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Cape Cod Cooperative Extension

New Shoreline Change Data Reveal Massachusetts is Eroding

Approximately 75 percent of the U.S. ocean shoreline is eroding. Massachusetts' ocean-facing shore is no exception. A recent study of shoreline change in Massachusetts by the U.S. Geological Survey, Woods Hole Oceanographic Institution Sea Grant Program, and Cape Cod Cooperative Extension reveals that approximately 68 percent, or 513 miles, of Massachusetts' ocean-facing shore exhibits a long-term erosional trend, 30 percent, or 226 miles, shows long-term accretion, and two percent, or 15 miles, shows no net change. Funding for the study was provided by the Massachusetts Office of Coastal Zone Management.

Updating Massachusetts Shoreline Change Data

Prior to the completion of this project, the most recently plotted Massachusetts shoreline for shoreline change analysis purposes was 1978. Since that time, there have been several high profile storms, including 1991's Hurricane Bob (August) and The 'Perfect Storm' (October), and the December 1992 nor'easter (all presidential disaster declarations), and many moderate coastal storms that made landfall along the Massachusetts shore. These storms have rendered any prior shoreline change data anaylsis obsolete.

The updated shoreline change project, completed in 2001, involved digitizing a new shoreline from digital color orthophotographs along approximately 800 miles of Massachusetts' shore. This new 1994 shoreline was added to an existing database that included up to four historic shorelines dating back to the mid-1800s. The data now span a maximum of 152 years.

Transects were drawn across all of the historic shorelines on an approximate lot-by-lot basis (every 40 meters or 128 feet), for a total of 30,354 transects. The distance between each of the five historic shorelines was measured at each transect

Photo courtesy of Jim Mahala, MA DEP

Figure 1. **Codfish Park area along the eastern shore of Nantucket.**

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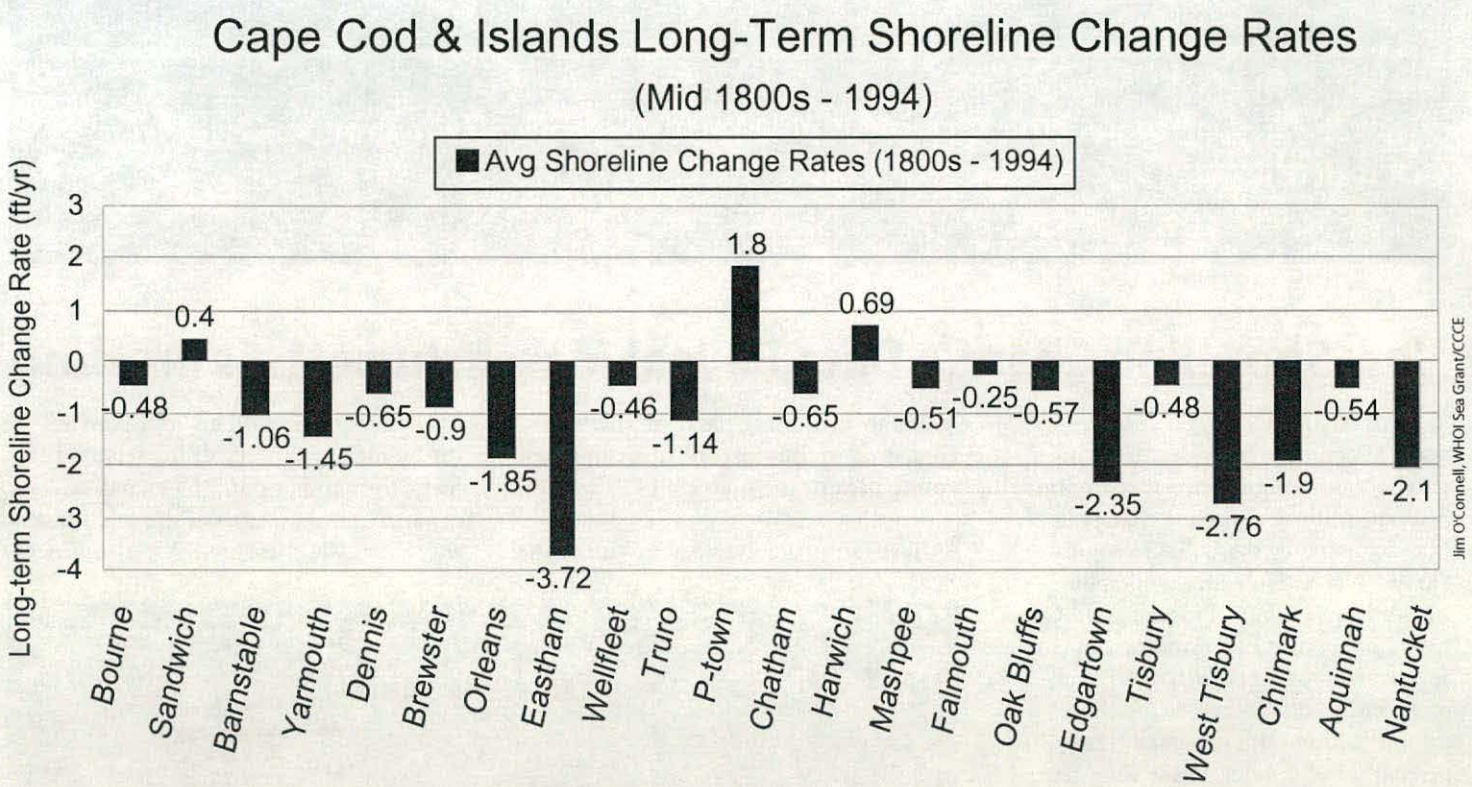

Figure 2. **Long-term average annual shoreline change rates, by town, for Cape Cod, Martha's Vineyard, and Nantucket, Massachusetts.**

and rates of shoreline change were calculated for each separate time interval, along with the overall long-term average annual shoreline change rate.

All of the historic shorelines were color-coded, overlaid, and printed on the color orthophotographs, along with the long-term average annual shoreline change rate for each transect. As a result, individual building locations, roads, jetties and other recognizable features can be easily identified.

Shoreline Change Data Results

For the most part, the Massachusetts shore is eroding. For the entire ocean-facing Massachusetts shore, the long-term average annual shoreline change rate ranges between –0.58 and –0.75 feet per year.

Approximately 46 percent of the Massachusetts shore is eroding at one foot or less per year, while 22 percent of the shore is accreting at one foot or less per year. Eighty-one percent of the shore fluctuates +/-2 feet per year. Based on other studies (Pilkey & Thieler, 1992), 75 percent of the U.S. ocean shore is eroding, with the U.S. East Coast eroding at an average rate of 2-3 feet per year (Leatherman, 1993). Thus, Massachusetts' average annual shoreline change rate is lower than the East Coast average. That statistic is of little comfort for shorefront property owners in the Commonwealth, where rates of shoreline change vary considerably along the shore with some areas eroding between 7-10 feet per year (**Figure 1**), and higher.

Long-term rates of shoreline change calculated for each of the 15 Cape Cod communities and the islands of Martha's Vineyard and Nantucket reflect this shoreline change variability (**Figure 2**). It is important to note that rates also vary considerably *within* communities.

Figure 3 shows the status of shoreline change for Cape Cod, Nantucket and Martha's Vineyard communities. Note that eroding transects predominate in most communities. The highest rates of erosion and the longer expanses of eroding shoreline within a community are generally located along high-wave energy, open-ocean shores. For example, the Eastham shore exhibits the highest number of eroding transects at 98 percent (2 percent accreting), followed by Truro at 83 percent eroding, (16 percent accreting), and Wellfleet at 81 percent eroding, (18 percent accreting). These communities are exposed to both predominant wind and waves from the northeast, and prevailing winds and waves from the west. Other communities have less severe erosion problems, such as Falmouth at 67 percent eroding (29 percent accreting) and Mashpee at 69 percent eroding (30 percent accreting), due to the sheltering effects from ocean storm waves by the islands of Martha's Vineyard and Nantucket.

Only three Cape Cod communities have a greater number of accreting transect locations than eroding transects, including Harwich at 63 percent accreting (36 percent eroding), which is protected from ocean storm waves by Monomoy Island. Also Provincetown at 62 percent accreting (37 percent erod-

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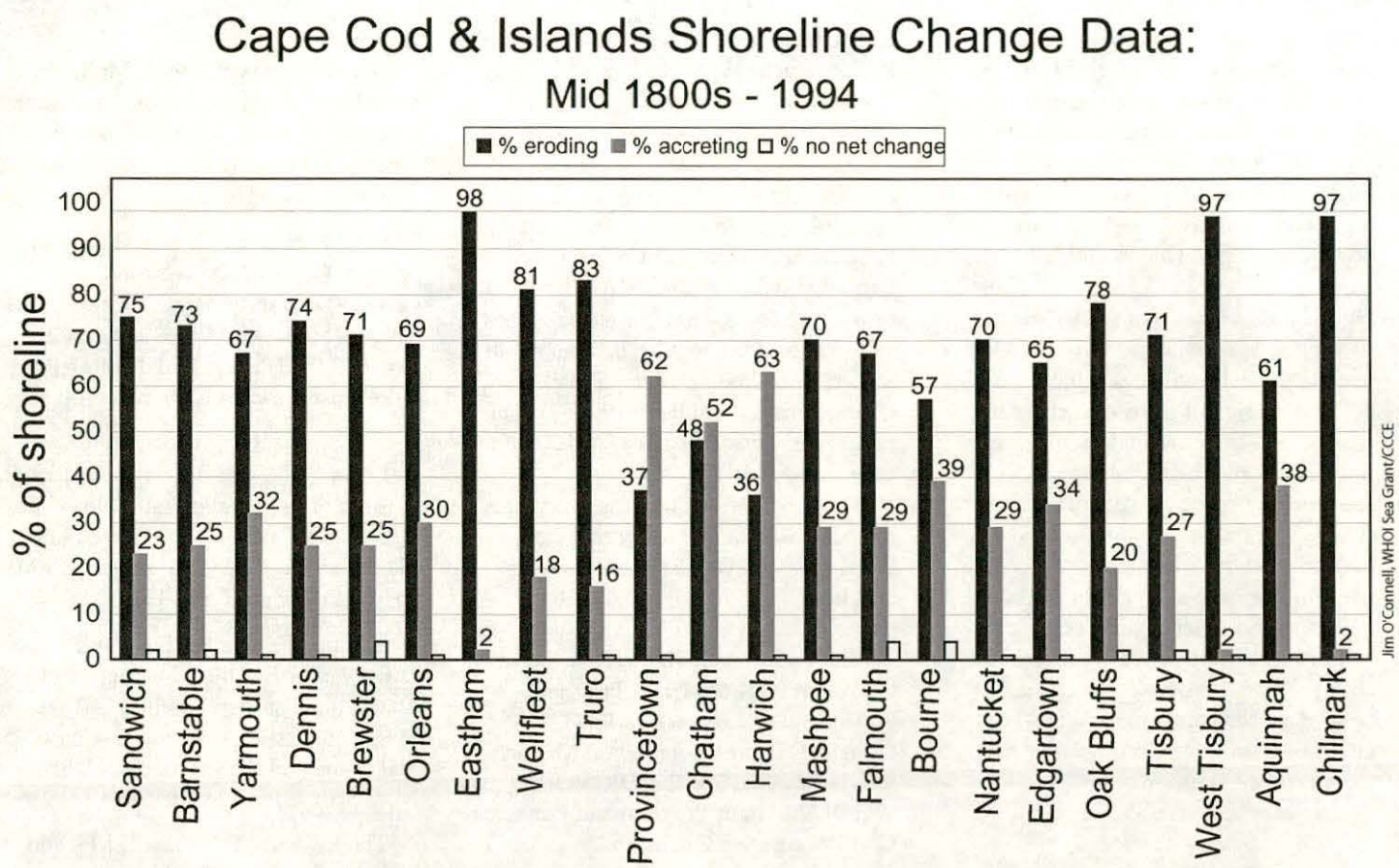

Figure 3. Percent of linear length of shoreline eroding, accreting and stable, by town, for Cape Cod, Nantucket, and Martha's Vineyard, Massachusetts, based on the long-term shoreline change data.

ing), which receives a large volume of sand from the eroding Cape Cod National Seashore bluffs.

A number of factors determine whether a community exhibits greater long-term erosion or accretion :

- exposure to high-energy storm waves,
- sediment size and composition of eroding coastal landforms feeding adjacent beaches,
- near-shore bathymetric variations which direct wave approach,
- alongshore variations in wave energy and sediment transport rates,
- relative sea level rise, and
- human interference with sediment supply (e.g. revetments, seawalls, jetties).

Interpreting Shoreline Change Data: Proceed with Caution!

A word of caution when reading long-term shoreline change rates: *always* analyze the short-term data that were used to calculate the long-term shoreline change rate. If short-term trend reversals in shoreline change have occurred (accretion to erosion or vice versa), it may be more appropriate to use the most recent short-term shoreline change rate than the long-term rate for siting a structure or for planning purposes.

For example, transects along the Codfish Park area of Nantucket's eastern shore show a long-term accretion rate of approximately +1.5 feet per year. However, the shoreline has been eroding since the 1950s, and erosion has accelerated since 1978 to 7-10 feet per year (**Figure 1**). The long period of accretion that took place from the mid-1800s to the 1950s biases the long-term rate, making the data suggest that the area is stable or accreting. The trend reversal and continuing erosion since the 1950s, however, illustrates the importance of analyzing short-term data and its potential utility in determining present-day construction setbacks and for planning purposes.

The widespread construction of coastal engineering structures, such as revetments, seawalls, jetties and groins—particularly since the 1940s and 1950s—has also affected shoreline change rates. In many areas, these coastal engineering structures have contributed to a trend reversal or accelerated downdrift erosion rates, and therefore their effects must be factored into analyzing long-term shoreline rates. The northern area of Humarock Beach in Scituate is a case in point, where erosion rates have accelerated in recent years due to both natural and human effects. The shoreline area east of Sandwich Harbor in Sandwich shows erosion has accelerated due, in part, to the effects of jetties.

Human activity, however, is not the sole reason for trend reversals and shoreline changes. In some areas, such as the southeastern shore of Nantucket, natural processes are responsible for large trend

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reversals (accretion to erosion back to accretion to erosion) over the 150-year study period. In this area, the data reveal that the shoreline has fluctuated between 50 to 100 feet of both erosion and accretion resulting in a long-term average suggesting stability. The shoreline is, however, exceptionally variable.

Ongoing Shoreline Change Analyses

WHOI Sea Grant and Cape Cod Cooperative Extension are conducting a detailed analysis of the recent shoreline change data to better understand why some areas are eroding and others accreting. They are also documenting areas where the use of short-term data may be more appropriate than long-term rates for planning and safe set-backs of buildings and other structures.

For more information on shoreline change, coastal processes, or erosion control alternatives contact WHOI Sea Grant or Barnstable County Cape Cod Cooperative Extension.

The Massachusetts shoreline change update project was completed by Dr. E. Robert Thieler, U.S. Geological Survey, Coastal and Marine Geology Program, Woods Hole, MA; Courtney Schupp, Virginia Institute of Marine Science, VA; and, Jim O'Connell, Woods Hole Oceanographic Institution Sea Grant Program and Cape Cod Cooperative Extension, Woods Hole, MA. The project produced shoreline change maps and an accompanying detailed technical report, "The Massachusetts Shoreline Change Project: 1800s to 1994: Technical Report," available as a *USGS Administrative Report.*

The shoreline change maps and data can be viewed on the Massachusetts CZM web site (www.state.ma.us/czm/czm.htm)

This bulletin should be referenced as follows: WHOI Sea Grant Program, 2003, *Marine Extension Bulletin*, "New Shoreline Change Data Reveal Massachusetts is Eroding," by Jim O'Connell, WHOI Sea Grant Program and Cape Cod Cooperative Extension.

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