in one type as a juvenile and move to another as they mature, and some eventually move out into the open ocean. Fish like shad and sturgeon are anadromous fish, which reproduce in rivers but live their lives in the ocean. Most eels spend their lives in fresh or brackish waters but go to sea to spawn. That makes them catadromous. The three types of estuaries found in North Carolina are the tributary, trunk, and back barrier sound. If we look right outside this building, what type of estuary can we see?

Slide 5: The estuaries in North Carolina provide important ecological services that are important to us. What is an ecological service? What fisheries do we rely on here in North Carolina?

Slide 6: The nitrogen cycle and the role of SAV and marshes have in removing nitrogen while producing oxygen.

The Nitrogen Cycle

In natural environments, nitrogen is frequently stored as decaying organic materials. It also is constantly being removed and added to both the biotic and abiotic environment in a complex biogeochemical cycle. "Fixed" nitrogen enters the biotic environment through the decay of organic materials (releasing amino acids, etc.), weathering, or from fixation by specialized bacteria. Generally, nitrogen is in the form of ammonium (NH_4^+) at this point and must undergo further modification to be more readily usable by plants. The process by which ammonia is converted to nitrites and nitrates is called **nitrification**. Two groups of microorganisms, *Nitrosomas* and *Nitrobacter*, drive this part of the nitrogen cycle. First, *Nitrosomas*bacteria utilize the ammonia available in soils as a source of energy. They metabolize the ammonia and promote its oxidation to nitrite ions and water. The nitrite-rich metabolic waste of these bacteria is then available as a food source for *Nitrobacter* bacteria, which oxidize the nitrite ions to nitrate. Plants then utilize nitrates for growth and respiration. Nitrogen taken up by plants is released as amino acids when the plant's tissue is eaten or the plant dies and begins to decay.

Slide 7: **De-nitrification**

Nitrogen is also lost from the biotic portion of the cycle in two ways—de-nitrification and mineralization of organic materials. Mineralization of decaying organic matter binds the nitrogen in the abiotic environment until weathering releases it. De-nitrification, or the reduction of nitrate to atmospheric nitrogen, is catalyzed under special, anaerobic conditions by denitrifying bacteria, such as Pseudomonas.

Slide 8: Coastal Processes

The barrier islands were formed and persist at the interface between the land, sea, and air in response to four physical factors:

1) The presence of the gently sloping Coastal Plane – Continental Shelf
2) The availability of adequate sediment
3) A rising sea-level
4) The occurrence of high-energy oceanic storms

They act as a buffer or dam between estuaries and ocean. Coastal processes such as wind, wave, and current are constantly reshaping these barrier islands.
Wind – produces waves and currents within the sounds
Waves – batter shorelines and kick up sediment
Currents – carry suspended sediment

Slide 9: Natural Estuary Shorelines
Discuss and describe each and the advantages/disadvantages

Slide 10: Modified Shorelines
Discuss and describe each and the advantages/disadvantages

Slide 11: Erosion in Our Estuaries
What does erosion look like?
What does it mean?
What causes it?
What can be done?

Slide 12: Video on shoreline mapping

ACTIVITY:

1. Depending on class size and availability of materials, split students up into groups of 2 or 3.
2. Provide each group with an Estuary Erosion Data Sheet and a pencil. Have them guess which samples will hold up to wave action the best and record their hypothesis on their data sheet.
3. The instructor, prior to class, prepares 4 demonstration paint trays. Paint tray #1 has only sand, #2 has only soil, #3 has sand and soil buffered by gravel, #4 has a sand and soil bank buffered by marsh grass. The instructor determines the beginning length of the shoreline that will be the same for each shoreline. For example all of the shorelines measure 12 cm. All of the shorelines need to be to universal so students can compare how each shoreline fairs to wave action.
4. Starting with sample #1 the teacher uses a wave-creating device, i.e., a flat plastic Tupperware top and produces waves for 30 seconds. It is up to the instructor to include students in the process as much as they'd like. Students can run the stopwatch or produce the waves, etc. Have volunteers measure the length of shoreline remaining after the erosion process and have them

record the data on their worksheets. Then have the students fill the 'actual' results on their data sheet.

5. Supply each group with a paint tray, one container each of sand, soil, and stone, a 10"x1" strip of AstroTurf (simulated marsh grass), and a measuring cup.
6. Instruct the students to create a shoreline using the materials provided with the stipulation being that certain materials with give them more points. The point system is provided on their worksheet.
7. Have each group explain to the class their shoreline composition strategy and the reasons behind it. Then test the shoreline to wave action. Recommendation: have the instructor be the sole wave producer, otherwise students will call foul of excessive wave action.
8. Have the students measure the shoreline after 30 seconds of wave action.

DISCUSSION:

- Encourage students to share observations they made while constructing their shoreline and what observations they made about others.
- Discuss why some shorelines held up better than others.
- Talk about the ecological benefits that things like natural shorelines, salt marshes and SAV provide to both humans and animals alike and why hard shorelines may not be the best alternative.
- This could be an opportunity to lead into beach nourishment projects, groins, jetties, and other human modified erosion deterrents.

Estuary Erosion Data Sheet

Today we've talked a little about the different shorelines you can encounter in the estuaries of North Carolina. What is your group's opinion on which shorelines hold up the best to wave action? Before we get started, number the shorelines in the order you think will hold up the best against erosion using the number 1 for the best and the number 4 as the least resilient.

Demonstration Erosion Measurements:

	Guess:		**Actual**
____	SAND:	_____ cm (longest)	_____
		_____ cm (shortest)	
____	SOIL:	_____ cm (longest)	_____
		_____ cm (shortest	
____	GRAVEL:	_____ cm (longest)	_____
		_____ cm (shortest)	
____	MARSH:	_____ cm (longest)	_____
		_____ cm (shortest)	

Were your assumptions correct? _____

_____

Estuary Erosion Competition

You may use any of the samples to create your shoreline, but there is a point system based on units of cup measurements.

Soil: +1
Sand +2
Gravel -3
Marsh +3

Your shoreline must be 12 cm. Take this number and add or subtract according to what materials you use and the measurements you take.

12 + _____ = _____