Assessing the Impact of Climate Change on Proposed Restoration of the Lynnhaven Ecosystem

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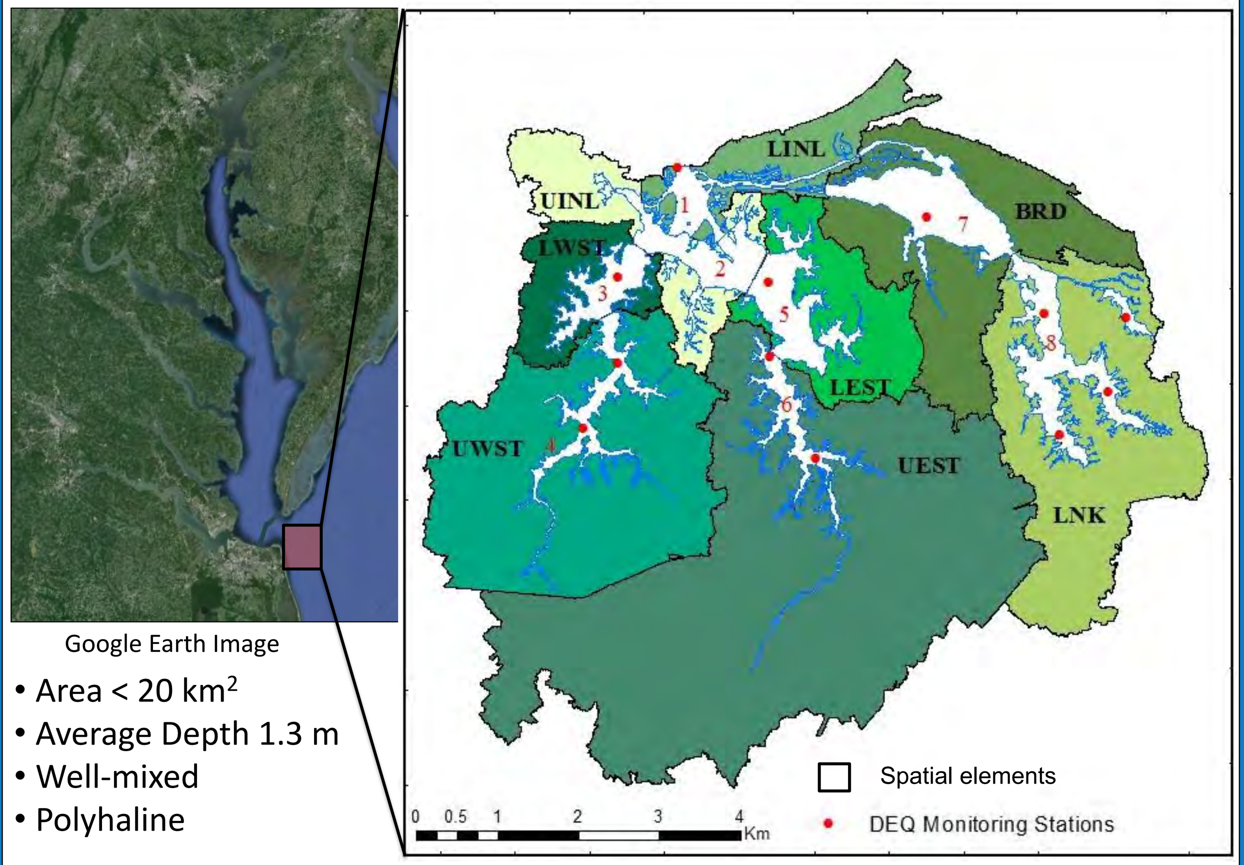
STUDY SITE

Lynnhaven River Watershed – Virginia Beach, VA



- Area < 20 km^2
- Average Depth 1.3 m
- Well-mixed
- Polyhaline

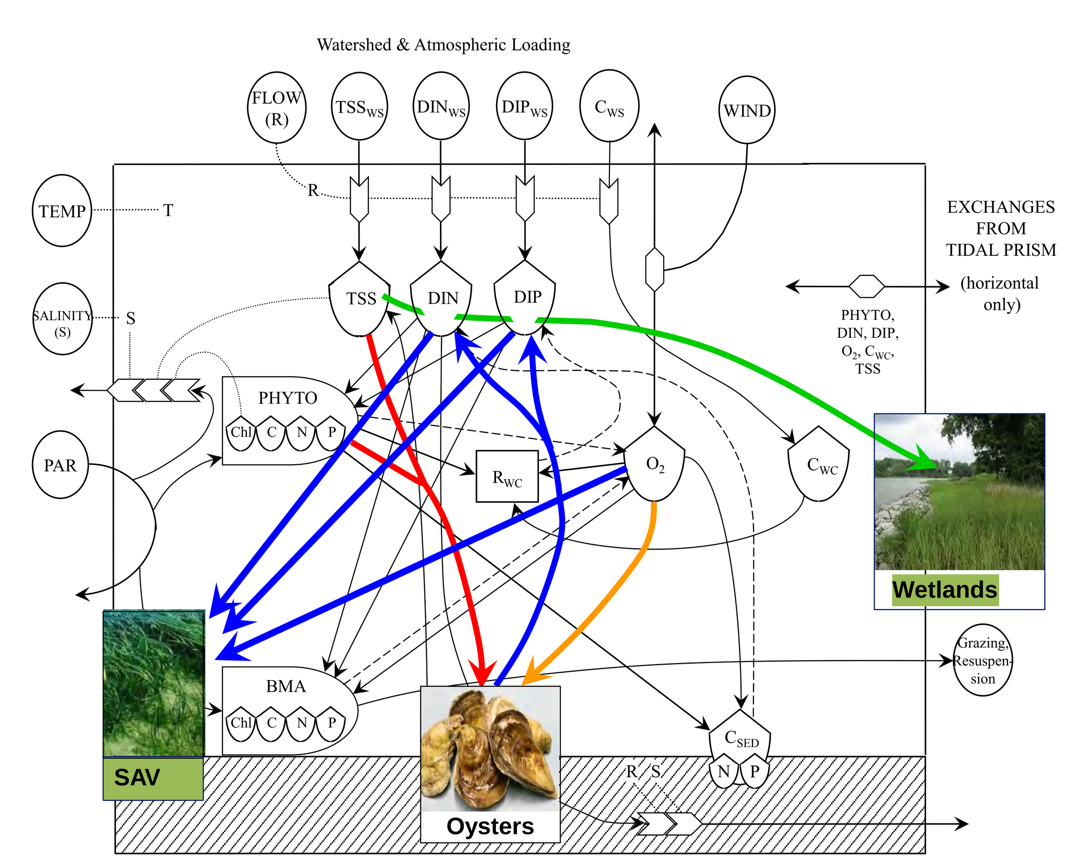
36°52'50.40"N 76° 5'12.17"W

The model has 8 spatial elements with their associated subwatersheds in green.

USACE Lynnhaven Ecosystem Restoration Plan

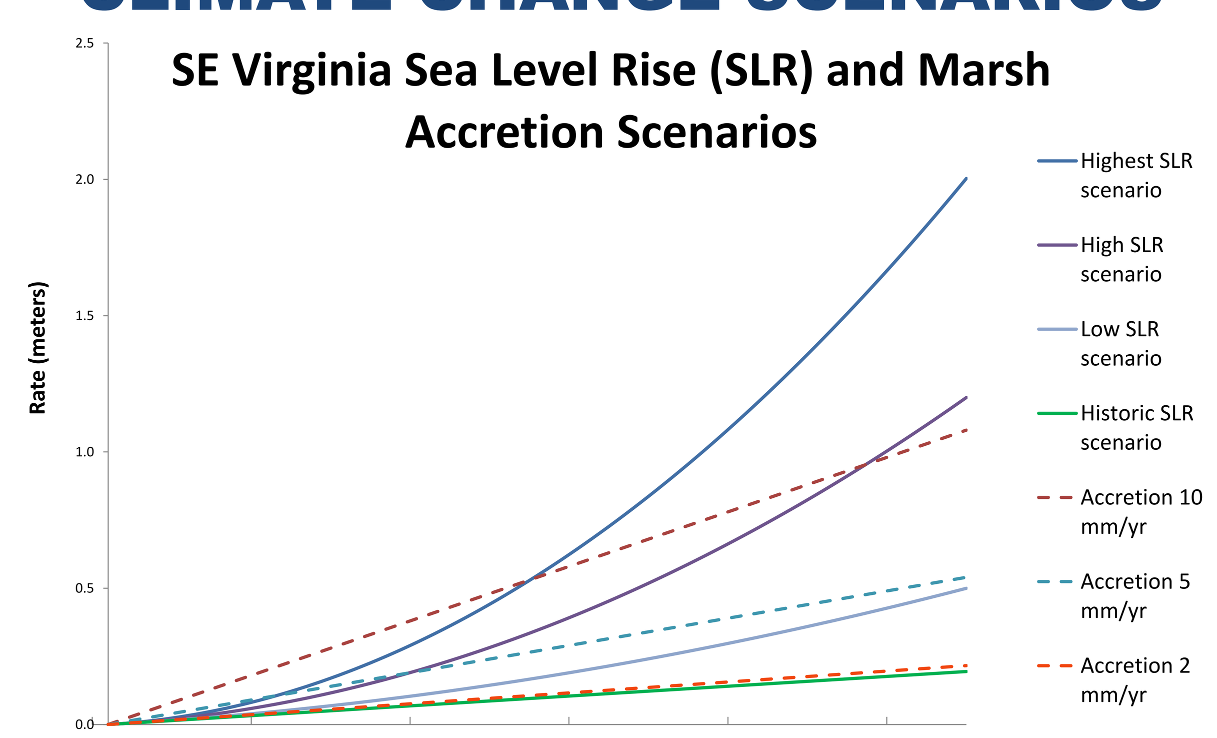
- Restoration of 94 acres of SAV
- Restoration of 38 acres of tidal salt marshes
- Construction of 31 acres of oyster reef habitat

MODEL DIAGRAM



CLIMATE CHANGE SCENARIOS

SE Virginia Sea Level Rise (SLR) and Marsh Accretion Scenarios



Model Simulations:

Temperature Scenarios: **+1, 2, 3, 5°C** (Najjar et al. 2009).

Sea Level Rise Scenarios: +**0.49, 0.99, 1.69, 2.29m** for 2100 - based on 2012 National Climate Assessment global sea level rise scenarios + **0.27mm/year local subsidence** in VA (Mitchell et al 2013).

OBJECTIVES

How will **climate warming** and **sea level rise** (SLR) affect the capacity of restored **submerged aquatic vegetation** (SAV), **oysters** and **marsh** habitats to provide ecosystem services in the Lynnhaven River?

1. Examine vulnerability of SAV, oysters and marsh habitats to increases in temperature and SLR.
2. Apply an intermediate complexity model (modified Brush and Nixon, 2008) to the Lynnhaven River Estuary and quantitatively predict climate-related impacts on ecosystem services resulting from the U.S. Army Corps of Engineers (USACE) Lynnhaven Ecosystem Restoration Plan.

Category	Outcomes
Parameters	Chlorophyll-a concentrations, K_D, O_2, water column DIP and DIN, TSS, and primary production.
Ecosystem Services	For each of the 8 boxes, run the model 25 times (for each scenario combination) and quantify: • Growth and survival of restored SAV, oyster, and marsh communities • Amount of N removed via denitrification • Volume of water filtered • Reduction in chlorophyll-a and TSS • Nutrients sequestered: Amounts of N and P buried in the sediments Amounts of N and P assimilated in animal tissues and shells

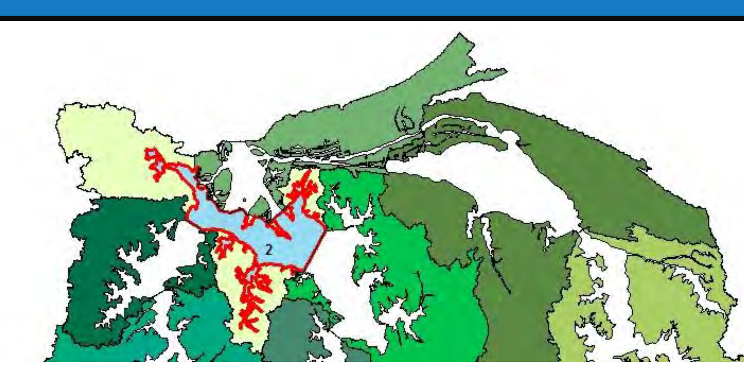
ESTUARINE ECOSYSTEM MODEL

Model Calibrations

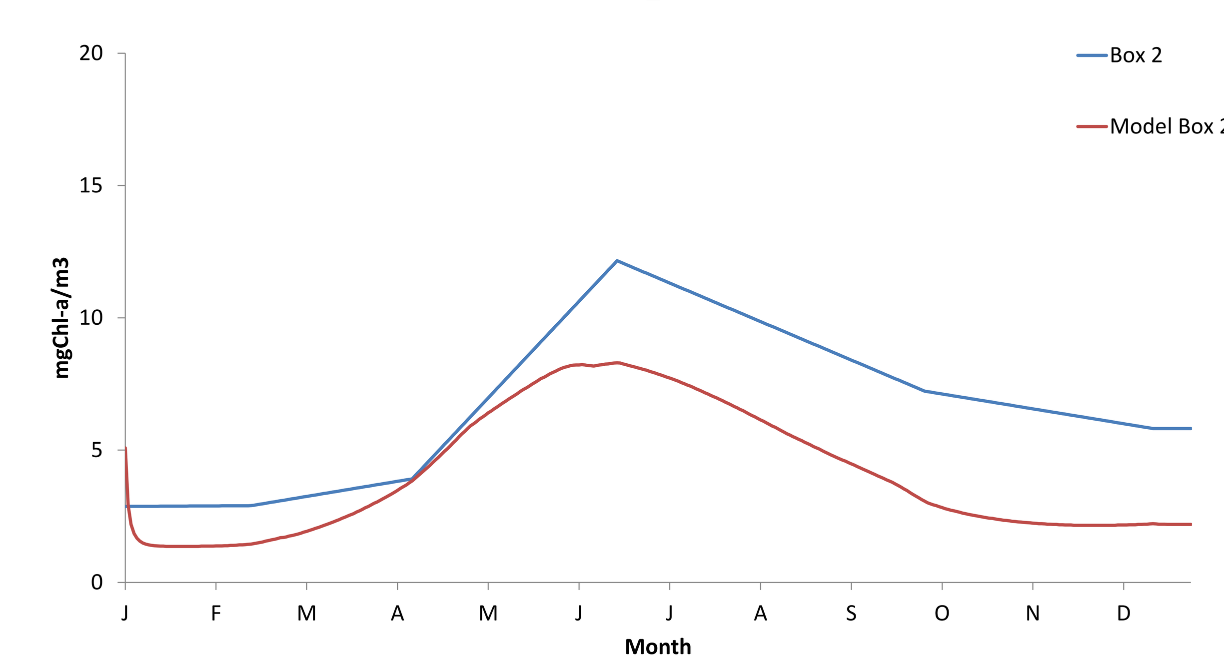
- Annual average cycle plots +/- 2 standard deviations from Virginia Department of Environmental Quality (DEQ) monitoring data.

Next Steps:

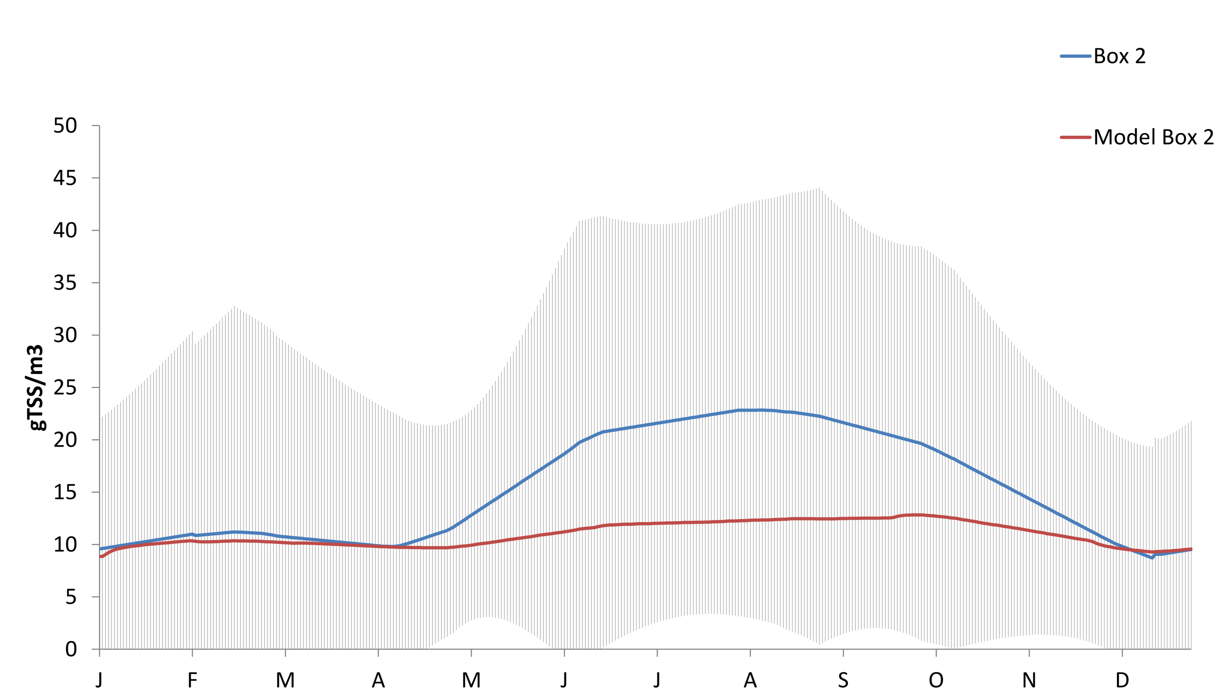
- Reduced complexity ecosystem model (Brush and Nixon 2008) coupled with:
  - *Crassostrea virginica* oyster (Hofmann 1992; Fulford 2006)
  - *Zostera marina* eelgrass (Jarvis et al. submitted), and
  - *Spartina alterniflora* marsh grass (Buzzelli et al. 1995; Buzzelli et al. 1996) sub models.
- Run simulations for the proposed restoration.
- Run simulations for the climate change scenarios.



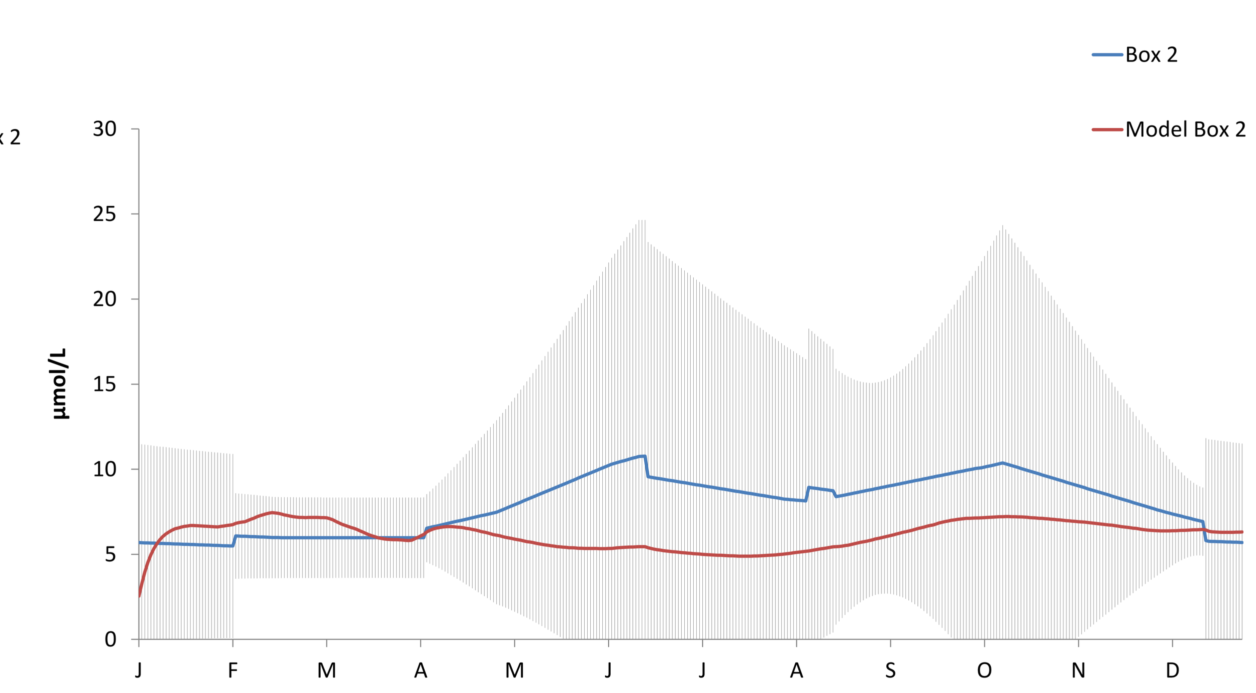
Calibration plots for Chl-a



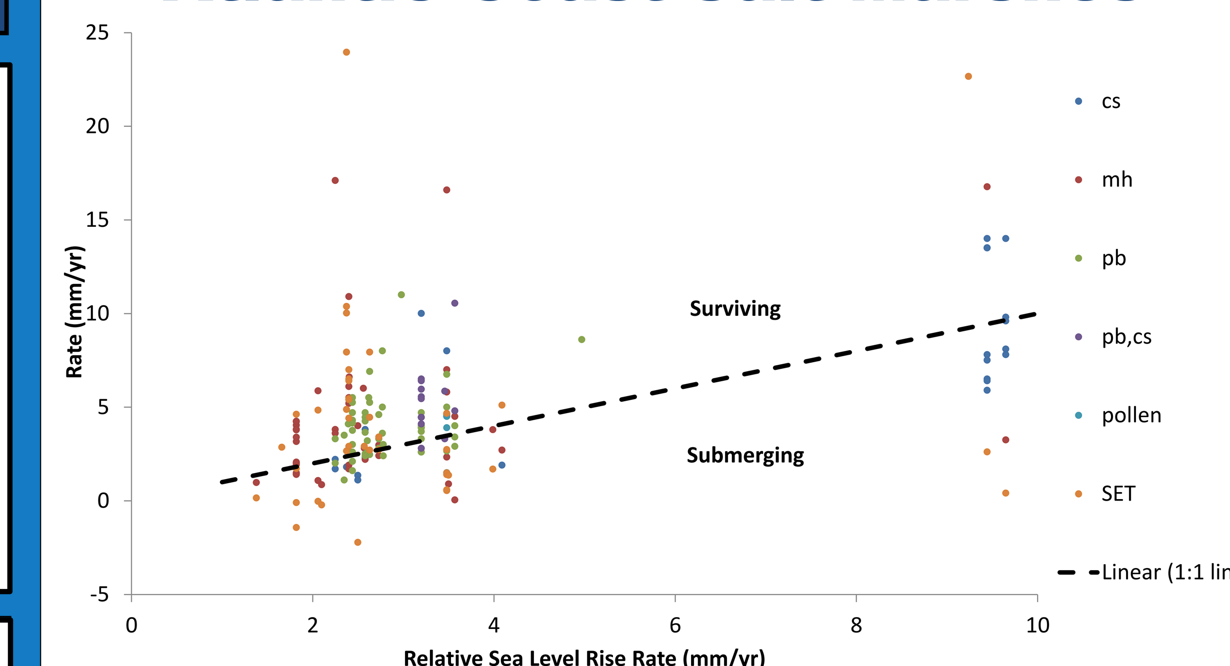
Calibration plots for TSS

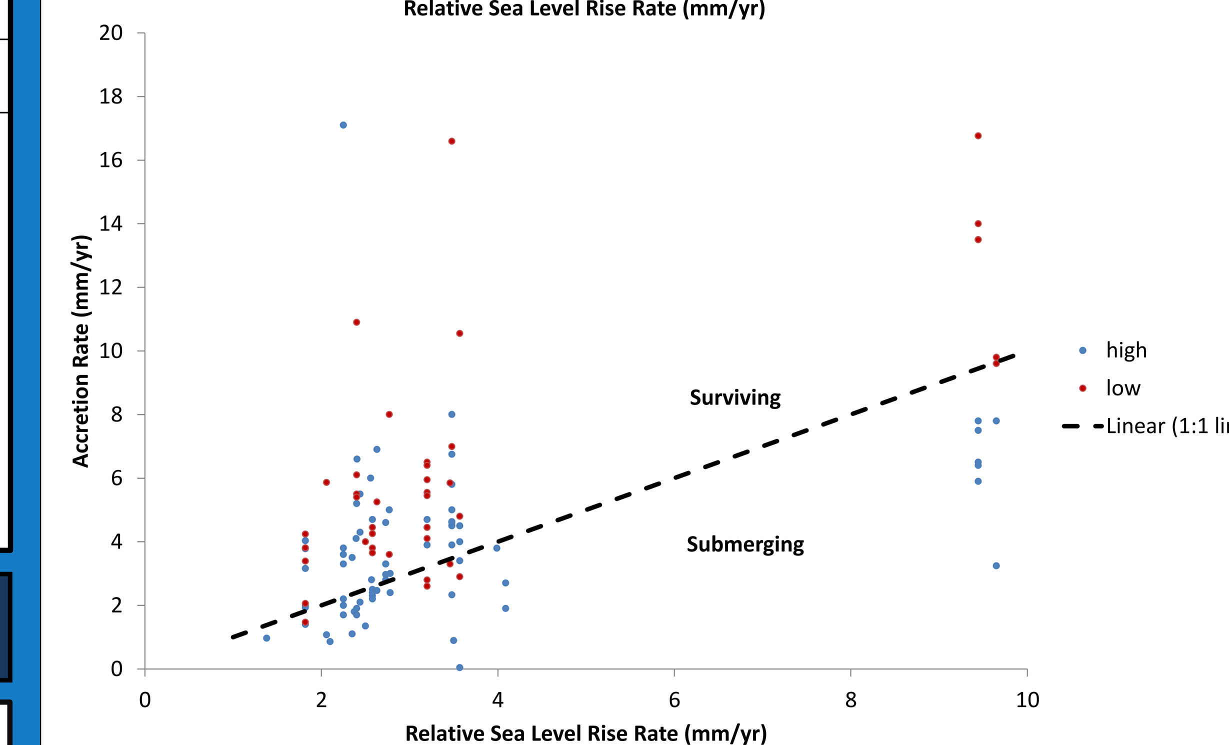


Calibration plots for DIN

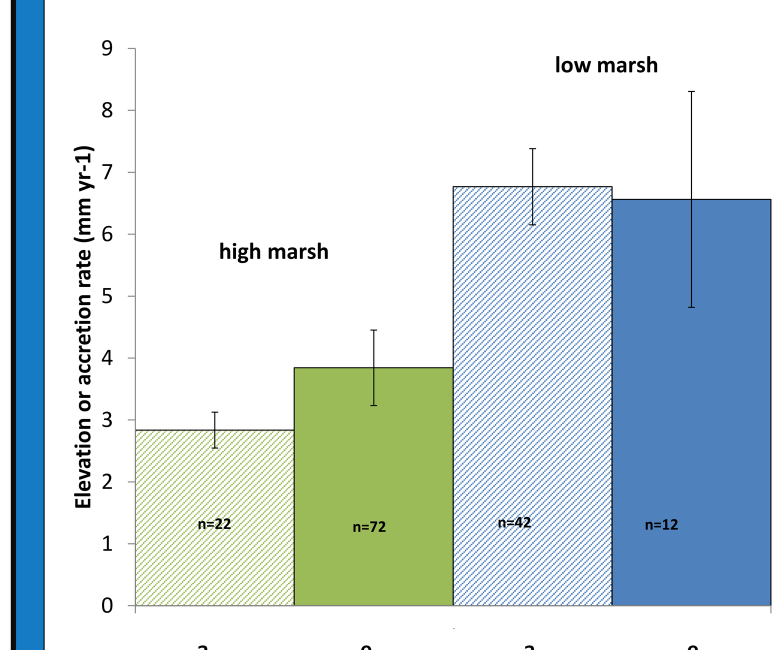


Atlantic Coast Salt Marshes





Comparison between rates of relative sea level rise and vertical accretion of Atlantic Coast salt marshes. The black line represents an equilibrium condition where marshes are building vertically at the same rate sea level rises. (A) measurements by method (B) discerns between high and low elevation portions of marshes (Kirwan, M., E. Skeehan, G. Guntenspergen, S. Fagherazzi, and S. Temmerman. In review. Overestimation of marsh vulnerability to sea level rise. Nature Climate Change).



Panel (C) accretion and elevation change rates for high marsh sites and low marsh sites. The labels on the x-axis represent accretion (a) and elevation change (e). This meta-analysis of demonstrates that marshes build faster when flooded for greater durations based on historic SLR trends (Kirwan, M., E. Skeehan, G. Guntenspergen, S. Fagherazzi, and S. Temmerman. In review. Overestimation of marsh vulnerability to sea level rise. Nature Climate Change).

183 unique measurements of accretion and/or elevation change from U.S., Canada, U.K., France, and Spain were included. Comparisons with the local rate of historic sea level rise indicate that 27 of 142 sites are submerging on the basis of measured accretion rates, and that 15 of 41 sites are submerging on the basis of measured elevation change. Although the mean elevation change rate for high elevation marshes is 2.8 mm/yr, whereas the mean rate of elevation change for low elevation marshes is 6.8 mm/yr which suggest accretion rates could more than double during the transition from high marsh to low marsh.

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