Sea Grant
Woods Hole
Focal Points

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Shoreline Change and the Importance of Coastal Erosion

The Massachusetts shore is, for the most part, eroding. Results of a statistical analysis of shoreline change spanning 140 years and covering approximately 1,000 miles of ocean-facing shore reveals that, overall, the Massachusetts shore is eroding at approximately 0.56 feet per year. Data from published charts and aerial photographs from the mid-1800s to 1978 show that 72 percent of the communities for which shoreline change data were available exhibit a long-term EROSION trend, while 28 percent exhibit long-term ACCRETION. The highest long-term average annual erosion rates occur along the south shore of Nantucket at approximately 12 feet per year.

The Importance of Coastal Erosion

Erosion of glacial landforms (including MORAINES, DRUMLINS, OUTWASH PLAINS, and KAMES) provides the primary source of sand and cobble for Massachusetts' 1,500 miles of beaches, dunes, and BARRIER BEACHES.

Words in SMALL CAPITALS *are defined in the glossary on page 3.*

James O'Connell, WHOI Sea Grant

Without erosion, many of the Commonwealth's biologically productive bays, estuaries, saltmarshes, and tidal flats would not exist. Yet coastal erosion is considered a major economic problem in Massachusetts and nationally.

The importance of the coast, economically, is easier to measure, in some cases, than its aesthetic value. Waterfront property, for example, generates much of the residential tax base for coastal communities. According to *Soundings* magazine, proximity to waterfront adds approximately 28 percent to the value of real estate. Mirroring worldwide trends, 75 percent of Massachusetts development, historically, has occurred in the coastal zone. And in many cases, development proceeds without consideration of long- and short-term shoreline change, particularly erosion. Right now, hundreds of millions of dollars of Massachusetts shorefront real estate is at risk due to both chronic, long-term erosion of coastal bluffs and episodic, storm-induced erosion of dunes and barrier beaches *(see photographs)*.

A 1994 Army Corps of Engineers report stated that, at that time, 74 structures could potentially be lost in the next 50 years along Humarock Beach in Scituate as a result of erosion. Today, many homes along the 100-foot-plus coastal banks of southern Plymouth and the east shore of Nantucket are presently at high risk of loss due to long- and short-term erosion and SLUMPING.

Causes of Shoreline Change

The causes of shoreline change are both natural and human-induced. The primary natural causes of erosion in Massachusetts are RELATIVE SEA LEVEL RISE and storms. The results of a study completed several years ago by scientists at the Woods Hole Oceanographic Institution (WHOI) document that relative sea level in Massachusetts is rising approximately one vertical foot every 100 years. Each year, on average, approximately 65 acres of COASTAL UPLAND are PASSIVELY SUBMERGED as a result of relative sea level rise. In fact, authors found that the contribution to shoreline retreat in Massachusetts from relative sea level rise is far greater in some areas than erosion

Phone: (508) 289-2398 • Fax: (508) 457-2172 • E-mail: seagrant@whoi.edu • Internet: http://www.whoi.edu/seagrant
Sea Grant Program, Woods Hole Oceanographic Institution, MS#2, Woods Hole, MA 02543

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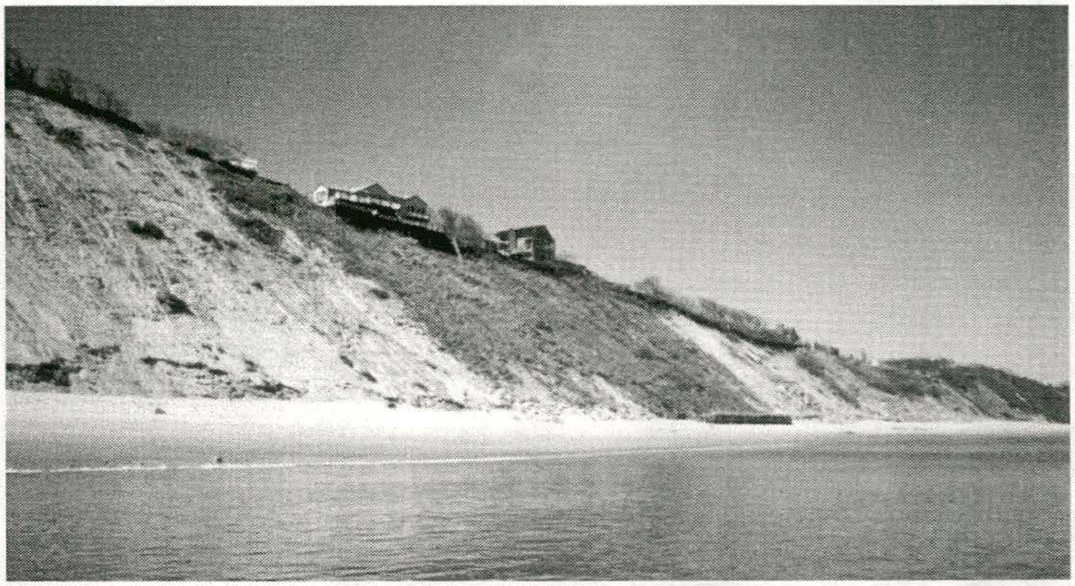
caused by wave action. For example, the total upland loss on Cape Cod from passive submergence due to relative sea level rise is approximately 24 acres per year, while wave-induced erosion is approximately nine acres.

According to the Army Corps of Engineers, the most important cause of human-induced erosion is interruption of sediment sources and LONGSHORE SEDIMENT TRANSPORT. Examples include the armoring of sediment sources with SEAWALLS, REVETMENTS, and BULKHEADS, and the interruption of longshore sediment transport by the construction of GROINS and JETTIES.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Understanding Shoreline Change

Identifying areas subject to both long- and short-term erosion, and understanding the causes of erosion are important if we wish to avoid building homes, structures, and infrastructure in high hazard coastal areas. Shoreline change maps and data for Massachusetts, as well as maps showing areas subject to storm waves and flooding, are available for viewing or for purchase *(see Resources section)*.

The correct interpretation of shoreline change data can help coastal planners, resource managers, and property owners identify appropriate and inappropriate areas to place structures. The combination of long-term shoreline change data analysis, measurements of short-term shoreline movements, an understanding of coastal processes, and knowledge of the effects of seawalls, revetments, bulkheads, groins, and jetties, is essential to proper citing of coastal structures.

Learning from past mistakes, though unfortunate, can also aid coastal planners. Consider the following lessons learned about shoreline change in Massachusetts:

• Jetty construction at the mouth of Sandwich Harbor on Cape Cod Bay resulted in downdrift erosion for approximately 5,600 linear feet, with a maximum erosion of the downdrift shoreline of approximately 361 feet. However, following readjustment of the shoreline to the new, artificially induced equilibrium profile, the shoreline has eroded only 38 feet.

• The erosion rate along the Humarock Beach shoreline of Scituate has accelerated since the 1950s. The principal sediment sources for this barrier beach, updrift glacial drumlins, have been armored with revetments. This has significantly reduced the major source material for the beach. The apparent cause and effect nature of the revetments seem to indicate that the rate of shoreline change since the construction of these revetments should take precedence over the long-term rate of change in future planning and management for this area.

• On Nantucket and in other areas, trend reversals—erosion followed by accretion, and vice versa—complicate matters. In many cases, short-term shoreline fluctuations can be orders of magnitude greater than the long-term rate of shoreline change. Nantucket's southeast shore has a long-term average shoreline change rate of +0.10 feet per year (net accretion of 2.1 feet between 1846-1978), suggesting a relatively stable area. However, between 1846 and 1978 the shoreline accreted 238 feet, then eroded 236 feet. This same phenomenon occurred at Codfish Park on Nantucket. Unfortunately, many homes were constructed during the accretion phase. Since the trend reversed to erosion beginning in mid-1950s, many houses have been lost to erosion and storms.

These examples make it clear that to properly manage the shoreline, analysis of both long- and short-term shoreline changes are required to determine which is more reflective of the potential future shoreline configuration.

On-going Shoreline Change Research and Information Needs in Massachusetts

The following studies, conducted by WHOI investigators, represent but a few examples of the many studies underway in Massachusetts:

Investigation into the timing, severity, and causes of coastal bluff erosion on the Cape Cod Bay shore of Truro involves the analysis of bluff erosion and the formation and migration of nearshore sandbars.

In collaboration with the U.S. Geological Survey, investigators are trying to understand the complex interplay and feedback mechanisms among the sea cliffs, beaches, and shallow water regions along the Cape Cod National Seashore. They are also attempting to determine the controlling factor or factors causing erosion 'hot spots.'

A multiple tidal inlet study, supported in part by WHOI Sea Grant, has the potential to determine the controlling

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factors of multiple tidal inlet stability that contribute to navigation and water quality improvement considerations.

Another Sea Grant supported study involves mapping and analysis of salt marsh response to relative sea level rise, and the frequency of storm-induced sedimentation on the community structure of existing and prehistoric wetlands.

A multi-year study of sediment transport between the middle continental shelf and surf-zone along the south shore of Martha's Vineyard has the potential to increase our understanding of the mechanisms which move sediment, ultimately giving insight into the processes responsible for shaping our shorelines.

On the legislative front, there have been a number of attempts to pass legislation in Massachusetts that would require sellers of shorefront real estate to notify prospective buyers about the frequency of flooding and erosion. For such legislation to be effective, up-to-date shoreline change data is essential. Presently, a Massachusetts shoreline change analysis and mapping update project is underway—a collaboration between the WHOI Sea Grant Program, USGS Marine Branch at Woods Hole, Cape Cod Cooperative Extension, and the Massachusetts Coastal Zone Management Office.

The forces of nature and the influence of humans living near the coast will continue to alter our shorelines for the rest of time. To coexist, the need for research, and workable management options, remains a necessity.

Resources

• Shoreline change maps for Massachusetts are available for purchase from Massachusetts GIS, www.magnet.state.ma.us/mgis. They can also be viewed at your local town hall (generally with the conservation commission or department), or at the Massachusetts Coastal Zone Management office, (617) 626-1200. They may also be viewed on line at: www.appgeo.com/atlas/project_source/czmcc/ccindex.html.

• Flood Insurance Rate Maps (FIRMs), showing areas subject to storm waves and flooding, are available for purchase from the National Flood Insurance Program, Flood Map Distribution Center, (800) 358-9616. They may also be viewed at your local town hall (generally with the building department).

• U.S. Army Corps of Engineers, N.E. Division. 1994. Reconnaisance Report, *Shore Protection and Erosion Control Project, Humarock Beach, Scituate, Massachusetts.*

• O'Connell, J.F. 1997. "Historic shoreline change mapping and analysis along the Massachusetts shore," *Proceedings of the 10th Symposium on Coastal and Ocean Management/Coastal Zone '97*, Boston, MA.

For more information about the research or outreach efforts profiled in *Focal Points*, contact the WHOI Sea Grant Program at the address listed above.

Glossary

Accretion—the gradual addition or accumulation of new land, either natural or human-induced.

Barrier beach—a narrow, low-lying strip of land, generally consisting of coastal beaches and coastal dunes, extending roughly parallel to the trend of the coast. A barrier beach is separated from the mainland by a narrow body of fresh, brackish, or saline water, or a marsh system. A barrier beach may be joined to the mainland at one or both ends.

Bulkhead—an upright structure or partition that acts as a retaining wall to prevent sliding of land.

Coastal upland—land areas along the coast exclusive of wetlands, such as saltmarshes.

Drumlin— streamlined, elongate hill, usually composed of till, shaped by advancing glacial ice.

Erosion—the gradual wearing away of land by the action of natural forces.

Groin—a shore protection structure, usually built perpendicular to the shore to trap littoral drift or retard erosion of the shore.

Jetty—on open seacoasts, a structure extending into a body of water, designed to prevent shoaling of a channel by littoral materials and to direct and confine the stream or tidal flow. When built at mouths of rivers or tidal inlets, jetties are designed to help deepen and stabilize a channel.

Kame—a knoll or hill underlain by stratified glacial drift deposited into a hole in the glacial ice or kettle ponds.

Longshore sediment transport—the movement of sedimentary material along the shore under the influence of wave-generated longshore currents.

Moraine—accumulations of poorly sorted glacial material deposited along the front (terminal or end), side (lateral), or base (underground) of a glacier.

Outwash plain—broad, gently sloping, alluvial surface underlain by outwash sand and gravel that was deposited by glacial meltwater streams.

Passively submerged—the submergence of land resulting from the gradual inundation by the sea.

Relative sea level rise—the combined effects of worldwide sea level rise and the movement of a land mass.

Revetment—a facing, generally made of stone, placed on a bank or bluff to protect a slope or embankment against erosion by wave action or currents.

Seawall—a coastal engineering structure separating land and water areas, primarily designed to prevent erosion and other damage due to wave action

Slumping—relatively rapid, mass movement slope failure caused by physical weathering, groundwater seepage, or toe erosion due to waves.

For More Information

For further information on shoreline change, erosion control alternatives, and technical assistance relating to the beneficial functions of coastal landforms, contact the WHOI Sea Grant Program at the address above or visit our web site at: www.whoi.edu/seagrant.