Sea Level Rise and Shrinking Salt Marsh

By Peter Phippen, Eight Towns and the Bay, and Anne Donovan, CZM

Situated on the North Shore of Massachusetts—covering more than 25,000 acres from Gloucester to Salisbury—sits the Great Marsh. This Commonwealth coastal jewel is the largest contiguous salt marsh north of Long Island, New York. More than marsh, however, the area includes barrier beaches, dunes, tidal rivers, estuary, mudflats, and islands.

The Great Marsh as seen from above—expanses of estuary, salt marsh, and beach.

Photo: Stephen Gersh

But with sea levels rising, what is the likely future of the Great Marsh? This article looks at some of the basic science behind sea level rise and salt marsh dynamics, and discusses some of the likely impacts to this important region. They key message: All we do to think green/go blue can make a real difference in the Bay State's own backyard, helping to ensure that shoreline ecosystems like the Great Marsh are here for future generations to enjoy.

Rising Seas/Sinking Shores

The Intergovernmental Panel on Climate Change (IPCC), which was established by the United Nations Environmental Programme and the World Meteorological Organization in 1988, is made up of more than 2,500 scientists from around the world. The IPCC estimates that in the next century, sea levels will increase by one-half to two feet. This wide-ranging estimate is based on uncertainty about the quantity of greenhouse gases that will be emitted during that time (see *Global Warming for Dummies* on page 75), as well as questions about the mechanics of sea level rise.

Global warming causes sea levels to rise by...

- Raising ocean temperatures, increasing the volume of ocean waters as the warmer water physically expands.
- Melting glaciers and ice caps, increasing the quantity of water in the ocean.
- Melting of the Greenland and Antarctic ice sheets, which not only hold vast quantities of water, but also could collapse into the ocean and cause substantial displacement of water and rapid sea level rise.

In addition to rising global sea levels, the tectonic plate that Massachusetts rests on is subsiding, resulting in relative sea level rise rates that are even more extreme. According to Climate's Long-Term Impacts on Metro Boston (CLIMB)—a 4-year, million dollar research effort funded by the U.S. Environmental Protection Agency and conducted by experts from Tufts University, the University of Maryland, and Boston University—relative sea levels in

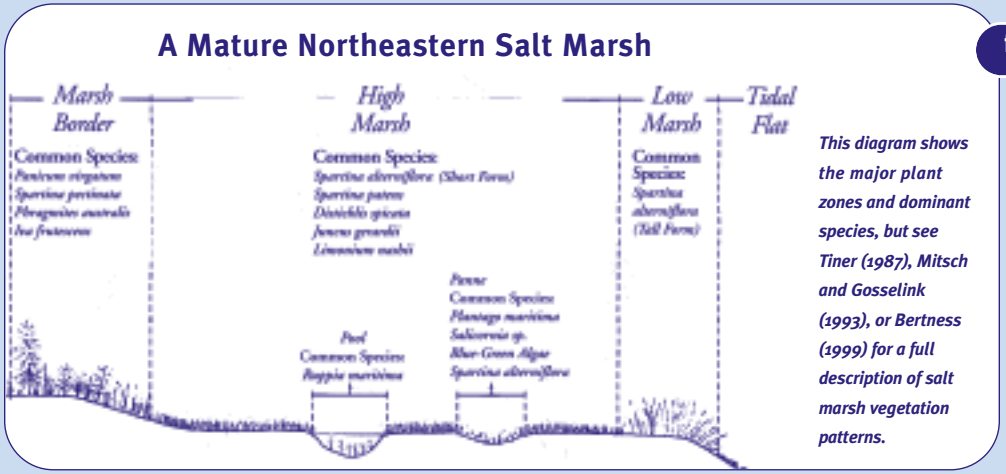

figure 1

This diagram shows the major plant zones and dominant species, but see Tiner (1987), Mitsch and Gosselink (1993), or Bertness (1999) for a full description of salt marsh vegetation patterns.

Massachusetts rose by almost a foot over the last century. Their estimates indicate that by the end of the 21st century, relative sea levels in the Boston area will rise from two to three feet. (More than double the sea level rise from the last century—data taken at the Boston Tide gauge indicate that sea levels rose 0.87 feet from 1921 through 1999.)

At the lower end of the estimate, flooding would primarily occur only during storms. However, even moderate storms with 2-foot storm surges (which typically occur several times a year in Massachusetts) would flood Boston's Financial District and parts of East Boston, South Boston, and Charlestown. For more on the CLIMB project, see www.tufts.edu/tie/climb and for a Boston Globe slideshow of potential flooding impacts in Boston, see www.boston.com/news/multimedia/interactive_bostonflood/.

The Birth and Growth of a Salt Marsh

Salt marshes develop in sheltered coastal areas that are protected from severe wind and wave action, allowing fine sediments (sand and silt) to be deposited and plants to take root. In Massachusetts, one of the first plants to take hold in these areas is *Spartina alterniflora* (smooth cordgrass), whose seeds are dispersed by wind and water. *Spartina alterniflora* is a perennial plant that develops extensive root systems, called rhizomes, which stabilize sediments and reduce erosion. As this plant establishes itself, it forms dense stands that trap sediments and buffer wave energy and currents, promoting further development of the infant salt marsh.

Bacteria and fungi slowly decay the organic matter trapped by a growing stand of *Spartina alterniflora*. Over time, the accumulation of dead and decaying marsh plants and other material results in the formation of peat (organic matter that only partially decomposes because of the lack of oxygen in waterlogged environments). Through years and years of peat accumulation, the elevation of the young marsh increases enough to reduce flooding frequency. Once this occurs, high marsh plants can become established, allowing a greater diversity of salt marsh plants to grow.

Salt Marsh: From Stable to Shrinking

A mature salt marsh has a well-defined low marsh and high marsh that continue to expand seaward and landward over time. As the height of the sea gradually increases, so does the reach of tidal waters—providing growth conditions that favor salt-marsh plants over terrestrial vegetation and allowing the marsh to expand. The gradual process of peat buildup also provides the appropriate growing medium for these plants. Unfortunately, coastal development at a marsh's edge can prohibit its landward movement—and with human-induced climate change (see *Global Warming for Dummies* on page 75)—sea level rise is beginning to exceed salt marshes capacity to build up peat levels. The result is that rising sea levels are leading to shrinking salt marshes.

When the peat-formation process does not keep pace with increasing sea levels, parts of the marsh become submerged. Ultimately, this kills the plants and degrades the edges of the marsh, making it more vulnerable to continued rising sea levels.

In a stable sea level situation, salt marshes expand on the gradually increasing layers of partially decayed plant matter called peat.

Illustration: Ethan Nedeau

Potential Impacts in the Great Marsh

As sea level rise rates accelerate, the marsh system becomes destabilized. The inundated plants are no longer provided with optimal growing conditions, making the marsh susceptible to greater levels of erosion and flooding. The cycle of destabilization increases over time, and landward areas once protected from storm damage by the marsh system become increasingly vulnerable.

As shown in Figure 2, as sea level rise increases, much of the area around Crane Beach (an important barrier beach in the Great Marsh system) will flood. As these areas are transformed to open water, many benefits of the system will be lost. Important habitats for fish, shellfish, and birds will be drowned; space for beach recreation will be reduced; and storm-damage prevention to inland areas will be compromised.

The rate of sea level rise is not fixed, however, and humans are having a big impact on global warming through release of greenhouse gases (see *Global Warming for Dummies* on page 75). To do what you can to help sustain the Great Marsh, see the feature section of this edition of *Coastlines*—and think green . . . go blue!

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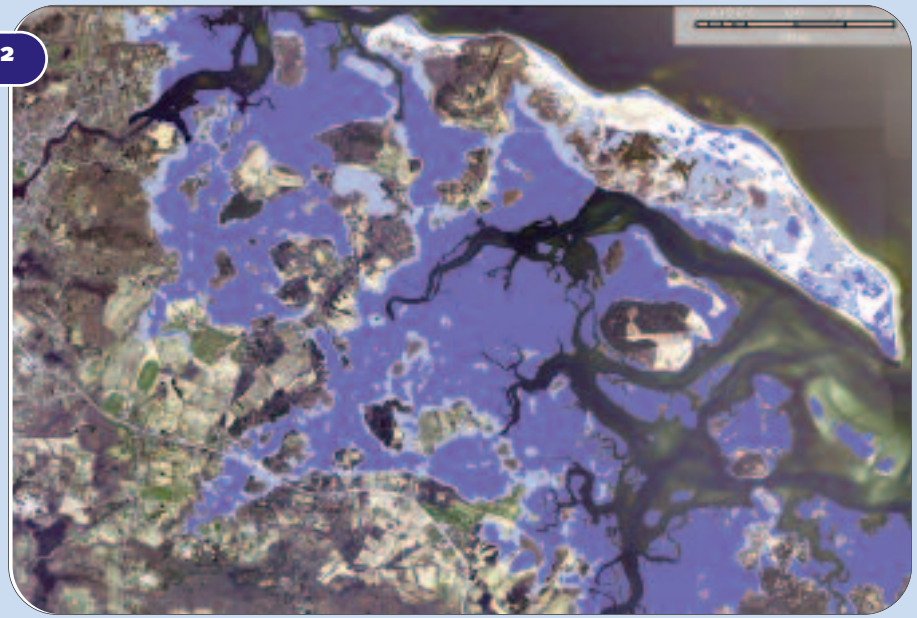
figure 2



Looking into the future of sea level rise shows the potential for a drastically different land/sea-scape around the Crane Beach area of the Great Marsh. The blue coverage shown here depicts low-lying areas with potential for inundation. Areas with the lowest elevation (darker blue) will be the first to experience the effects of sea level rise.