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Coastal Processes on Long Island
An Introduction to Erosion

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Top photo: This bluff is eroding; the face is unvegetated and slumping. As a result, the houses on top are in danger of sliding off unless immediate action is taken.
Bottom photo: This bluff is stabilized by terracing the slope and installing a rock revetment at the toe. Image credit: Jay Tanski

Most Long Islanders enjoy the many benefits of living on or near our ocean, sound or bays. However, the fact that some of our land is being lost to the sea each year due to erosive processes is apparent to most, particularly those who own coastal land. What people must consider is that a particular section of the shoreline is part of a much larger system that relies on the movement of sediment within it. Sand is constantly being rearranged – moving offshore then back on again (sometimes at a different location) and moving along the shoreline from east to west and/or vice versa. These processes are normal; however, when a smaller amount of sediment is permanently removed from the system, the deficit is considered to be an erosion problem.

The process of coastal erosion is defined by the removal of beach, dune, and/or bluff sediments by the physical forces of wave action, tides, currents, high winds, or a combination of these. Shoreline erosion can be very complex and most landowners are not familiar with the multitude of factors that are creating their erosion problems. There are treatments for erosion, perhaps not cures, but the choice of a particular tactic depends on a clear idea of the cause(s) of erosion, as well as what asset needs protection.

The purpose of this fact sheet is to assist landowners in identifying and understanding the primary causes and processes responsible for their erosion issue. With a general understanding of these causes and processes, the owner can move forward, with the appropriate professional assistance, and effectively deal with the specific erosion problem they have encountered.

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On both the North and South Shore of Long Island the main cause of erosion and accretion[1] is wave action. Waves are responsible for the movement of sediment along the beach; beach sediment is constantly being rearranged, resulting in changes in the shoreline's shape and beach profile. Most commonly, waves impacting Long Island beaches are gentle. However, coastal storms like nor'easters bring large, steep waves to our shores. Variations in the strength of wave attack produce movement of sand perpendicular to the shoreline, or cross-shore transport. Sand is transported and temporarily stored offshore in large sand bars, which move back onto the dry beach once smaller waves return and the beach will grow in width and height. Therefore, eroded sediment is very rarely lost to deeper waters; the beach width shrinks and grows with respect to a seasonal cycle. It is quite normal for the beach to change nearly 15 feet in elevation and up to 180 feet in width over the course of one year.

When waves approach the shoreline at any angle, currents are created that move the sand in the same direction (Figure 1). This phenomenon is called the "longshore sediment transport" and it carries beach and dune sand into the surf zone and moves parallel to the coastline. This sediment is picked up by the wave action, transported, and later deposited further along the beach. With changes in wave condition, beach sand in one place might be shifted to other places along the shore, moved offshore, or even pushed inland from the beach. If for some reason more sand moves out of a stretch of beach than moved into it due to longshore transport, the beach will erode.

Along the South Shore of Long Island when waves come from the southeast sand will move from east to west; this process typically moves sediment along the beach at a rate of up to 500,000 cubic yards each year. Although the average direction of longshore transport is to the west, sand can move to the east if and when the wave conditions regularly change. Due to the irregularity of the Long Island Sound's shoreline, sediment moves in variable directions at a much slower rate of 100,000 cubic yards[2] each year. On either shoreline, when sediment

Longshore Sediment Transport

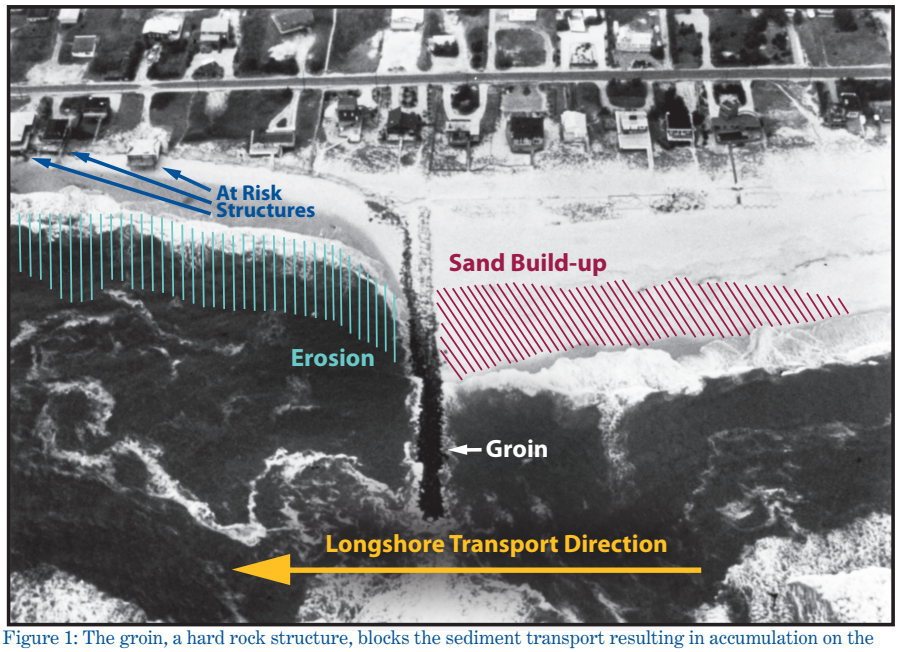

Figure 1: The groin, a hard rock structure, blocks the sediment transport resulting in accumulation on the updrift side and increased erosion rates downdrift. Image credit: Loriann Cody

transport is interrupted by an inlet or other hard structure, the sediment will be trapped on the updrift side and the beach will widen. However, this process increases the erosion rates at the downdrift beach as the current resumes and subsequently carries away new sediment because the structure prevented the sand from reaching this beach.

Storm-Related Damage

Most of the erosion on Long Island is associated with storm impacts. As previously mentioned, large waves will erode the beach and higher water levels from storm surges will occur. The erosion that results from a storm can cause more damage in a shorter amount of time than would occur during normal conditions over several years. Sometimes, Long Island is impacted by larger than normal storms, such as Superstorm Sandy in 2012. A storm of great magnitude will bring with it waves that are steep enough to remove the sediment from beaches and deposit it past the 'depth of closure'. This is defined as the depth at which sediment cannot return to shallower water by further wave action. Once the sediment is past this designated offshore water depth, the gentle waves cannot return it to the beach and it is permanently removed from the system. This results in a net loss of sediment from the beach and the shoreline recession commonly seen by property owners. Additionally, the rates of sea level rise are a concern and will be discussed later in this fact sheet.

Aerial view of the breach created by Superstorm Sandy at Old Inlet, Fire Island National Seashore. Image credit: Kathleen Fallon

Dune Erosion

If a storm's surge is large enough, the entire expanse of beach could be flooded and waves will begin to attack the dunes. Once the dunes have been flattened, infrastructure located adjacent to the beach will become vulnerable to large storm waves. In order to grow dunes, vegetation can be planted; beach grass traps wind-blown sand and roots aid in keeping the sand in place. Not only do dunes act as barriers, like levees, against coastal flooding but they also play an important role in natural beach nourishment. Sediment stored in dunes can replace the sediment that was lost to erosion. Washovers are a concern for barrier islands and occur when waves cut away the beach resulting in breaches that connect the ocean water to the bay area. These have occurred on Long Island's barrier system in the past, most notably when Superstorm Sandy opened multiple inlet breaches along Fire Island.

This dune was recently stabilized with beach grass. Once the plants mature, their roots will both trap sand to grow the dune and keep sand from blowing away.
Image credit: Jay Tanski

Bluff Erosion

During heavy rainfall, sand can be washed down the face of the bluff if it is not vegetated, similar to the beach and dune erosion processes just discussed. Storm-related increases in water height can also be detrimental to coastal bluffs. When waves begin to attack the base of the bluff, which is normally protected from wave conditions by a beach, sediment will be removed from the base (i.e., toe) resulting in undercutting and leaving a vertical scarp. This will make the entire bluff unstable due to continual slumping of bluff material from above the eroded toe, which in turn removes the vegetation that provides stability and protective cover, furthering erosion. Typically, the addition of a bulkhead or revetment installed at the toe can aid in protecting against erosive wave attack.

When people walk on bluffs, they risk trampling plants and/or loosening sand in the face. Image credit: Cornell Extension Marine Program

To provide further erosion control, additional processes that are also acting on the bluff must be considered. One such influencer is water entering the ground, whether by natural causes such as rainfall or human-induced causes like sprinkler systems. Long Island's coastal bluffs are composed of a wide variety of sediment ranging in grain size from fine silts and clays to large boulders. As the groundwater moves, it loosens and picks up material; erosion will result when the water flows out of the bluff removing sediment with it. The coarser the bluff material, the more easily this can occur. Gullies, which form as a result of surface water flowing down or through the bluff face, indicate groundwater-related problems. In freezing temperatures, the groundwater will become trapped in the bluff and expand as cracks. This separates larger chunks of sediment, which slide down the face. Property owners can usually remedy erosion issues caused by groundwater by installing a drainage system that will intercept and transport the water down the bluff face in a pipe.

Landowners can take some measures in order to lessen the amount of surface runoff running over and groundwater moving through their bluff. One practice would be to build a berm or ridge of soil along the top of the bluff, preventing water from flowing over the edge. To stop the water from penetrating the soil and flowing through the bluff face, it should be directed to a drain pipe that can carry the water to the bottom and prevent further erosion. Another option would be to plant vegetation along the edge and bluff face to slow runoff.

Bare, unvegetated portions of the bluff face are very susceptible to erosion by rain and wind that pick up and remove unconsolidated materials. To lessen the effect of these processes, the bluff slope could be graded or terraced and vegetation planted; roots would aid in keeping the soil in place and the plants would take in excess water in the bluff.

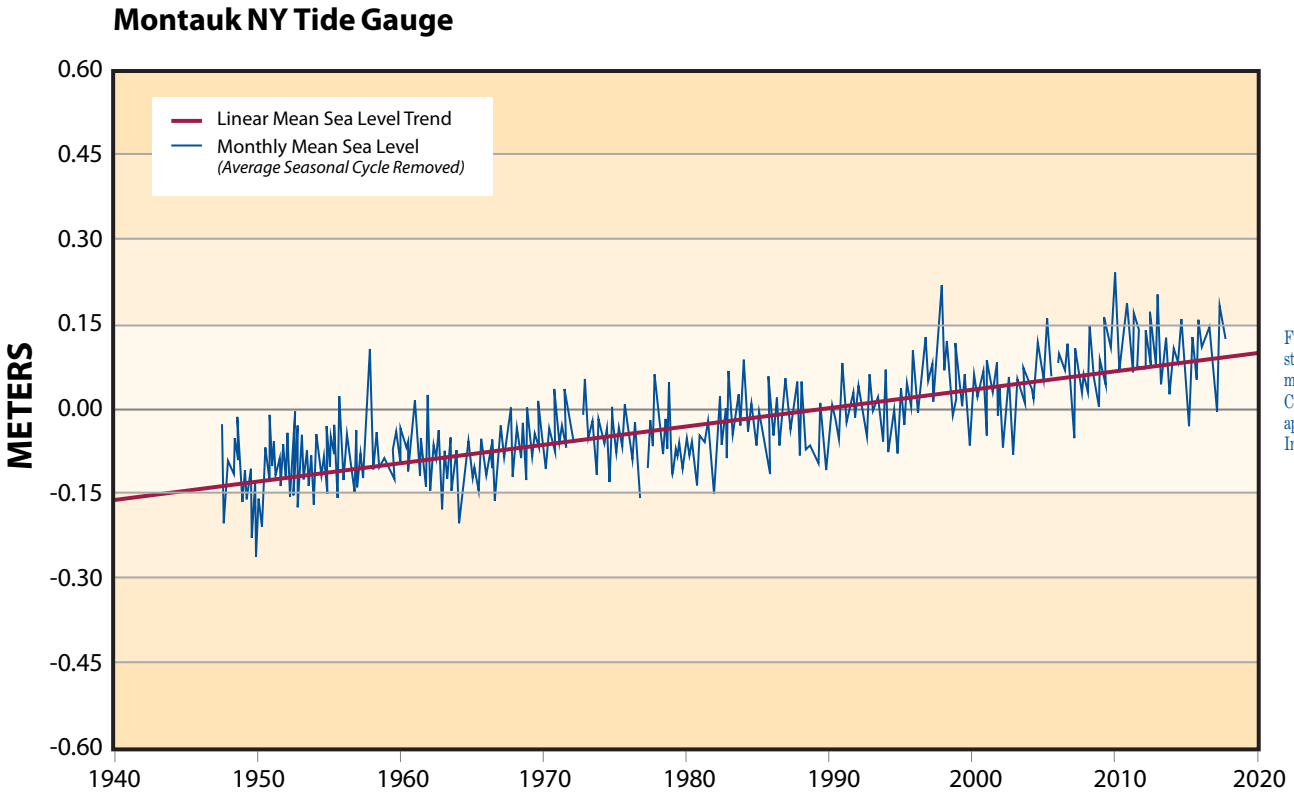

Figure 2: Sea level has risen steadily at Montauk, the eastern most point on Long Island. Current Sea Level Rise rate is approximately 3 mm/yr. Image credit: Loriann Cody

While property owners on bluffs want to protect their infrastructure and investment, they need to consider that bluff erosion is the primary source of material for the beaches below. Bluffs can be protected with a variety of measures, however these techniques may also deprive the beach of sediment. Therefore, complete stabilization may result in the reduction of beach size and eventually in its disappearance.

Sea Level Rise

On Long Island, sea level is rising close to the global rate[3]. Rising water will have many adverse impacts, however this fact sheet focuses on the impact higher sea levels will have on erosion processes. As sea levels rise, shorelines will move further landward resulting in permanent inundation and dry areas becoming more susceptible to flooding. Dunes will shift further inland as the barrier islands attempt to "roll-over" and move closer to the mainland. Coastal property owners on Long Island already experience flooding during full moons and storms; with higher sea levels, storm surges from tropical systems and nor'easters will only be greater.

Landowners who are already struggling with erosion of their coastal bluffs will unfortunately only face more issues. As higher water levels flood their beach, waves will attack further up the bluff eroding away more sediment and resulting in a greater amount and faster frequency of slumping. Although sea levels are rising slowly (currently about one inch per decade) on Long Island, this is something property owners should be considering now as they deal with their current erosion issues.

Conclusion

Coastal erosion processes on Long Island can be complicated. Therefore, before attempting to solve the erosion problem, it is important for landowners to identify the main cause of their erosion issue. A quick fix might result in a greater issue down the line. A better understanding of erosion processes will result in selection of the right solution.

More information about coastal and bluff erosion and on erosion control methods is available from Sea Grant's Marine District Extension Office at (631) 632-8730.

Foot Notes:

[1]Accretion is by definition the opposite of erosion; the widening of a beach due to the permanent addition of sediment onto the shore.

[2]A standard dump truck holds about 20 cubic yards of sand; therefore, the rate of sediment movement on the South Shore would be equivalent to the loads of 25,000 trucks and on the North shore, 5,000 trucks.

[3]The global sea level is rising at an average rate of 3 millimeters per year.

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