Teacher background information – Estuarine shorelines behind complex barrier islands 1

Complex barrier islands (figures 1-13B and 1-16), such as Kitty Hawk Woods, Nags Head Woods, and Buxton Woods, represent sediment-rich island segments. These high and wide barrier islands contain large volumes of sand in the form of beach ridges and back-barrier dune fields that do not allow inlets to form or overwash events to flow over the island. Rather, overwash is restricted to a narrow zone along the front side of the barrier. Thus, the back-barrier estuarine system is largely unaffected by oceanic processes and operates in a fashion similar to other mainland estuarine shorelines. The back-barrier estuarine shorelines are either eroding sediment-banks or eroding marsh platforms. The Nags Head Woods – Nags Head Cove Site illustrates both eroding sediment-banks and eroding marsh platforms.

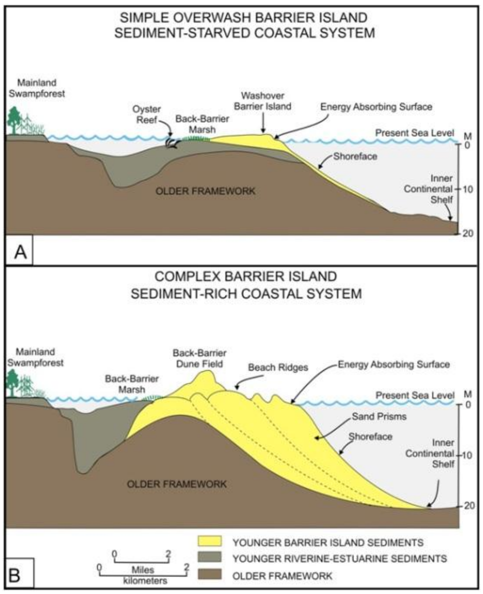


Figure 1-13. Schematic cross-sectional diagrams show simple overwash (Panel A) and complex (Panel B) barrier islands and the associated back-barrier estuarine shorelines. The older framework sediments on the Outer Banks are Pleistocene in age (>10,000 years), while the younger sediments are all Holocene in age (<10,000 years). Figure 4-5-1 p. 50 in Riggs and Ames

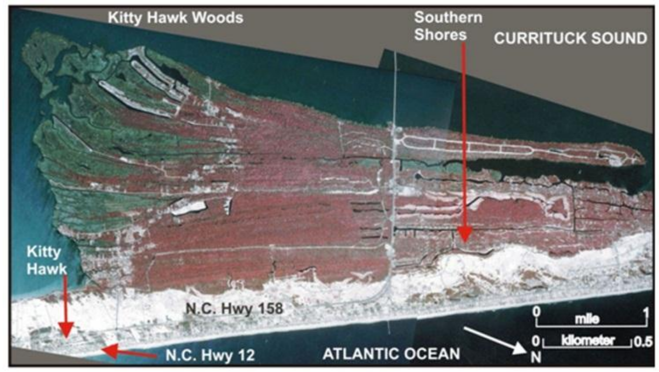


Figure 1-16. A 1982 infrared aerial photograph of Kitty Hawk shows the extensive sequence of beach ridges that constitute Kitty Hawk Woods. This is an example of a complex barrier island. The red color in this false color image taken in the winter is photosynthesizing plants (e.g. pines, bay trees, live oaks, etc.), whereas the gray-green color represents the marsh grasses. The white zone west of N.C. Highway 158 is a series of slightly developed back-barrier dunes, whereas the white zone east of N.C. Highway 158 is the highly developed active beach. Figure 4-5-3 Panel A p. 52 in Riggs and Ames (2003).

Marsh platform shorelines: Because the Northern Coastal Province of North Carolina is characterized by few inlets through the barriers (figure 1-11), fluctuating water levels are generally caused by irregular wind tides, except when adjacent to the inlets, where astronomical tides are also important. Thus, marshes are generally wave dominated with irregular storm-tide flooding and water that ranges from middle- to low-brackish. This situation determines the following characteristics of the northern marshes:

1. They tend to occur as vast and spectacular wetland habitats that form as broad, flat platforms with few tidal creeks. (Tidal creeks typically occur around major overwash plains or inlets.)
2. The marshes are dominated by black needle rush, with narrow outer rims of salt meadow hay or salt marsh cordgrass.
3. The outer shoreline in most areas exposed to a significant fetch is in a destructive or erosional phase characterized by an undercut vertical erosional scarp.
4. Upslope, the marsh grades into a transition zone of small shrubs composed of wax myrtle, marsh elder, and silverling. Notice in figure 1-23 that trunks of dead trees often remain standing, a sign that the salt marsh is moving inland, killing species of plants that are intolerant to salt water and rising water level.

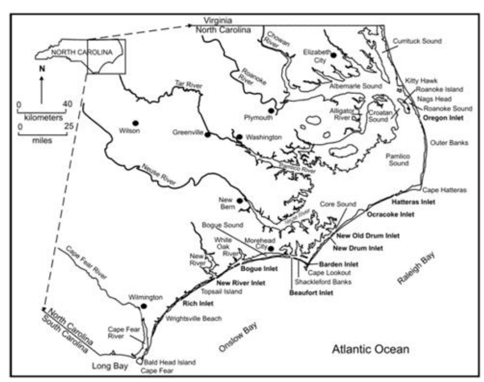
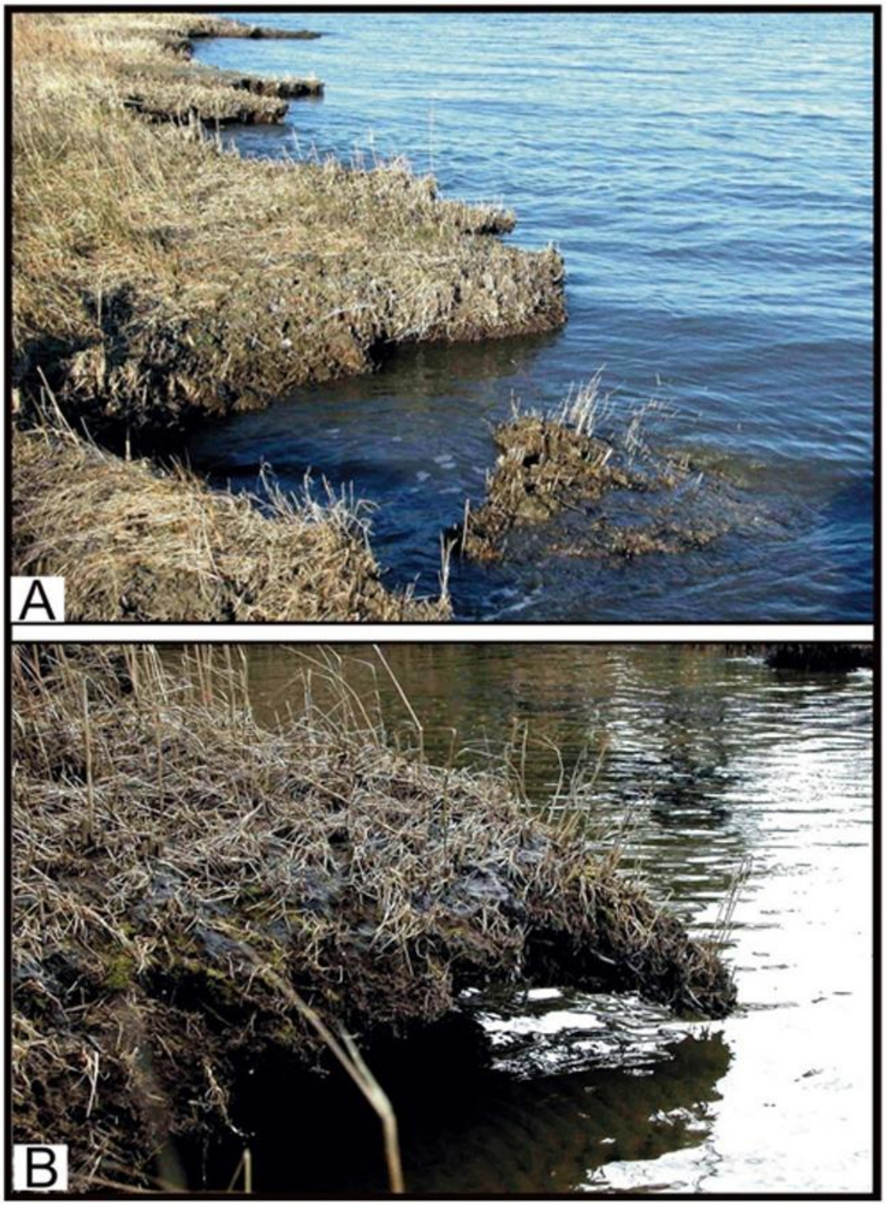


Figure 1-11. Location map shows major towns and coastal features for the North Carolina coastal system. Figure 2-1-2 p. 18 in Riggs and Ames (2003).

5. The transition zone grades into the adjacent upland that may be composed of pines and hardwoods (figure 1-23).
6. Freshwater marshes occur within the island interior and typically host cattails, bulrushes, and reeds.

Figure 1-23. Photograph of a typical shoreline transition zone – from the marsh grasses at the edge of the shoreline through shrub-scrub such as wax myrtle and pond pine – to the upland pines and hardwood trees in the background. The tree stumps in the water and standing dead upland pines behind the shoreline are a direct response to rising sea level, which drowns the upland trees as the transition zone and marsh vegetation migrate upward and landward. Photograph by S. Riggs.

Marsh shorelines behind complex barrier islands are characterized by the accumulation of thick beds of peat deposited in response to rising sea level. Peat is formed by the accumulation of organic materials (from the marsh grasses) over a long period of time. Most marshes that constitute the back-barrier shoreline are highly irregular (figure 1-24A), and eroding marsh platforms that display steeply scarped perimeters vertically drop off into several feet of water. The upper portion of the marsh peat is bound by a dense root mass from the living marsh plants. Below this root mass, the peat is decomposed, very soft, and highly erodible. A low tide places the water level below the root mass of the modern marsh grasses, which forms an extremely tough upper six to twelve inch layer. Thus, the wave energy is expended against the underlying layer of soft decomposing organic matter, which easily erodes to produce a major undercut surface (figure 1-24B). With time, the overhanging root-bound mass will break off and fall to the estuarine floor (figure 1-24A) where it is slowly broken down. This is the main mechanism of erosion along the marsh shorelines. If the outer marsh perimeter is exposed to large stretches of open water with high wave energy, the peat sediment is actively eroded, producing vertical and undercut scarps that drop abruptly into relative deeper water (greater than two feet).



<u>Figure 1-24</u>. **Panel A**: A highly irregular and eroding marsh platform shoreline occurs at Wades Point along the Pamlico River, Beaufort County. Nags Head Woods has similar steeply scarped and undercut platform marshes. The upper peat is bound by a dense root mass of modern marsh plants. Below this root mass, the peat is decomposed, very soft, and highly erodible. As the platform is undercut, large blocks of the upper bound peat break off, as can be seen in the lower right hand corner. Figure 8-4-1 Panel F, p. 124 in Riggs and Ames (2003).

Panel B: Wave action during low tide levels erodes the soft peat layer underlying the tough root-bound modern marsh surface to produce this severely undercut peat block. During higher water levels, wave energy causes the root-bound overhang to break off – this is the mechanism for eroding marsh shorelines. Figure 8-2-16 Panel D, p. 96 in Riggs and Ames (2003).

Erosion of marsh peat shorelines is a major source of fine organic material that forms the organic-rich mud sediments within the estuarine system. The organic material helps to provide the nourishment that makes the estuary into “the nurseries of the ocean.” Many fish species spend the first few years of their lives in the estuaries. Marshes provide critical habitat for many fish species and other vertebrates, as well as many invertebrate species.

As sea level rises, the landward side of these marshes migrates onto the adjacent upland areas (figure 1-23). Thus, as the marshes are eroded on the estuarine side, they are generally expanding onto low-sloped uplands on the landward side. Rising sea level causes the ground-water level to rise, which stresses and finally drowns the lowermost zone of upland vegetation. The marsh accumulates peat sediment vertically, which allows the growth of grasses to keep up with sea level. This vertical growth in the marsh encroaches on the upland, burying the old stumps and logs in the process. Landward expansion of the marsh continues until the upland slope becomes too steep or the upland is filled or hardened for development. Then marsh expansion is ended, and future rise in sea level will result in a net loss of marsh habitat.

Sediment-bank shorelines: Sediment-bank shorelines erode into older sand and clay sediment units and can range from low banks that are a foot high to bluffs that are more than fifty feet high. Because of differences in size and weight, waves wash away the very fine particles of mud, which may remain suspended in the water for quite some time. The heavier, larger sand grains are deposited at the shoreline to form a strandplain beach on top of a wave-cut platform (figure 1-25) if the eroding sediment-bank contains adequate sand supplies. The sand that comprises the beach is derived primarily from the erosion of the wave-cut scarp on the adjacent sediment-bank. The beach forms along the water line and absorbs much of the day-to-day wave energy. The wave-cut scarp does not erode on a daily basis, but requires a high storm tide that causes the water level to overstep the sand beach and allows the wave energy to break directly on the sediment-bank. Bluffs and high sediment-banks are the least abundant types of shorelines and are in great demand for home-site development (figure 1-26). Low sediment-banks are the most abundant type of sediment-bank shoreline in coastal North Carolina (figure 1-27A).

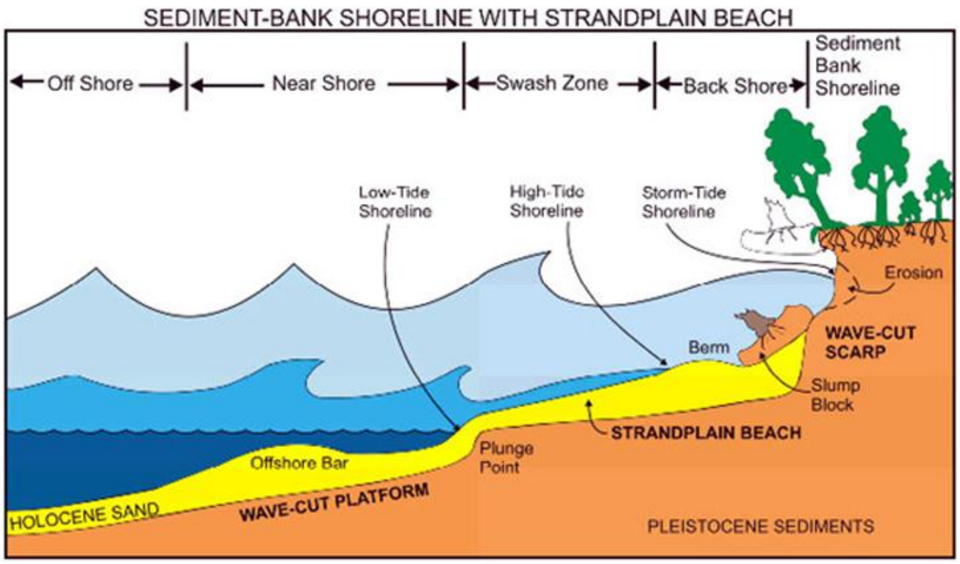


Figure 1-25. Schematic model of a sediment-bank shoreline shows the following geomorphic features: 1) A wave-cut scarp and wave-cut platform have been eroded into older sediment units with a strandplain beach perched on the platform. 2) Different water levels and wave sizes that do the work of shoreline erosion, beach-building, and beach maintenance. 3) The process of eroding and undercutting the bank top during high storm tides and subsequent slumping and reworking of slump blocks to produce the beach sediments. Figure 4-2-1 p. 38 in Riggs and Ames (2003).

Figure 1-26. A high sediment-bank shoreline in Nags Head Woods is being severely eroded by the wave energy along the eastern end of the Albemarle Sound. However, erosion is not occurring during the low-energy conditions shown in this photo. Rather, bank erosion occurs during storm conditions when the water level oversteps the beach and directly intersects the sediment-bank. Notice the extensive strandplain each that is derived from the erosion of the wave-cut scarp comprised of a sand sediment-bank. This figure is on p. 24 in Riggs and Ames (2003).

Teacher background information – Estuarine shorelines behind complex barrier islands 5

Combination shorelines: Shorelines often do not fit into one specific category (marsh or sediment-bank). Many shorelines are composed of both sediment-banks (high or low) with a zone of fringing marsh or swamp forest vegetation. These occur throughout the estuarine system and in all variations from marsh to mixed combinations of sediment-banks. Further complications occur when a given shoreline is modified by humans who build structures, add new materials, or alter the landscape geometry.

Many strandplain beaches contain natural combinations that are beneficial to slowing the rate of shoreline recession. For example, sediment-bank shorelines with wide strandplain beaches develop fringing marshes in areas where the shoreline is somewhat protected. Vegetation along sediment-bank shorelines buffers wave energy and helps protect the adjacent shoreline in all but the largest storms. Marsh platform shorelines that have a source of sand can develop small strandplain beaches. Sand is often derived from the erosion of a particularly sandy unit underlying the shallow perimeter platform. The presence of a sand apron in front of a marsh shoreline will help absorb wave energy and protect the shoreline in all but the largest storms.

Low-sediment-bank shorelines are frequently dominated by remnant forests of pine stumps in the water. Because pine trees have a deep tap root, sediment is frequently eroded out from around the stump as the shoreline recedes, leaving a ghostly tangle of stumps, logs, and roots in the shallows offshore (figure 1-27). The resulting obstructions require boaters and swimmers to beware. However, removal of these remnants of the forests will result in the immediate increase in rates of shoreline recession.

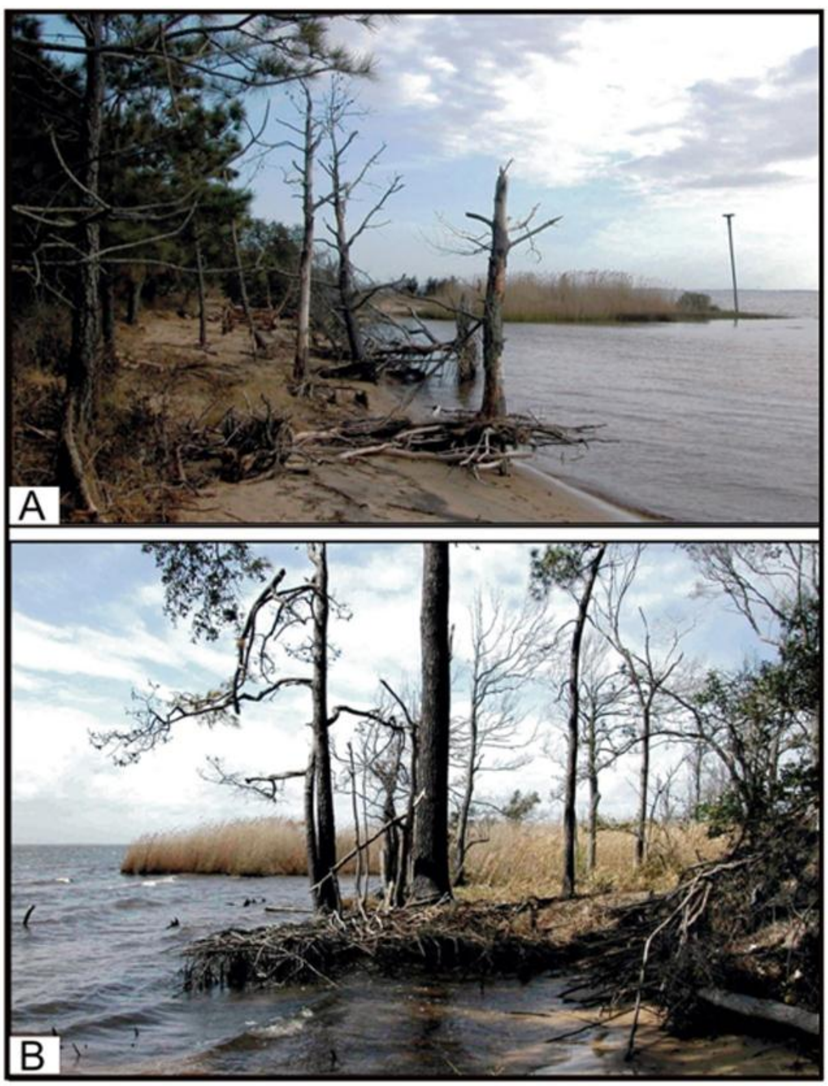


Figure 1-27. Low sediment-bank shorelines.

Panel A: This photograph shows a shoreline along the estuary shoreline at Jockey's Ridge State Park. Much of the Nags Head Woods and Nags Head Cove shorelines are similar to this photograph. Notice how the sediment has been eroded from beneath the pine tree roots, leaving the dead trees standing in the water as the shoreline retreats. The minor sand that forms the strandplain beach is derived from the erosion of the low sediment-bank. Figure 8-2-11 Panel E p. 91 in Riggs and Ames (2003).

Panel B: A low sediment-bank (in the foreground) and platform marsh (in the background) are actively eroding along the Nags Head Woods estuarine shoreline at the eastern end of Albemarle Sound. About two feet of sediment and topsoil have been removed by wave action, completely exposing the root structures of the slowly dying oak and pine trees. Notice the small sand strandplain beach in the lower right hand corner that is covered with wood debris forming natural breakwaters. Figure is on p. 68 in Riggs and Ames (2003).