The placement of buildings and roads should take into account the certainty of change in barrier island shorelines, as dramatically illustrated by the history of the Cape Hatteras Lighthouse. The base of the original Cape Hatteras Lighthouse, built in 1802, finally eroded into the sea in the 1970s. The present Cape Hatteras Lighthouse was constructed in 1870 when it was approximately 1,500 to 2,000 feet inland of the ocean shoreline, as indicated in figure 1-31. This map of historic shorelines reflects a fairly constant rate of shoreline recession from 1852 to 1965 (113 years) for the area from Buxton to Cape Hatteras.

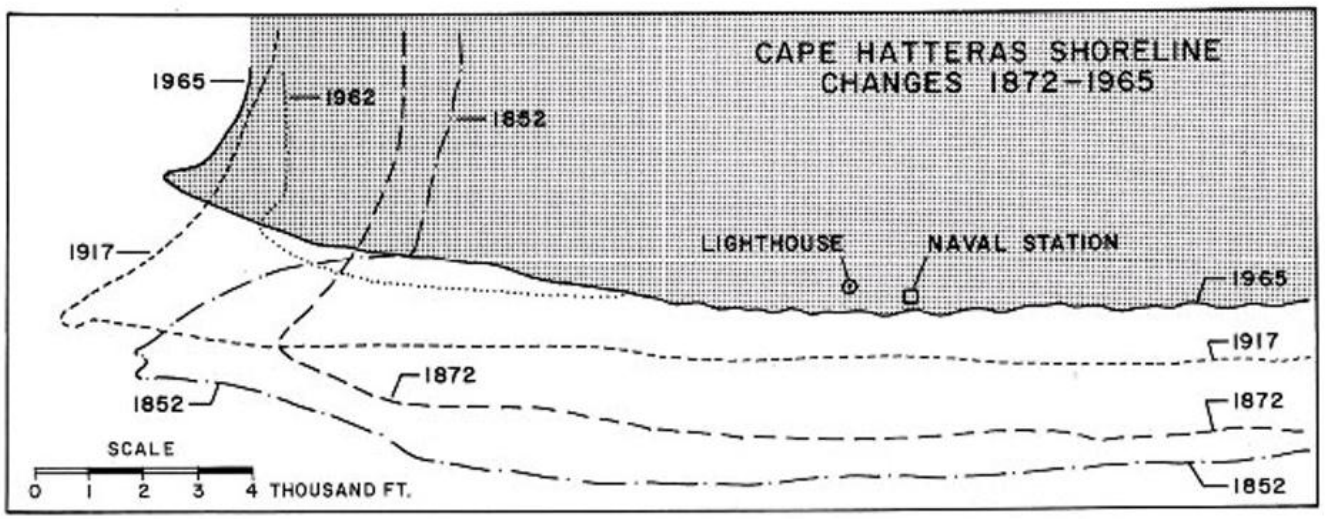

Figure 1-31. This map of historic shorelines reflects a fairly constant rate of shoreline recession for the 113 years from 1852 to 1965 in the area from Buxton to Cape Hatteras. Figure is from Fisher (1967), who modified it from the US ACE (1963). Figure 6-3-1, p. 64 in Riggs and Ames (2003).

Although the builders of the current lighthouse anticipated a very long life span for the structure, you can see from figure 1-31 that the gradual rise in sea level and the regular impact of storms was sure to complicate those expectations. In fact, as the amount of shoreline erosion encroached upon the lighthouse, an extensive series of shoreline hardening structures (figure 1-32) were built (steel groins, rock revetments, and many sandbag bulkheads), along with a series of beach nourishment projects, in desperate efforts to “hold the shoreline” and protect the lighthouse during the 1960s and 1970s.

Figure 1-32. Panels A and B: Photographs of the extensive effort to protect the Cape Hatteras Lighthouse from encroaching Atlantic Ocean with massive hardened structures. These photos show a steel bulkhead, a steel groin, several rock revetments, and many layers of sand bags that have been used over decades in desperate attempts to “hold the line.” Photographs are by S. Riggs.

Several decades of heated debate took place during the 1980s and 1990s about the future of the Cape Hatteras Lighthouse as it continued to be threatened by shoreline erosion. Many citizens wanted to preserve the structure at all costs, while others wanted to allow natural forces to take the lighthouse. The latter would provide a lesson about the constant change in the shorelines of barrier islands and the vulnerability of human-made structures built on those shorelines. Their rationale was that the loss of such a structure to the sea would prompt more careful consideration of construction policies on barrier islands.

The decision was made by the U.S. National Park Service and Cape Hatteras National Seashore to move the lighthouse in 1999 to a site inland of its original location. Figure 1-33 shows the lighthouse in its original position at the top left of the photo and a prepared roadway to the new site at the bottom right. Figure 1-34 shows the lighthouse in route to its new location further inland from the ocean.

Figure 1-33. Cape Hatteras Lighthouse is being prepared for its move from the old threatened site adjacent to the rapidly eroding shoreline to a new inland site. Photograph is by the N.C. Department of Transportation.

Figure 1-34. Cape Hatteras Lighthouse is on its slow and deliberate move towards the new inland relocation site. Photograph is by the N.C. Department of Transportation.

The conflict continues between the natural processes of sea-level rise and coastal storms, causing the ocean to continue its erosional transgression on human infrastructure and houses. Figure 1-35 shows the N.C. Department of Transportation shoring up N.C. Highway 12 in Kitty Hawk. The photograph was taken on March 30, 2003 and the date of the newspaper article was April 22, 2003. It was not even a storm that took out this segment of N.C. Highway 12 but just an abnormally high spring tide.

GDR 4/22/03

The Associated Press

Tide forces closure of N.C. 12

The Associated Press

KITTY HAWK — High tides washed away a 1,500-foot stretch of the shoulder along state Highway 12, forcing officials to close the road indefinitely and divert travelers to nearby Highway 158.

The damage was caused by recent storms and a lunar tide that together pushed the tides to about 1½ feet above their normal level of 3 feet, said R.H. Sanderson, director of the Dare County Emergency Management Agency.

"The shoulder of the road is cracking, and some of it is caved in," Sanderson said Monday. "This is the first time that it has gotten this far into the road system. It was necessary to close the area until the Department of Transportation fixes it."

The two-lane highway was closed Saturday just north of Kitty Hawk Road, officials said.

The Department of Transportation is assessing the damage and hasn't determined when the road will reopen, department spokesman Bill Jones said.

Figure 1-35. A newspaper article documents damage to N.C. Highway 12 in Kitty Hawk with nothing more than an abnormally high spring tide, not a storm. This segment of beach has already lost the ocean front homes and is now working on the road, which has been repaired and rebuilt many times in the last decade. The photograph was taken on March 30, 2003 and the date of the newspaper article was April 22, 2003. Photograph is by S. Riggs. Article is used with permission of the *The Daily Reflector*, Greenville, N.C.

Estuaries constitute large portions of coastal systems, and they also have shorelines. In fact, there are over 4,000 miles of estuarine shorelines in eastern North Carolina. Most of the estuarine shorelines behind the barrier islands and along the mainland shore of the large Pamlico and Albemarle Sounds are also characterized by severe rates of erosion (figure 1-30).

As ever-increasing numbers of people and businesses move to the coastal region and more and more hotels, restaurants, and beach houses are built, decision makers have used many methods to deal with the problems of shifting shorelines. In some cases, they have chosen hard structures that were considered to be permanent solutions to coastal erosion. On the ocean shoreline, hardened structures such as those used around the Cape Hatteras Lighthouse (figure 1-32) were no longer allowed by the mid-1980s. However, no such rules have been put in place for the estuarine shoreline. This has resulted in the extensive use of hardened structures associated with most development (figure 1-36).

Rock revetments, bulkheads, and other forms of shoreline hardening on eroding sediment-banks cut off the internal sand supply, and beach sands soon begin to disappear. The hardening of one piece of property along a shoreline will generally increase the rates of erosion on adjacent properties. This is the domino effect that usually forces the neighbors to begin hardening their shoreline, accelerating the rate of beach loss. Hardened shorelines will lose their sandy beach completely (figure 1-36) unless their neighbors allow the adjacent shorelines to continue to erode.

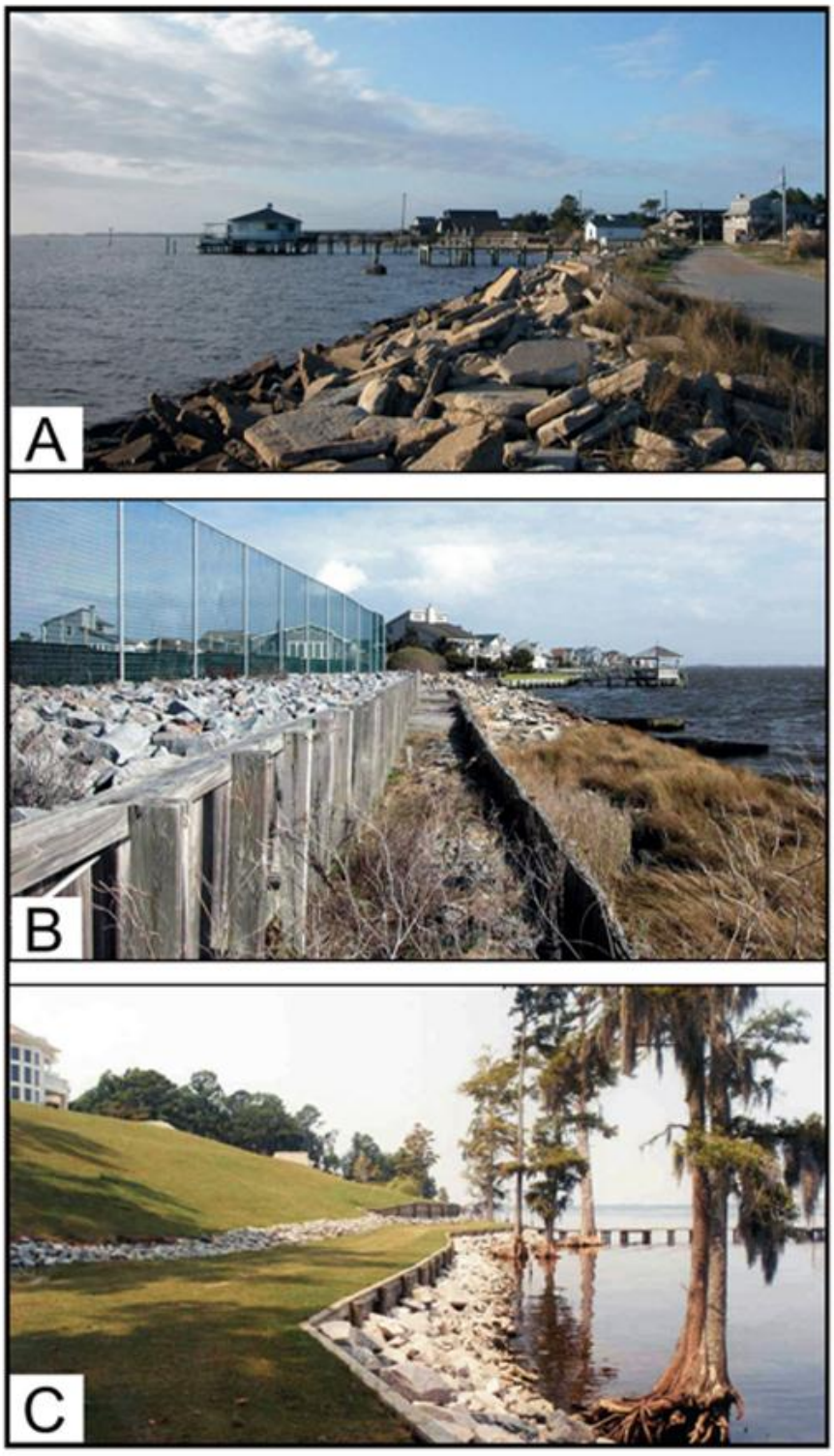

Figure 1-36. Hardened structures along the sediment-bank shorelines within the estuarine system were built in an effort to stabilize the rapidly eroding shoreline. Notice that there are no sand beaches in front of most stabilized estuarine shorelines.

Panel A: Concrete rip-rap has been dumped multiple times along Sound Side Road on the back side of the barrier island at Nags Head.

Panel B: Multiple layers of wooden groins, wooden bulkheads, and rock revetments have been emplaced to protect the tennis courts on the back side of the barrier island at Nags Head Cove.

Panel C: The sediment bluff was terraced; steel bulkheads and rock rip-rap were emplaced along the shoreline at Mauls Point in the Pamlico River estuary. All photographs are by S. Riggs.