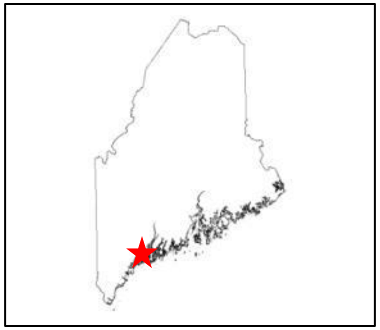
Maine Geologic Facts and Localities

May, 2011

Simulating future impacts of sea level rise on coastal wetlands: An example from Scarborough, Maine



43° 32' 59.00" N, 70° 20' 12.27" W

Text by
Peter A. Slovinsky

Introduction

For a number of years, the Maine Geological Survey has been working with the Southern Maine Regional Planning Commission (SMRPC) on a project to create more resilient coastal communities in the vicinity of Saco Bay, Maine, including the communities of Scarborough, Old Orchard Beach, Saco, and Biddeford. Saco Bay, located in southwestern Maine (Figure 1), is a long, crescent shaped bay that is bound by the headlands of Fletcher Neck in the south, and Prouts Neck in the north, and includes the Saco River, Goosefare Brook, and Scarborough River.

Saco Bay

Saco Bay is also home to the largest expanse of beaches, sand dunes, and contiguous coastal wetlands within the State of Maine, mostly associated with the Scarborough River watershed (Figure 1). One of the goals of the project is to create not only resilient built communities, but also resilient coastal wetlands in the face of sea level rise. This Site of the Month provides an abbreviated look at how the Maine Geological Survey has been looking at the potential impacts of sea level rise on coastal wetlands within Saco Bay.

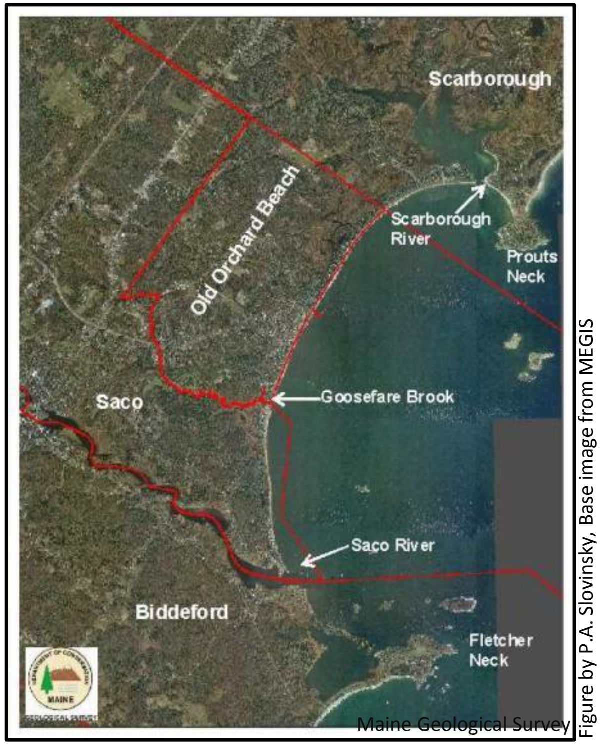
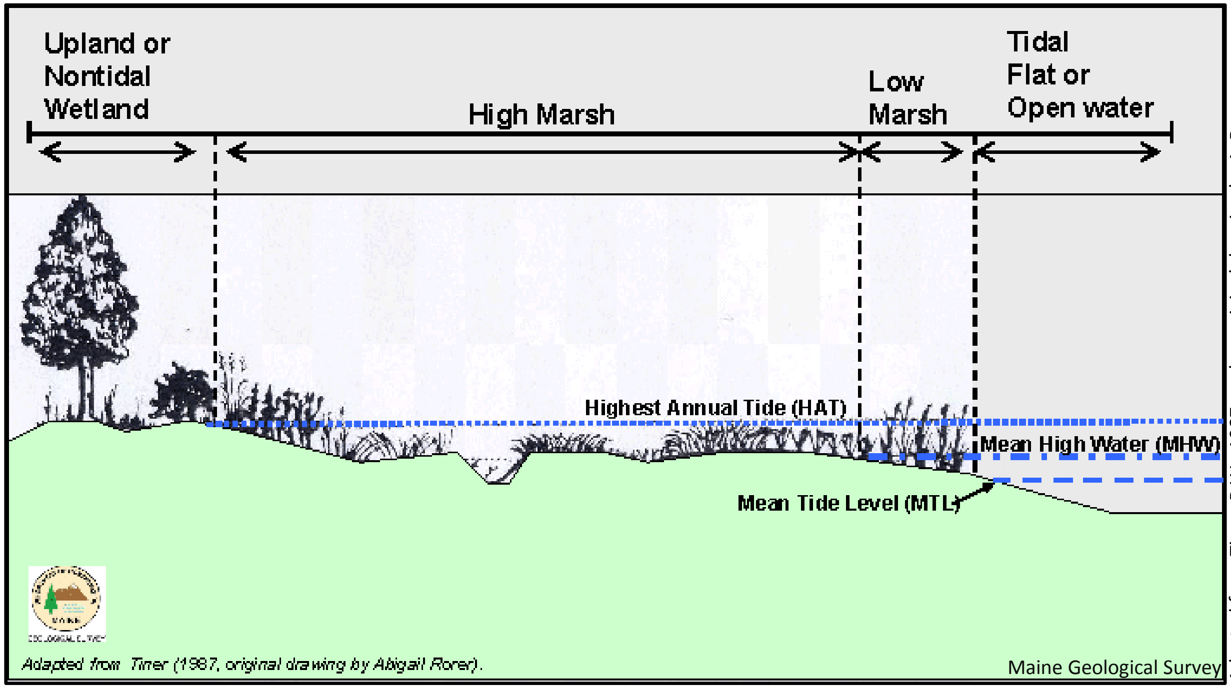


Figure 1. The Scarborough River marsh system, at the northern end of the bay, is the largest expanse of contiguous coastal wetlands in the State.

Marsh Zonation

Coastal wetlands in Maine and New England are typically comprised of low or high marsh, and both are dominated by distinct vegetative species that prefer different levels of salinity and tidal inundation. This marsh zonation is due to slight topographic differences in the marsh surface, and different tidal elevations reach to different portions of the marsh, driving species dominance. Generally speaking, areas of low marsh occur from about mean tide level (MTL) up to mean high water (MHW). High marsh generally exists from mean high water up to the limits of the highest annual tide (HAT) (Figure 2).



Adapted from Tiner, R.W., 1987, and an original drawing by A. Rorer.

Figure 2. General marsh zonation as it relates to tidal elevations for Maine's marsh systems.

Calculating Tide Heights

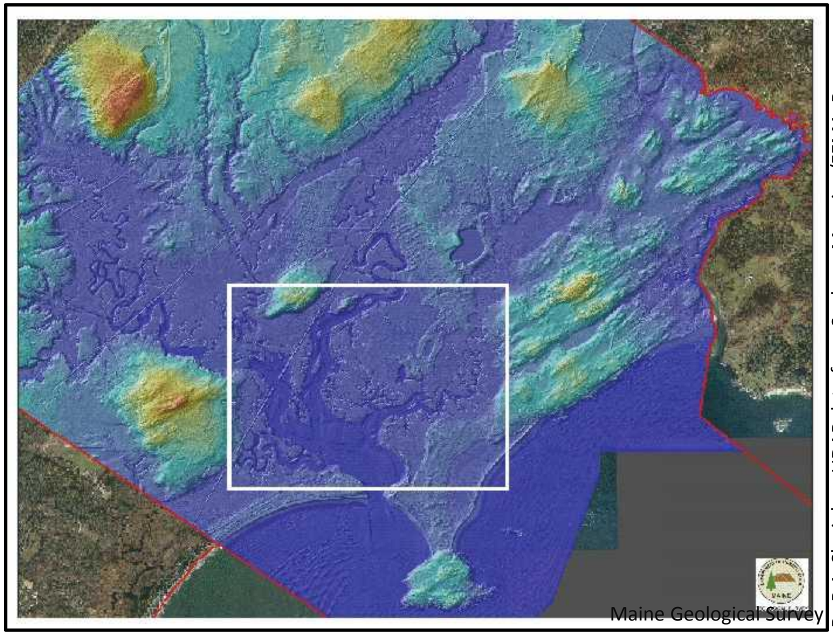
These tidal elevations relate to specific water levels that can be determined using tidal data from the NOAA Tides and Currents website for the southern Maine coastline. MGS creates a table of highest annual tide data (pdf) in support of the Maine DEP Shoreland Zoning Program using a simplified method of inputting tidal data from the NOAA website.

For example, in the vicinity of the Scarborough River, Old Orchard Beach is the closest tidal station, and has the following 2010 tidal elevations relevant to coastal wetlands, referenced to the Mean Lower Low Water (MLLW) tidal datum and the North American Vertical Datum of 1988 (NAVD88):

Mean Tide Level:	4.7 ft MLLW	-0.4 ft NAVD88
Mean High Water:	9.2 ft MLLW	4.1 ft NAVD88
Highest Annual Tide:	11.3 ft MLLW	6.2 ft NAVD88

LIDAR

As part of this project, MGS has undertaken efforts to investigate how sea level rise may potentially impact the coastal wetlands within Saco Bay. To do this, we use the tidal elevation data listed above in conjunction with Light Detection and Ranging, or LIDAR, topographic data collected from an airplane using optical laser remote sensing technology. This data is extremely accurate, with measured vertical accuracy errors around ±15 centimeters (~6 inches). An example of color-coded 2006 LIDAR topographic data for an area of the Scarborough River marsh system is shown in Figure 3.



By P.A. Slovinksy, LIDAR data from Sanborn Mapping/FEMA, Base image from MEGIS

Figure 3. Color-coded LIDAR topographic data draped over a hill-shade raster and aerial photograph for a portion of the Scarborough River marsh. Town boundaries are noted in red; the white outlined box denotes an area of the marsh that will be used to illustrate further analysis in Figures 5 to 7.

LIDAR Classification of Marsh Area

By using a combination of LIDAR data and known tidal elevations as proxies for the existing marsh surface, we can query the LIDAR data to determine those elevations between the specific tidal elevation ranges. An example of an aerial image depicting a smaller section of the Scarborough marsh system showing the boundaries delineated between the coastal wetland and upland, and between the low marsh and high marsh, is shown in Figure 4.

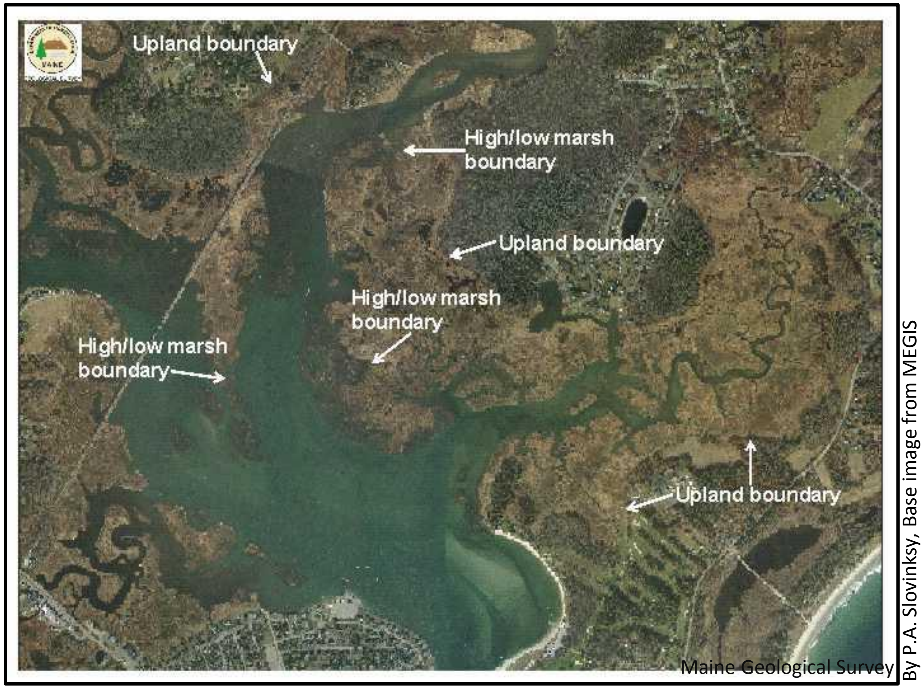


Figure 4. Aerial photograph depicting a section of the Scarborough River marsh system referenced in Figure 4. Note the delineation of the visible existing upland/wetland boundaries, and the visible boundaries between the low/high marsh zones.

LIDAR Classification of Marsh Area

Figure 5 shows the same boundaries delineated using the LIDAR data in conjunction with known tidal elevations listed. This section of the Scarborough marsh system is comprised of over 1,850 acres. High marsh dominates the system, making up about 68% of the total coastal wetland. Low marsh appears to mainly occur adjacent to the larger tidal channels, and accounts for the remaining 32% of the marsh surface.

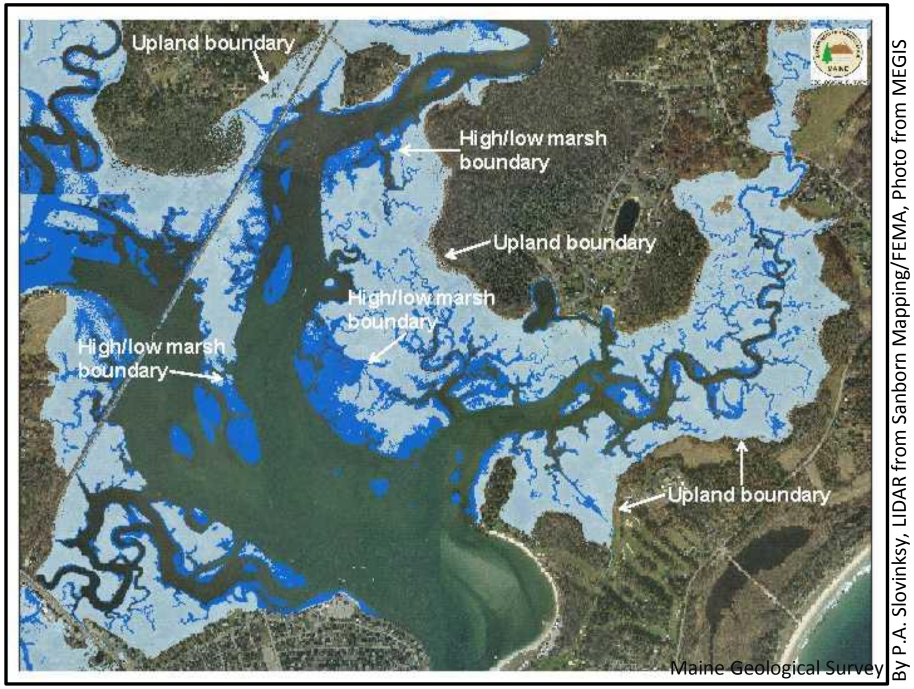


Figure 5. Simulation of existing conditions for a portion of the Scarborough River marsh system, delineated using tidal elevations of mean tide level, mean high water, and highest annual tide as proxies for the low marsh (MTL - MHW) and high marsh (MHW-HAT) areas. LIDAR data was queried to find all elevations within these ranges.

LIDAR Classification of Marsh Area

The existing areas of this sample section of the marsh are described below.

Wetland Type	Existing Area (ac.)	% Total Area	Future Area (ac.)	% Total Area	Change (ac.)
Low Marsh (MTL-MHW)	593.7	32.0	808.3	60.5	214.6
High Marsh (MHW-HAT)	1258.8	68.0	526.7	39.5	-732.1
Total Wetland (MTL-HAT)	1852.5	100	1335.0	100	-517.5

Maine Geological Survey

LIDAR Classification of Marsh Area

This method does miss classifying some areas of marsh properly (for example, open salt pannes and ponds are many times included as "high" marsh). However, it is generally quite accurate in delineating between the overall coastal wetland (areas below the highest annual tide, or HAT) and adjacent uplands, and even the boundaries between the different marsh zones (areas between low marsh and high marsh).

Maine has adopted using two feet of sea level rise as a middle of the road prediction over the next 100 years in its coastal sand dune systems. In order to analyze the potential impacts of sea level rise on existing marsh surfaces, 2 feet of sea level rise were added onto each of the existing tidal elevations that were used for proxies for the existing marsh surface. *It is important to note that this method is a 'bathtub' style approach to simulating sea level impacts, as it assumes static topography in the future (no changes to the land topography due to erosion or accretion resulting from the sea level rise).*

LIDAR Classification of Marsh Area

Results of simulating the potential impacts of 2 feet of sea level rise for the sample section of the marsh is shown in Figure 6.

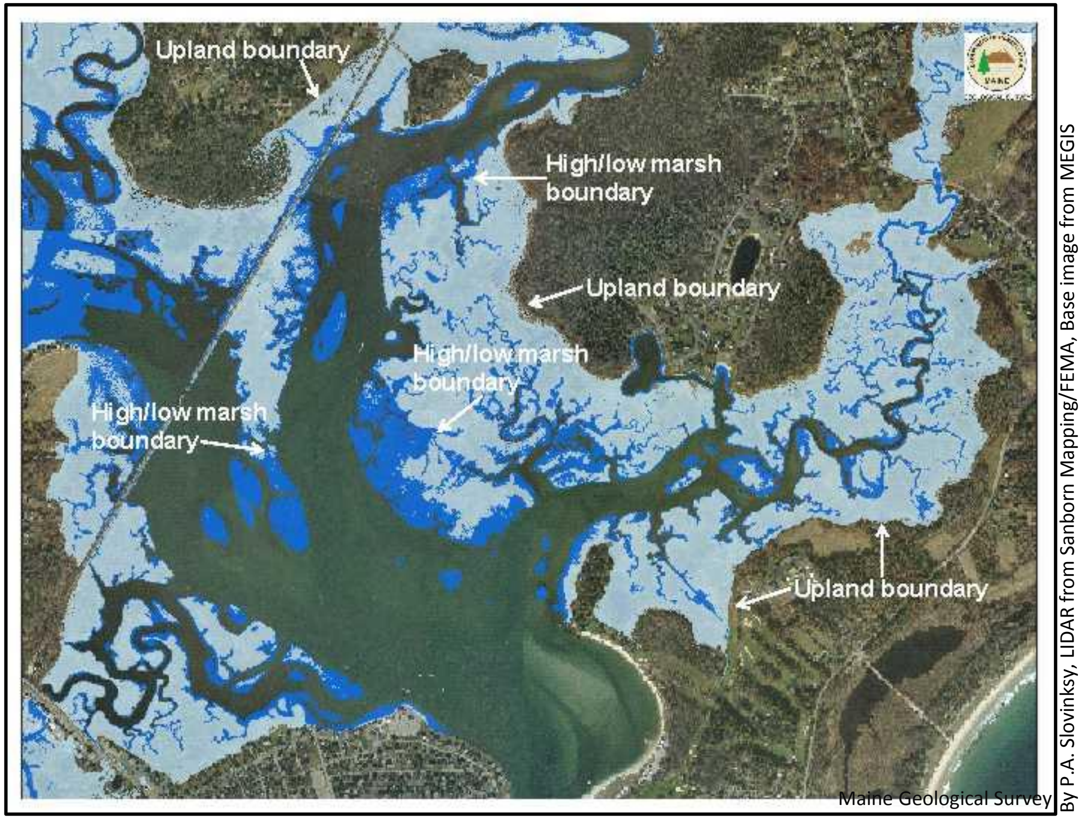


Figure 6. Simulation of potential future conditions after 2 feet of sea level rise for a portion of the Scarborough River marsh system. Two feet of sea level rise was added to each of the different elevation ranges that were proxies for different marsh surfaces to simulate potential future marsh zones based on topography.

LIDAR Classification of Marsh Area

According to Table 1, the marsh may see a dramatic change in the overall makeup of the dominant marsh type. The area of high marsh may decrease substantially from existing conditions, making up only about 40% of the future total coastal wetland area. On the other hand, the area of low marsh may increase, making up over 60% of the future total coastal wetland area. It appears that the majority of this expansion would occur from the potential conversion of existing high marsh areas into low marsh dominated areas. As a whole, the coastal wetland in this section could potentially decrease in size by around 500 acres (nearly 28%). It appears that much of this potential loss could be due to pinching out of existing high marsh areas against steeper sloped or highly developed uplands, and conversion of existing low marsh into areas of open water (below the future mean tide level).

However, this simulation also shows that there are some areas *where the existing marsh system may be able to transgress; that is, move unimpeded into low-lying, undeveloped upland areas*. These areas are identified in Figure 6. This type of information is very important for communities to use to be able to identify these low-lying, susceptible upland areas that could be designated for either conservation or as future flood-prone areas. Such measures would help ensure that the marsh system is able to respond to a rising sea.

Similar simulation work has been completed for the existing marsh systems within Saco Bay, including the remainder of the Scarborough River marsh system, and marshes in Goosefare Brook, the Saco River, and further south within the Biddeford Pool area.

References and Additional Information

Tiner, R.W., 1987, A Field Guide to Coastal Wetland Plants of the Northeastern United States: University of Massachusetts Press, 287 p.

More information on the overall community resiliency project and MGS and SMRPC efforts to simulate the potential impacts of sea level rise for both the built and natural environments is available at the SMRPC website.

Note: images shown are for general planning purposes only.