Sea Level Rise Impacts on Delaware Estuary Wetlands

Delaware River Basin Commission

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March 2, 2021

3-D Hydrodynamic Model

Photo courtesy of Joseph Smith Ph.D

Wetland complexity
Tidal Wetlands in the Delaware Estuary

**Wetland types**
1. Freshwater tidal marshes (green)
2. Brackish estuary marshes (orange)
3. Salt marshes or salt fringe (red)

**Why marshes are important**
- Buffer the coastal storm
- Protect shoreline from erosion
- Essential habitat for wildlife
- Support commercial and recreational fishing
- Provide educational opportunities
- Absorb excess nutrients, improve water quality
- Impressive natural carbon sink, reduce climate change
- And more …

The different tidal marsh can be delineated by salinity gradient. Among many functions, they are important natural carbon sinks to mitigate climate change.

Tidal wetlands of the Delaware Estuary (Reed et al. 2008.)
http://risingsea.net/papers/federal_reports/Titus_and_Strange_EPA_section2_1_Reed_Cahoon_et_al.pdf
Local Relative Sea Level Rise (SLR) in Delaware Bay and Estuary

DRBC have proposed SLR scenarios (0.3, 0.5, 0.8, 1.0, 1.6) for 2060 water resource planning and salinity study

Likelihood of those SLR scenarios was also considered

- 0.3 m SLR, and the chance for this to happen is 91 to 92% for 2060;
- 0.5 m SLR, and the chance for this to happen is 46 to 49% for 2060;
- 0.8 m SLR, and the chance for this to happen is 9 to 10% for 2060;
- 1.0 m SLR, and the chance for this to happen is 1 to 2% for 2060;
- 1.6 m SLR, and the chance for this to happen is 0 to 1% for 2060

We proposed 5 SLR scenarios for 2060. Current SLR rate is 3.53 mm/year
Edward W et al. (2018):
- Tidal wetlands lost at a rate of \(-1.03\) sq-km/year in the Delaware Estuary.
- Land cover analysis shows 43.5 sq-km tidal wetlands lost to open water since 1975.

NJ SAB (2020):
- Marsh loss rate: 1.1-1.9% per decade (horizontal extent).

Phillips (1986):
- Shoreline erosion: average rate is 3.2 m/year (2-5 m/year at different segments between 1940 to 1978).

Shoreline might erode, and marsh may migrate further inland due to SLR.
As sea level rises, more water get into the estuary.
Relative percent of water volume over marshes w.r.t. volume in the open water area of Zone 6 increased with the SLR.
Cross-sectional view at RM 37 across the Ship John Shoal area.

Based on predicted water surface elevation (WSE) range over one-year simulation period and with a low-flow hydrologic conditions from 2002. Noted that X,Y are not on the same scale.
Selected Locations for Diagnostic Analysis of Water Surface Elevation

- Johnson’s Ditch north of the Egg Island Fish and Wildlife Management Area
- Bay Point, NJ
- Hope Creek Nuclear Power Plant, NJ
- Nantuxent Cove, NJ
This example is for SLR = 0 m (baseline), only flooded during short period of time often during spring tide with shallow water depth.
Simulated WSE Showing Flooding at Selected Locations, SLR = 0.8 m

This example is for SLR = 0.8 m (2.6 ft)

Inundation duration became longer, water depth increased more with SLR
Simulated Inundation Frequency at Selected Locations

<table>
<thead>
<tr>
<th>Location</th>
<th>SLR</th>
<th>Predicted Inundation Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location 1</td>
<td>0</td>
<td>61.50%</td>
</tr>
<tr>
<td></td>
<td>0.3</td>
<td>75.79%</td>
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<tr>
<td></td>
<td>0.5</td>
<td>88.16%</td>
</tr>
<tr>
<td></td>
<td>0.8</td>
<td>92.84%</td>
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<tr>
<td></td>
<td>1</td>
<td>96.42%</td>
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<tr>
<td></td>
<td>1.6</td>
<td>99.58%</td>
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<tr>
<td>Location 2</td>
<td>0</td>
<td>14.61%</td>
</tr>
<tr>
<td></td>
<td>0.3</td>
<td>31.11%</td>
</tr>
<tr>
<td></td>
<td>0.5</td>
<td>39.91%</td>
</tr>
<tr>
<td></td>
<td>0.8</td>
<td>50.90%</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>61.63%</td>
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<tr>
<td></td>
<td>1.6</td>
<td>88.44%</td>
</tr>
<tr>
<td>Location 3</td>
<td>0</td>
<td>16.95%</td>
</tr>
<tr>
<td></td>
<td>0.3</td>
<td>30.70%</td>
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<tr>
<td></td>
<td>0.5</td>
<td>37.02%</td>
</tr>
<tr>
<td></td>
<td>0.8</td>
<td>52.42%</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>60.11%</td>
</tr>
<tr>
<td></td>
<td>1.6</td>
<td>85.27%</td>
</tr>
</tbody>
</table>

As Sea level rises, inundation frequency increases. For example, at the 2 locations further north, it increased from ~15% (or 3.6 hours a day) to more than 50% (or 12 hours a day) with 0.8 m SLR.
Predicted Salinity, 0 m vs. 1 m SLR
long-time averaged results, 2002 hydrologic conditions

One year simulation with 2002 hydrology. Look at long-term tidally averaged salinity on a large spatial scale and over a long time period. Investigate the change in salinity regime over marsh areas.
A clear gradient in salinity exists from the bay mouth towards upstream. For given marsh, tidally-averaged salinity increases as sea level rises.
Predicted Long-term-averaged Salt Mass In Marsh Areas (metric tons per square meter per hour)

As sea level rises, the amount of salt in the water column in marsh increases in terms of mass per unit area per given time period.
As sea level rises, total amount of saltwater moving in and out of marsh areas, the inundation frequency, and water depths all increase. Sea level rise may change the salinity regime in marsh wetlands that may have profound influence on the health of marsh habitat.

Ecologist and biologist may take this physics predicted by the model and make their assessment of the ecological effects associated with SLR on these marsh habitats.

Numerical model simulations indicate that SLR may significantly alter the key environmental parameters in the Delaware Estuary wetlands. We should look at the difference predicted by the model rather than the absolute values in these parameters.
Questions?

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