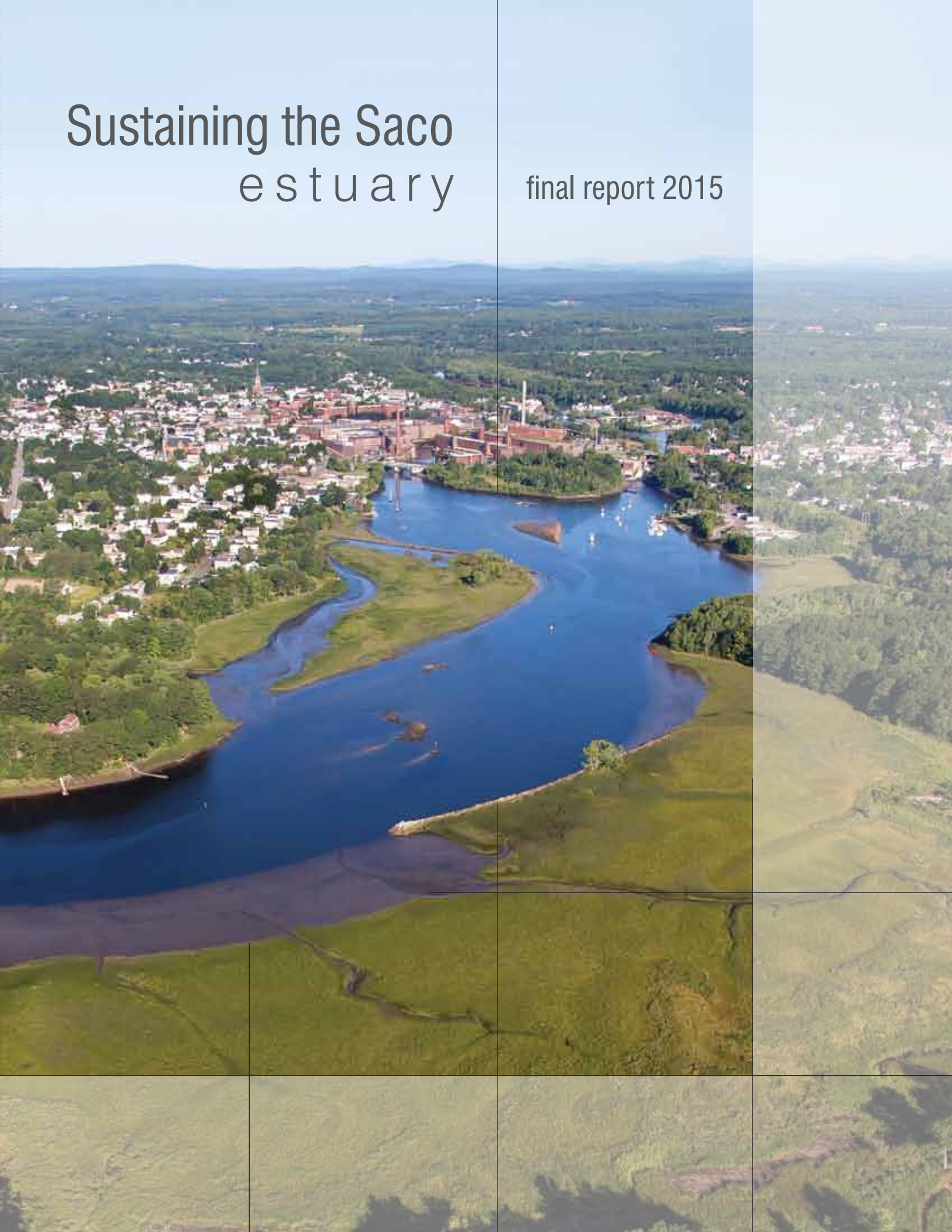# Sustaining the Saco
e s t u a r y

final report 2015

Sustaining the Saco
e s t u a r y

final report 2015

Project Leaders

Christine B. Feurt, Ph.D.
University of New England and
Wells National Estuarine Research Reserve
Tel: (207) 602-2834
Email: cfeurt@une.edu

Pamela A. Morgan, Ph.D.
University of New England
Tel: (207) 602-2227
Email: pmorgan@une.edu

Project Team

University of New England

Mark Adams, Ph.D.
Anna Bass, Ph.D.
Carrie Byron, Ph.D.
Michael Daley, Ph.D.
Michael Esty

Noah Perlut, Ph.D.
Michele Steen-Adams, Ph.D.
James Sulikowski, Ph.D.
Stephan I. Zeeman, Ph.D.

Wells National Estuarine Research Reserve

Jacob Aman
Michele Dionne, Ph.D.

Jeremy Miller
Kristin Wilson, Ph.D.

CONTENTS

SEA LEVEL RISE AND THE SACO ESTUARY

TIDAL MARSHES

BY MICHAEL ESTY

INTRODUCTION

One of the consequences of climate change is that the seas are rising. Sea level rise will have a significant impact on tidal wetlands worldwide, including the tidal marshes of the Saco Estuary. It will also affect areas that border the tidal marshes. Fortunately, tidal marshes have the ability to accumulate sediments vertically and grow in elevation, so they will not necessarily be drowned out by rising seas. Scientists have discovered that one possible future scenario for tidal marshes is that, as the sea rises, marshes will accrete sediments and move inland. This is called *marsh migration*. But tidal marshes do not always have someplace to go—human or natural barriers to marsh migration can prevent marsh movement and result in marshes decreasing in size (Torio and Chmura 2013). This prevention of marsh movement is known as *coastal squeeze*. Because tidal marshes protect against flood, storm, erosion and wave damage, it may be prudent to plan ahead to mitigate the effects of coastal squeeze on the Saco Estuary's tidal wetlands. In addition, with more frequent storms predicted for the future, understanding how storm surge and flooding events are affected by sea level rise is important to make wise management decisions.

Tidal marshes are complex systems, as shown in all chapters of this report. To model what might happen to them and plan for the future requires involvement of local municipalities. Modeling the effects of sea level rise requires a large amount of data and local review if the models are to be useful in specific locations. Examples of local studies of the impacts of sea level rise on communities are the Town of Cape Elizabeth report (Slovinsky 2013) and the Climate Vulnerability Assessment for Coastal Washington County (Johnson and East 2014).

STUDY OBJECTIVES—SEA LEVEL RISE

Our objectives for the sea level rise (SLR) study were to answer these questions related to the tidal marshes:

1. Based on a model of SLR using the latest light detection and ranging (LiDAR) data, digital elevation models, orthophotos, tidal marsh definitions,

sea level rise data, and other information, how might the tidal marshes of Biddeford and Saco be affected by ongoing sea level rise?

2. What are some potential steps that could be taken to prepare Biddeford and Saco for the increasing effects of SLR?

RESEARCH DESIGN AND METHODS

There are several ways to map a tidal marsh. One can survey the marsh in the field with a Global Positioning System (GPS) and/or map its vegetation and other characteristics. A tidal marsh can also be defined using orthophotos (i.e., aerial photographs that have been corrected or orthorectified). These methods are expensive and time consuming. They also require a great deal of expertise. A third method is to define the tidal marsh as the area between the low tide level and the Highest Annual Tide (HAT). Community zoning tends to use the third definition. There is also some discussion about which high tide level to use, but the HAT level
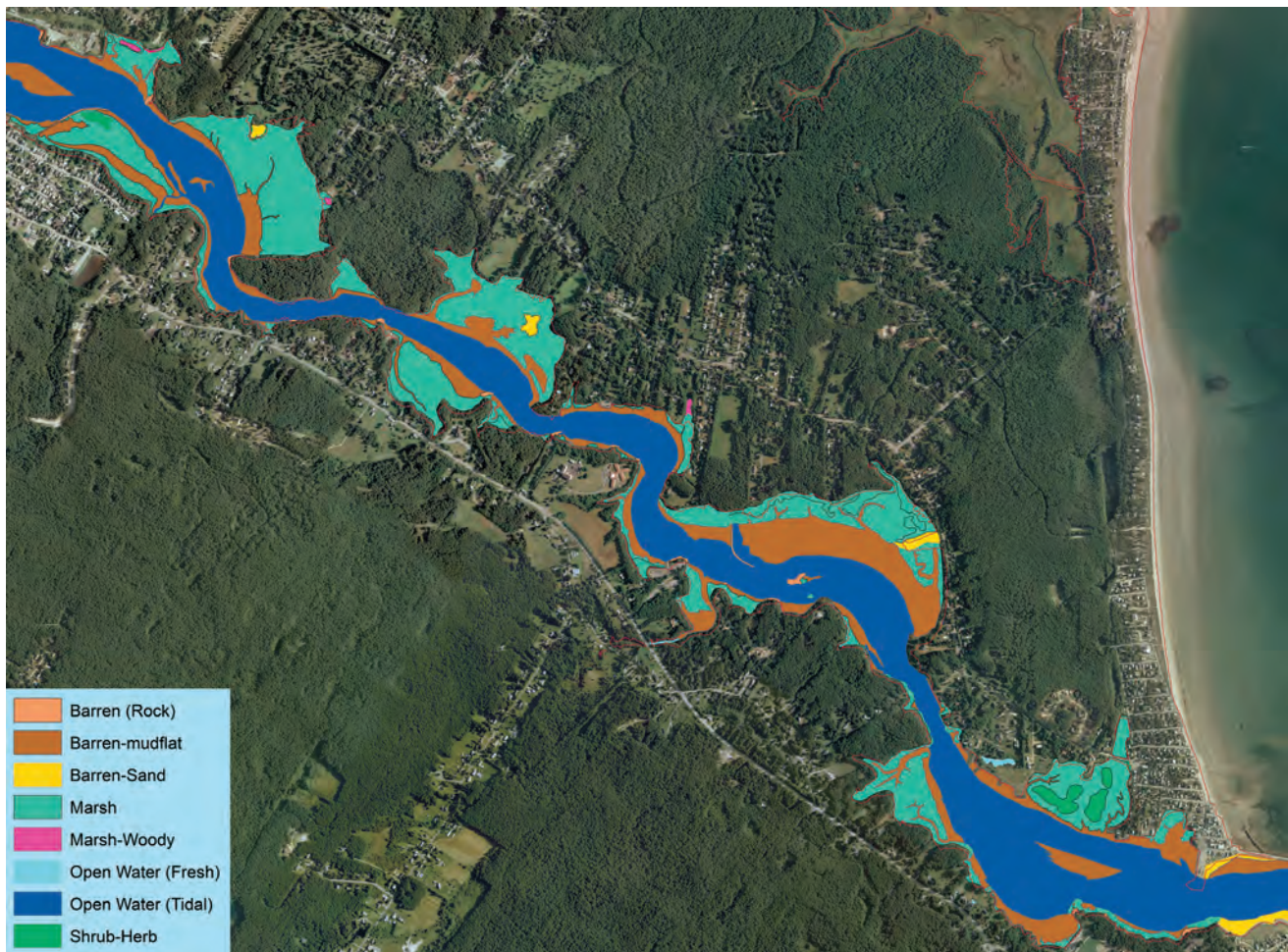

Barren (Rock)
Barren-mudflat
Barren-Sand
Marsh
Marsh-Woody
Open Water (Fresh)
Open Water (Tidal)
Shrub-Herb

FIGURE 1 Current tidal marshes of the Saco Estuary.

is commonly used in Maine (Slovinsky 2013). Maine's Highest Annual Tide Levels are located at http://www.maine.gov/dep/land/slz/predictions.pdf.

The City of Saco Zoning Ordinance defines a coastal wetland as:

All tidal and subtidal lands; all lands with vegetation present that is tolerant of salt water and occurs primarily in a salt water or estuarine habitat; and any swamp, marsh, bog, beach, flat or other contiguous low land that is subject to tidal action during the highest tide level for the year in which an activity is proposed as identified in tide tables published by the National Ocean Service.

Figure 1 shows the current tidal marshes in the Saco Estuary. The blue shape is the river at low tide and the red line is the HAT line. Although it is not a perfect match, this map shows that the HAT, orthophotos, and vegetation boundaries are similar.

Which sea level rise scenario should we use?

There are several possible scenarios to review for sea level rise. Low and high average SLR scenarios used by states and communities range from 0.6 to 1.1 m (2 to 3.6 ft) by 2100 (Marcy 2014). We used an intermediate value of 3 ft for the Saco Estuary. It should be noted that the work we present here is just a start to our understanding and planning for SLR in the Saco Estuary. Ideally, one would run several different scenarios when developing a plan for a community. Also, storm surge levels, storm frequency and coastal squeeze are important to model. The flooding and erosion that may be a result of sea level rise should also be a part of local community planning.

RESULTS AND DISCUSSION

Based on a model of SLR using the latest light detection and ranging (LiDAR) data, digital elevation models, orthophotos, tidal marsh definitions, sea level rise data, and other information, how might the tidal marshes of Biddeford and Saco be affected by ongoing sea level rise?

Coastal squeeze will affect the Saco Estuary's marshes

As sea level rises in the coming decades, streets, manmade barriers such as seawalls, and natural ledges will block the tidal marsh from migrating inland. Figure 2 shows examples of barriers to marsh migration in the Saco Estuary. Coastal squeeze will be a major issue in the Saco Estuary, given the large number of barriers present. On the Saco side of the estuary, Route 9, the Camp Ellis development, and other developed areas close to the river are areas of concern for coastal squeeze. On the Biddeford side of the estuary, natural rock barriers are more common. Each marsh in the Saco Estuary should be reviewed and any barriers on its borders further defined and mapped.

FIGURE 2   Human-made and natural barriers in the Saco Estuary. Photos by M. Esty.

A 3-ft SLR scenario for the Saco Estuary[1]

The maps and models that follow were created using Digital Elevation Models (DEM) available from Maine Office of GIS (Digital Elevation Model—2m from LiDAR (4/08/2013) http://www.maine.gov/megis/catalog/). The DEM files were downloaded into a Geographic Information System software program (ESRI ArcMap). An ArcMap tool, raster calculator, was used to select elevation levels. The raster files were converted to polygons using GIS conversion tools. The Erase function was used to create polygons of only the future tidal marshes. Additional metadata on the files are located in the reference section of this chapter and at the sources listed. Orthophotos were downloaded from Geolibrary 6in 2012 CIR (http://mapserver.maine.gov/basemap/index.html). The HAT lines were prepared by Mark Adams.

---

[1] Disclaimer

The maps and files in this chapter were generated as one scenario of tidal marsh migration using elevation models. They should not be used for other purposes. The data and maps do not account for erosion, subsidence, wind driven tides, complex hydrology, or future construction. They are not meant to be used for navigation or in place of official National Weather Service flood warning and watch forecasts. Onsite evaluation of the data is the user's responsibility. Multiple scenarios and additional data from local, state, and federal organizations should be used in management decisions.
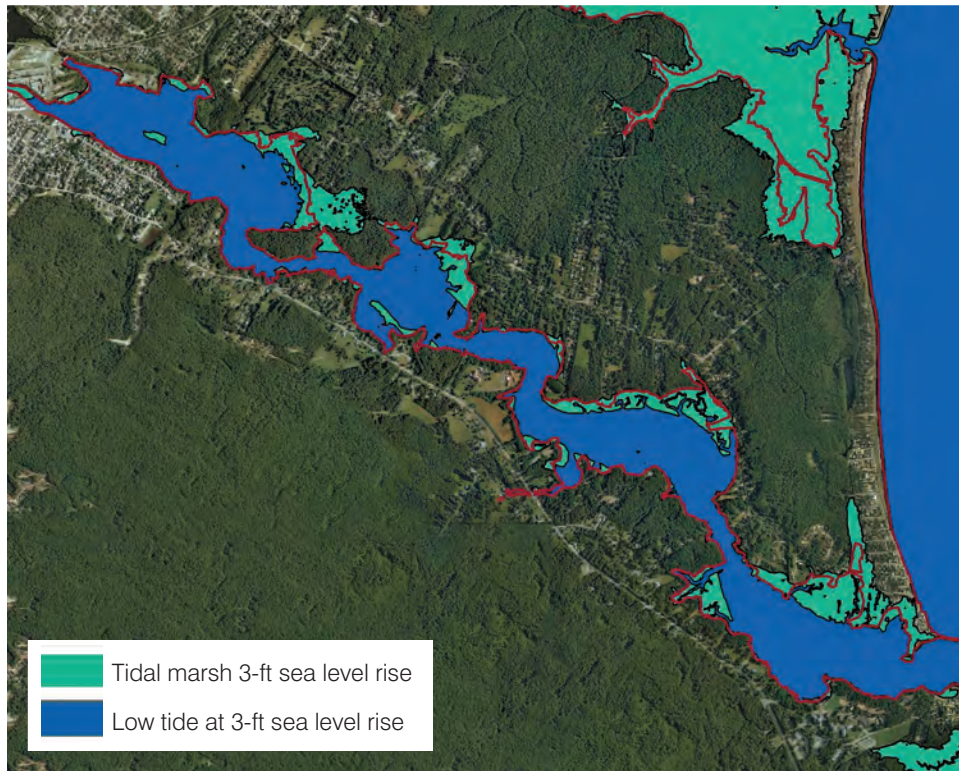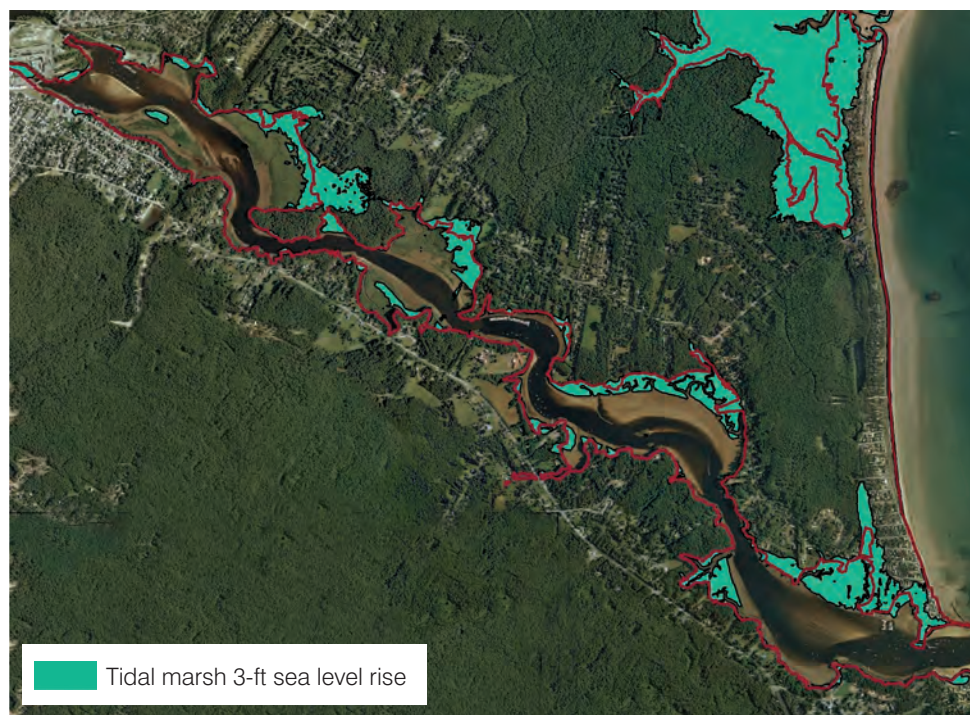
FIGURE 3   Projected 3-ft sea level rise by 2100 in the Saco Estuary. Green areas are predicted future areas of tidal marsh. The blue area is the low tide water level, and the red line is the 2011–2012. Highest Annual Tide (HAT) line.

Figure 3 is a map of the tidal marshes of the Saco Estuary with a projected 3-ft sea level rise in 2100.

The tidal marshes are smaller in this future scenario than they are at the present time. In the Camp Ellis area, the marsh overlaps Route 9 and several houses. Figure 4 shows the marshes overlaid on a current orthophoto. This figure shows many areas of coastal squeeze. Figure 5 shows a marsh in the Cow's Island area that migrates significantly beyond the current HAT line.

Future storm surges will cause more damage because of SLR

Storm surge and flooding are typically also included in SLR modeling scenarios. A 3-ft sea level rise added to the storm surge levels means that significant flooding will be much more frequent in the future. Smaller tidal marshes will provide less of a buffer to these storm surges. Figure 6 is an output map from modeling the flooding during a storm in 1978 plus a 3-ft sea level rise, providing an example of potential future storm surge.

Tidal marsh 3-ft sea level rise

FIGURE 4   Projected 3-ft sea level rise by 2100 scenario showing tidal marshes overlaid on current orthophoto. Note that many of the future tidal marshes are much smaller than marshes existing today. Current HAT line is red.

0   750   1,500 feet
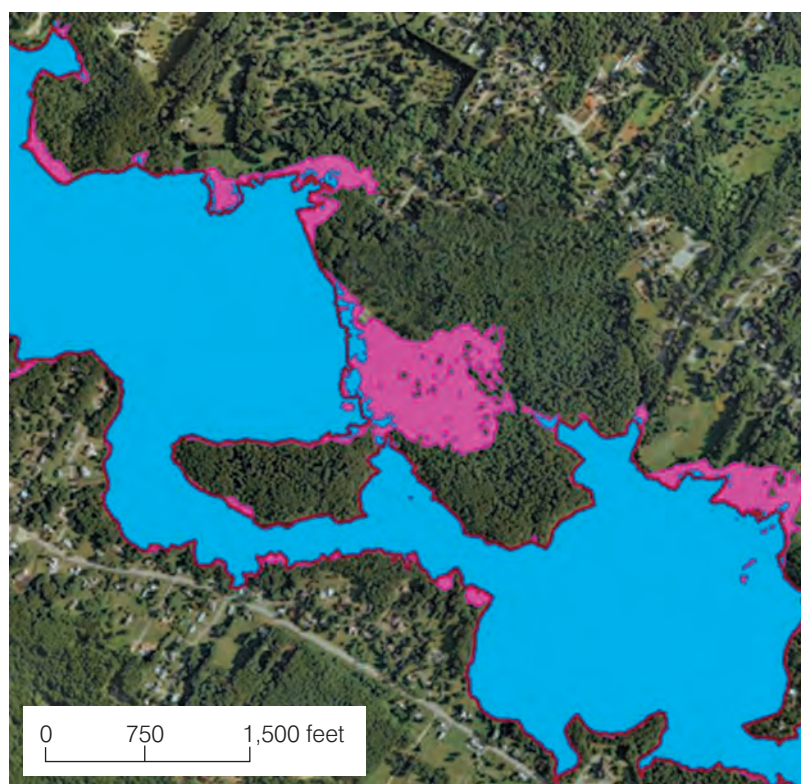
FIGURE 5   Migration of marsh near Cow Island beyond current Highest Annual Tide line in 3-ft sea level rise scenario. Potential (future) marsh is pink, and current HAT line is red.

FIGURE 6   Map showing the modeled effects of storm surge during a major storm in 1978 plus a projected 3-ft sea level rise. Modeled using NOAA's Coastal Inundation Mapping Tool (http://www.csc.noaa.gov/digitalcoast/tools/slrviewer).

What are some potential steps that could be taken to prepare Biddeford and Saco for the increasing effects of SLR?

Based on the results of our study of the effects of projected sea level rise on the Saco Estuary tidal marshes, we make the following recommendations to build on this preliminary work:

1. Discuss SLR model results with local Biddeford and Saco communities as a component of local climate change adaptation planning.

2. Survey marsh borders for barriers to inland migration of tidal marshes.

3. Create a localized, more accurate version of the NOAA SLR viewer that allows running multiple scenarios.

4. Model predicted low tide changes and effects on mudflats.

5. Model interaction of the invasive common reed (*Phragmites australis*) and sea level rise.

CONCLUSIONS

We made the following conclusions from our research on the effects of SLR on the Saco Estuary's tidal marshes:

- Roadways, seawalls, and natural ledges adjacent to tidal marshes will block many marshes from migrating inland as sea level rises.
- Because marsh migration will be blocked, tidal marshes will become smaller.
- Smaller marshes and the higher sea level will increase the vulnerability of Biddeford and Saco to storm surge damage.

ACKNOWLEDGEMENTS

LITERATURE CITED

Anonymous. 2012. Climate Vulnerability Assessments for Coastal Washington County. GROWashington-Aroostook. http://gro-wa.org/washington-county-climate-change-response.htm#OnLineMaps.

Gregory, J. 2013. Projections of sea level rise. Intergovernmental Panel on Climate Change. Chapter 13, Sea level change. http://www.ipcc.ch/pdf/unfccc/cop19/3_gregory13sbsta.pdf.

Johnson, T. and J. East. 2014. Climate Vulnerability Assessment for Washington County. GRO-WA.org. http://gro-wa.org/assets/files/climate-change/CVA-Washington-County-June-2014.pdf.

Marcy, D. 2014. Mapping and visualizing sea level rise and coastal flooding impacts. Presentation for NOAA Coastal Service Center. https://noaacsc.adobeconnect.com/_a1005979616/p3h5x2ubnkc/?launcher=false&fcsContent=true&pbMode=normal.

Portland, ME, Bouy 8418150. 2014. NOAA Center for Operational Oceanographic Products and Services [Web]. [accessed 2014 Apr 30]. Available from: http://tidesandcurrents.noaa.gov/waterlevels.html?id=8418150.

Slovinsky, P.A. 2013. Town of Cape Elizabeth: A summary of some of the latest sea level rise science and storm surge data to help guide municipal ordinance changes. Maine Geological Survey. http://www.capeelizabeth.com/planning_board/2013/10-29-2013/Slovinsky_CapeEliz_10-29-2013.pdf.

Torio, D.D. and G.L. Chmura. 2013. Assessing coastal squeeze of tidal wetlands. *Journal of Coastal Research* 29(5):1049–1061. Coconut Creek, FL ISSN 0749-0208.