BARRIER ISLAND PROCESSES AND MORPHOLOGY: WRIGHTSVILLE BEACH, NORTH CAROLINA
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INTRODUCTION

The shape or morphology of any shoreline is determined by the processes that act upon that shoreline. Not only are the processes themselves important, but the degree to which each individual process influences the shoreline is important. In general, most shorelines are influenced by a combination of the following factors:

1. Climate— including periodic storms
2. Wave and Tide action
3. Type and amount of Sediment input
4. Plant and animal life
5. Tectonic Activity— passive or active
6. Sea level changes
7. Man's activity

The combination of these factors determines the shape and mobility of a shoreline. We will examine how these factors are influencing the present day North Carolina shoreline along with how they have influenced it in the past.

Figures 1 and 2 show the general form of a barrier island and in more detail the active beach. These feature will vary from place to place along and between barrier islands.
Processes

Climate-Storms and Oceanic Overwash

Oceanic overwash characterizes barrier beaches with low tidal range, moderate to strong wave climate and a history of intense storms. Overwash is the process whereby sediment from the lower portions of the active beach zone are transported through breaks in the dune system to the back barrier environments during periods of increased wave activity (Figure 3). Sand transported across the island during major storms is used to maintain elevation and volume as the island retreats landward under rising sea-level. The depth of overwash penetration (ocean to marsh distance) is determined by many site-specific characteristics such as island width, height, gradient, and intensity of the storm (tidal surge, etc.). A controversy exists concerning the importance of overwash in island migration and the overall sediment budget along the barrier islands. Most of the coarse sediment on Shell Island north of the Holiday Inn is washover material.
EOLIAN ACTION

A variety of depositional and erosional features associated with wind are observed along North Carolina’s shoreline. These features include a variety of small vegetated dunes, including natural foredunes, and man-made stabilized dunes. Factors which determine dune morphology observed on the barrier islands include the density of vegetation; the wind regime; the degree of stabilization and the time since the most recent disturbance; the availability of sediment; and the position of the shoreline.

Islands or portions of islands where washovers are frequent, recent, or chronic have either no dunes or scattered foredunes which generally do not form continuous ridges. Where washovers have occurred in the past, yet recovery has taken place, usually a single foredune ridge exists and in some cases multiple rows indicating progradation (building) and ample sand source. This morphology can be observed on portions of Shell Island.

WAVE AND TIDE ACTION

Southeastern North Carolina is in a high microtidal to low mesotidal regime (tidal range=1-2m.). Tides in combination with waves and periodic storms have a major influence on the transportation of sand and inlet history of the region.

One of the most dominant process observed along our shoreline is longshore transport of sand by waves (Figure 4). This is typically, and incorrectly, given as the reason for erosion along the beaches. We will see that many factors are responsible for shoreline erosion. Longshore transport in this area is generally from north to south. This may be seen in the buildup of sand on the north side of Masonboro Jetty (Figure 5).
INLETS

Inlets form during storms when trapped soundside water overtops the narrowest and lowest areas of the barrier island. Analysis of historic charts indicates there has been a general decrease in the number of inlets along the North Carolina coast during the past 300 years. During the 17th century, as many as seven additional inlets occurred between Cape Lookout and Cape Fear. The reason for the decrease is open to speculation. Inlets vary in respect to size, tendency to migrate, and the number of years each remains open. Following inlet closure or migration, the flood tidal delta (Figure 6) which occurs on the lagoon side of the inlets is preserved. Typically the flood tidal delta in microtidal and low mesotidal regions is larger than the corresponding offshore ebb tidal delta. The flood tidal delta located on the landward side is an important inlet-related sand body for three reasons: 1. subsequent attachment to the barrier adds volume and elevation, 2. after inlet closure, it forms a substrate over which the barrier migrates, and 3. it is a mechanism for infilling the lagoon. This combination of processes (migration and closure) effectively widens the island as the inlet migrates down longshore transport. Behind Shell Island, elongate islands are found in the partially marsh-filled lagoon. These islands, indicative of former inlet locations, commonly parallel the main tidal channel, are usually vegetated, and may reach elevations of up to 3 m.
Development of these features occurs in a zone where sands from the flood tidal delta overtop the marsh during unusually high wave activity. The presence of these features along the length of Shell and Wrightsville Beach's lagoon indicate that at least two, possibly three, inlets have migrated through the area during the past 150 years.

Figure 6—Formation and preservation of flood tidal delta after migration or closure of an inlet.

TYPE AND AMOUNT OF SEDIMENT INPUT

Typically when people think of the beach they think of sand. In this area, sand, material between 2 and 1/16th mm, is the dominant sediment. The sand is composed of three components: quartz, heavy minerals, and shell fragments. The lagoons will also have mud (material less than 1/16th mm and organic materials—plant debris). Quartz sand makes up over 90% of the sediment in most of the area with 5-7% as shell fragments and 3-5% as heavy minerals. Most of the sediment associated with barrier island systems in this area is relict sediment. Sediment which is several thousand years old and is being re-distributed. It has been estimated that up to 70% of the sediment in this area
is relict. Due to sea level rise, most modern sediment is being trapped in bays, estuaries, and lagoons and not transported to the barrier system.

PLANT AND ANIMAL LIFE

Plant and animal life provide sediment to the barrier system in the form of shell fragments and decomposing plant materials (peat). Plants are also an important stabilizing agent on the dunes and marshes. They tend to trap wind and water transported sediment and keep it in the barrier island system.

TECTONIC ACTIVITY AND SEA LEVEL RISE

The entire east coast of the United States is a tectonically passive margin. There is virtually no earthquake, volcanic, or plate tectonic activity so the region remains stable in respect to its position with sea level.

Sea level on the other hand is rising at the present time. It has been estimated by historic records that from approximately 1900-1940 sea level rose at a rate of 1 foot per 100 years. Since 1940, that rate has doubled to 2 feet per 100 years and within the next 75 years it could rise an additional 3 to 7 feet.

The combination of a passive margin and sea level rise produces changes: 1. as mentioned, sediment is being trapped in increasingly larger and deeper lagoons, bays, and estuaries instead of being transported to the ocean shoreline. This starves the barrier island system of sediment. 2. with low elevation, sea level rise produces a drowning effect on the island which increases the possibility of overwash and inlet formation. Both of these processes cause the islands to migrate landward at an increased rate. A general rule of thumb is that for every 1 foot rise in sea level a barrier island will migrate landward 1000 feet.

MAN'S ACTIVITY

The issue of man's activity in the development of the shoreline is needless to say complicated. Many ideas and suggestions have been proposed on how to "correctly" use and preserve this environment. It is beyond the scope of this guidebook to detail all of the environmental problems associated with our shoreline except to say that a barrier island system is an equilibrium system and to the degree in which we change that equilibrium we will be responsible for maintaining that change.

WRIGHTSVILLE BEACH AND SHELL ISLAND

A series of barrier islands form the 185 km stretch of open coast between Cape Lookout and Cape Fear North Carolina
(Figure 7). This field trip covers Wrightsville Beach/Shell Island a 7.3 km long barrier island located 40 km northeast of Cape Fear. These low mesotidal islands which form the southeastern coastal compartment of North Carolina, often referred to as Onslow Bay, can be classed into two morphologically distinct groups with the approximate division between Browns Island and Onslow Beach. North of this point the islands are classified as wide, high beach ridge, or modified beach ridge barriers. South of Brown's Inlet the islands have a low narrow profile and more commonly have inlet and washover related features. Wrightsville Beach belongs to this group.

Figure 7—Location map for the southeastern North Carolina coast

Compilation of data from aerial photographs and historical charts show that nearly all of the island rests on old inlet fill. Moore's Inlet, now closed (in the vicinity of the Holiday Inn), was the major inlet in the area during the past century. As late as 1920, the inlet was located in the vicinity of Mercer's Pier. Today, much of the marsh north of pier rests on tidal delta sands associated with its migration.
Masonboro Inlet to the south became a prominent inlet when Moore's Inlet began to close naturally in the late 1950's. It, too, has influenced lagoon sedimentation and has migrated over a distance of more than 2 km.

Early photographs (1915-1920) show that the northern portions of Wrightsville Beach had large elevated dunes and a wide island profile. To the south the island was very narrow and low. In order to create more elevated land, Waynick Boulevard, the road parallel to Banks Channel, was built over marsh land in the 1930's.

Erosion on Wrightsville Beach is not a new problem. From the earliest attempts at building along the ocean front in the 1860's, erosion problems have existed. For example, between 1923 and 1939, more than two dozen concrete and timber groins were constructed to halt erosion. The first attempt at replenishing the sand lost to erosion occurred in 1939, when 535,000 m3 of sand were pumped onto the beach. Between 1944 and 1965, four major hurricanes, including Hurricane Hazel, 1954, and a number of winter nor'easters resulted in significant shorefront erosion. In 1965, the Wrightsville Beach Erosion Control and Hurricane Protection Project was constructed along 4515 m of ocean shoreline north from Masonboro Inlet Jetty. Additional sand was pumped on the shore to close Moore's Inlet and connect Wrightsville Beach with Shell Island. In all, a total of 2,280,000 m3 of sand was placed on Wrightsville Beach.

Between 1938 and 1965, Moore's Inlet migrated along a 1.5 km section of Wrightsville Beach and adjacent Shell Island. Historic aerial photos show this inlet affect the shape of the adjacent barrier island beaches by producing a convex shoreline protuberance immediately adjacent to the inlet. This bulge is common along inlet-influenced shorelines where sand packets in the form of swash bars from the protective ebb tidal delta are welded onto adjacent beaches. The end result is a shoreline which curves seaward (Figure 8).
Evidence for rapid erosion along the newly formed portion of Wrightsville Beach fronting Moore's Inlet was obvious by the late 1960's. This necessitated the placement of an additional 1,070,000 m³ of sand on the northern one-half of the beach. By the middle 1970's, homes and structures along the northern flanks of the bulge were fronted by bulkheads and rip-rap. Additional restoration in 1980-81 placed 1,380,000 m³ of fill along the northern portion of the project area.

In 1986, an additional 670,000 m³ of sand was placed on the beach. US Army Corps of Engineers estimates that the convex shape of the shoreline accelerates the annual erosion (99,392 m³) of fill by 31.5%.

The north section of Shell Island shows evidence of recent washover fans (1955-1962) that extend into the marsh. Washover sediments are composed of coarse sands overlain by windblown fine quartz sands.

PROCEDURES

Figure 9 shows the location we will be visiting today. To understand the processes and history of a barrier island or any area, measurements must be taken. This will be accomplished by measuring a beach profile and taking core samples from a track across the island.

TOPOGRAPHIC PROFILING

Equipment needed:
--Hand Level
--Two measuring sticks
--Measuring tape

--Field notebook
--Compass
1. Lay out track line with tape. Locate track line on aerial photo or map. Measure direction of track line with compass so it may be plotted on the map.

2. With hand level, tape and measuring sticks, measure the changes in elevation and distance between points along the track line.

3. Plot the points from sea level (or any reference point) on an X-Y graph (regular graph paper). Connect the points a smooth line for a topographic profile.

4. Several track lines may be combined to produce a topographic map.

CORE SAMPLING

Equipment needed:

--PVC pipe-5 to 10' --Water Jug
--Rubber Ball Stopper --Pull Rod
--2 X 4 pounding rod --Screwdriver

1. If needed, locate core location on map or aerial photo. Pound core pipe in with pounding rod to about 1 foot above ground surface.

2. Fill top of core pipe with water and push in rubber ball to create a vacuum. Place pull rod in holes at top of pipe. Twist and pull core pipe out. If core is much longer than 7-10', an automobile jack may be necessary to pull core out.

3. Core may be extruded (pushed out) of the pipe on site for examination or you can cut the core pipe with a skill saw in the laboratory.
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PROFILE ___________________ DATE ___________________
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