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Chesapeake Bay Marsh Change Under Sea Level Rise

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Hampton Roads Sea Level Rise/Flooding Adaptation Forum

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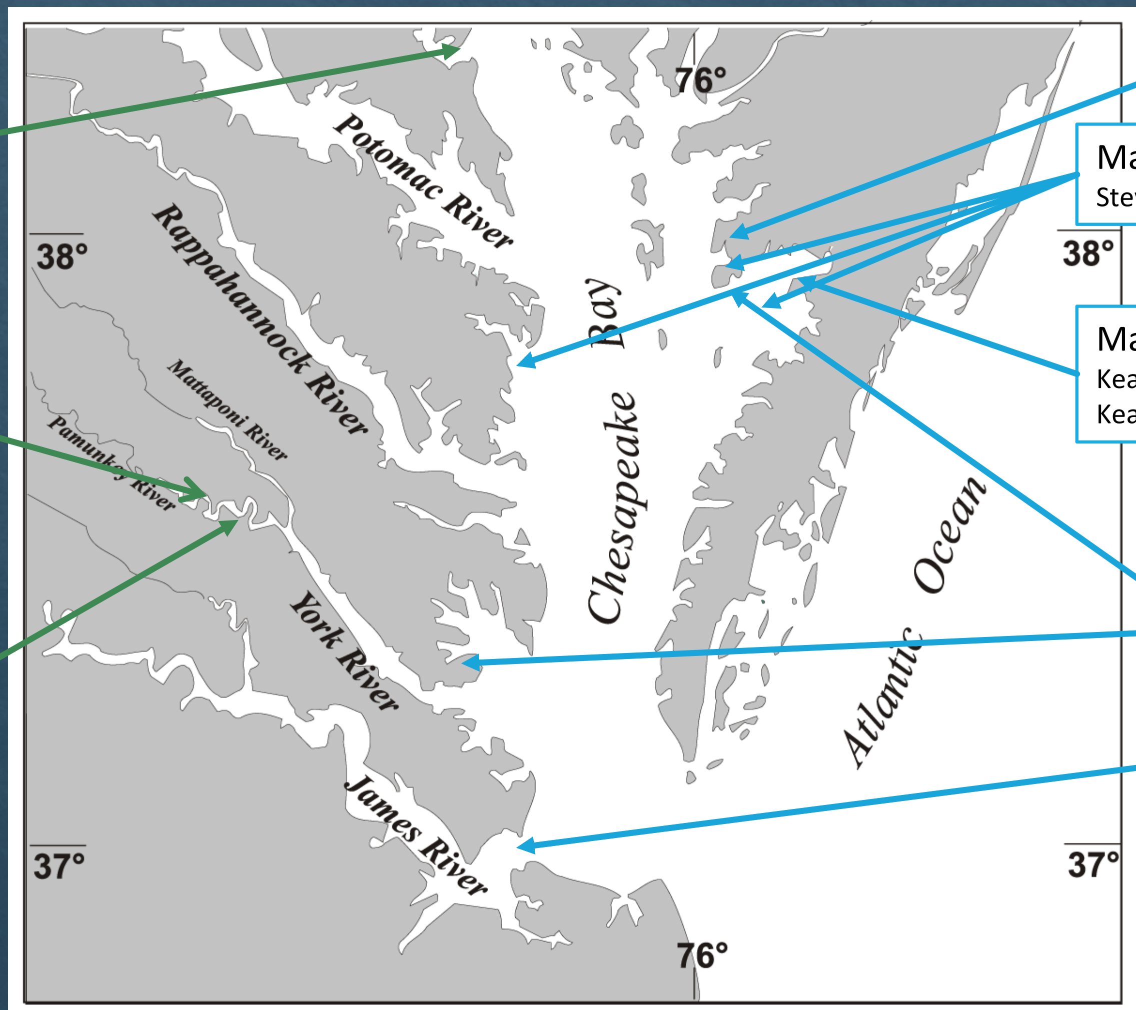
Past research suggests changing communities

Δ plant community
Swarth et al 2013

Δ plant community
Bilkovic et al 2012

Δ plant community
Perry & Hershner 1999 &
Davis 2004 &
Sutter 2014



Marsh loss
Wrey et al 1995

Marsh loss/disintegration
Stevenson et al 2002

Marsh loss/disintegration
Kearney et al 1991 &
Kearney et al 1985

Marsh loss
Kearney et al 2002

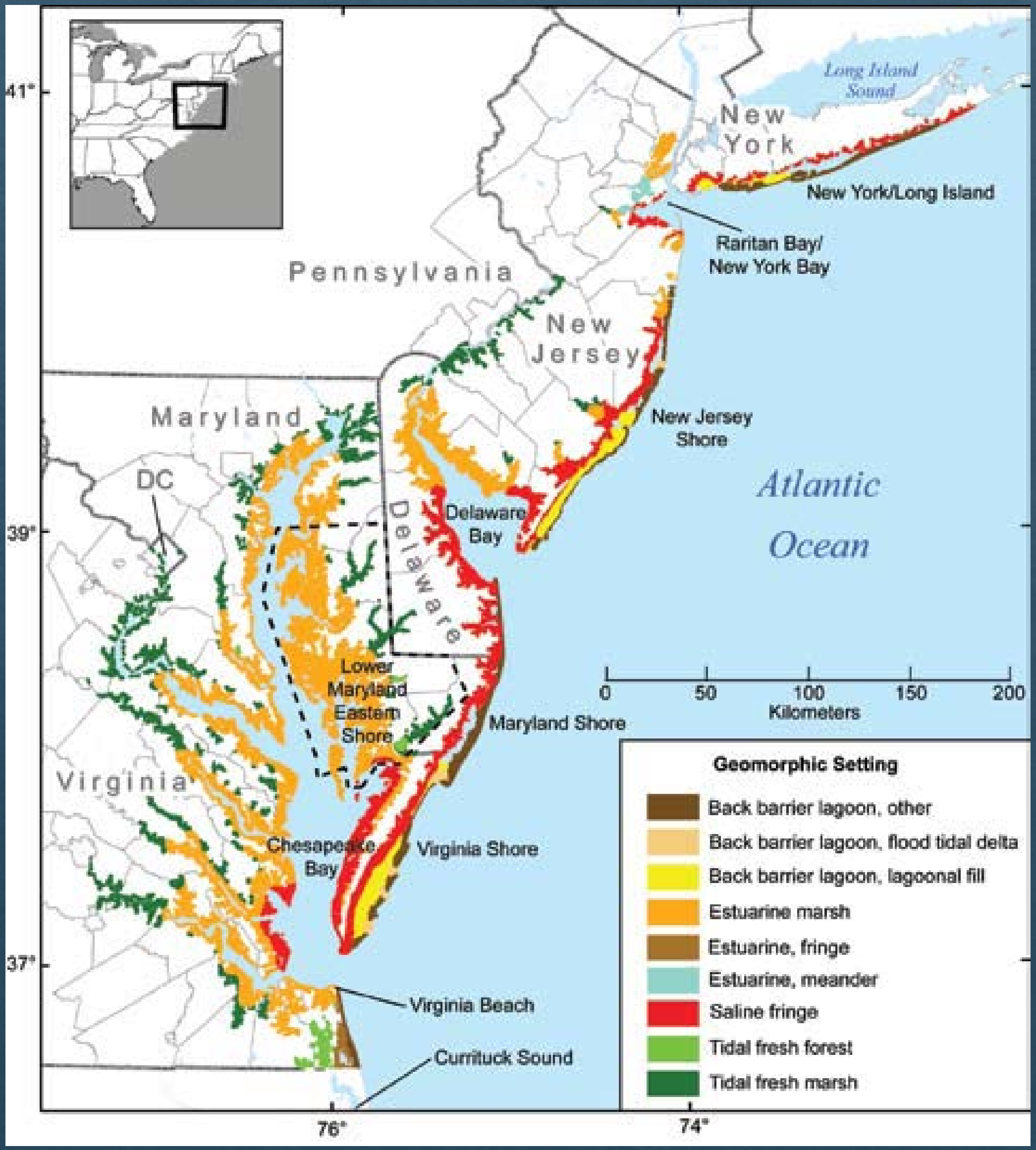
Marsh loss
Tiner & Foulis 1994

Questions to consider

- What processes affect marsh persistence?
  - How does climate change alter those processes?
- What climate change impacts do we expect?
- What are the signals of marsh vulnerability?
- Are there any patterns in these signals that we can use to predict vulnerable marshes?




Geomorphic settings of mid-Atlantic tidal wetlands



CCSP 2009: Cahoon et al. 2009; data source: Reed et al., 2008; map source: Titus et al., 2008

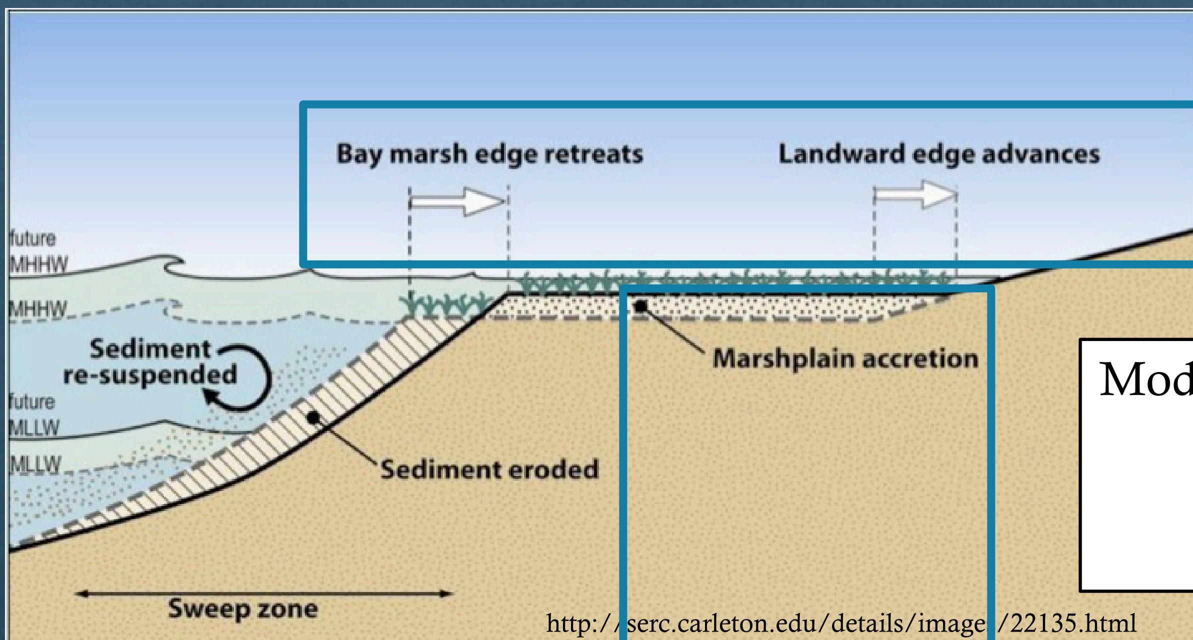
- Geomorphic settings have differing hydrodynamics, sediment sources, & vegetative communities
- Wetland response to climate change is expected to vary with geomorphic setting
- Different climate drivers are important in different settings
  - Precipitation more important for non-tidal, stream and headwater wetlands
  - Sea level rise more important for tidal wetlands

Climate Interactions with Marsh Processes

To keep pace with sea level: 1) Marshes migrate
2) Marshes accrete

Δ Water Levels

Controlled by:
SLR
Land elevation



http://serc.carleton.edu/details/images/22135.html

Modified by:
Shoreline alterations
Erosion rates
Human Activity

Δ CO_2

Δ Water Levels

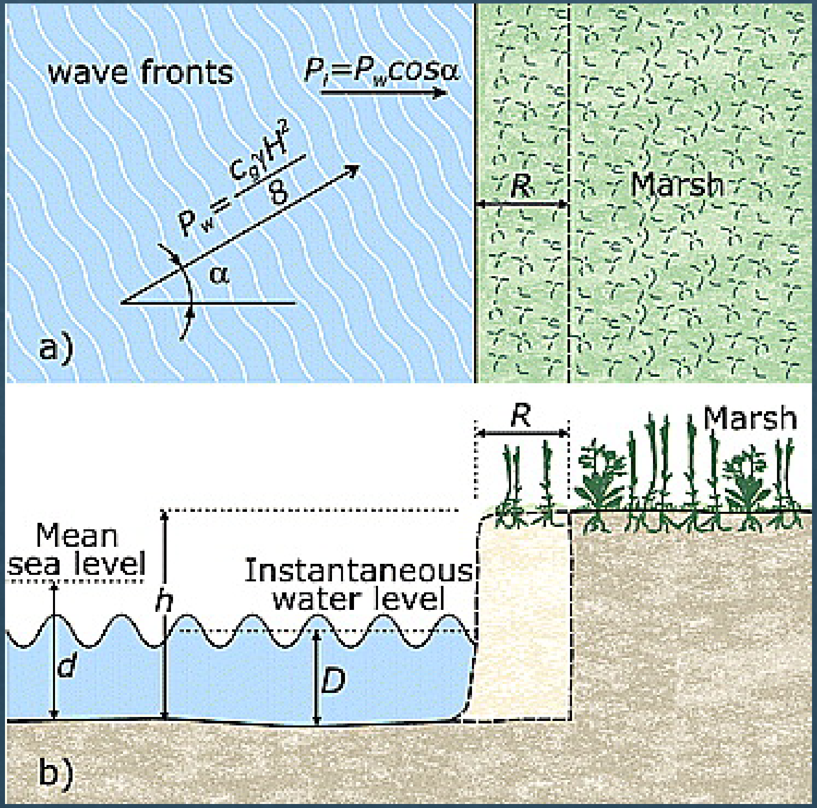
Δ Temperature

Controlled by:
Plant production
Sediment availability
Sediment respiration

Δ Erosion?

- Marshes are among most stable Bay shoreline
  - 0.54 – 0.66 m/yr (Rosen 1980)
  - Lower on tributaries ~0.21 m/yr (Byrne and Anderson, 1978)
  - Lowest in creeks
- Erosion rates have been steady over the recent past
- BUT predicted to increase with SLR

What about migration?



Marani et al. (2011) *Geophysical Research Letters*, *38*(21).

What processes interrupt marsh migration?

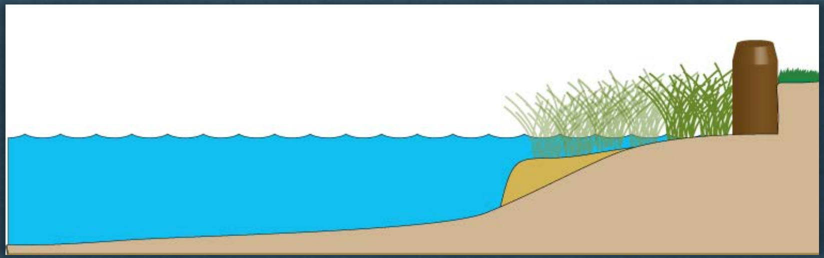


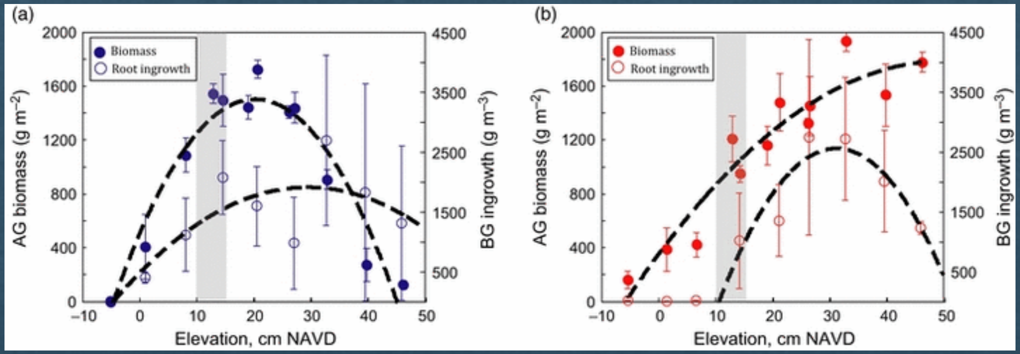
Photo by Karen Duhring

Photo by Skip Stiles

Organic marsh accretion affected by:

1. Changes in plant community due to changing salinity or inundation (sea level rise driven) & temperature
   - Change in plant type affects production rates or root:shoot ratio and decomposition rate ; Changes in inundation affect production rates of roots and shoots (species specific response)

Schoenoplectus america *Spartina patens*



   - Theoretical maximum ~ 5mm/yr (Morris et al. 2016)

2. Changes in sediment decomposition rates due to changes in temperature

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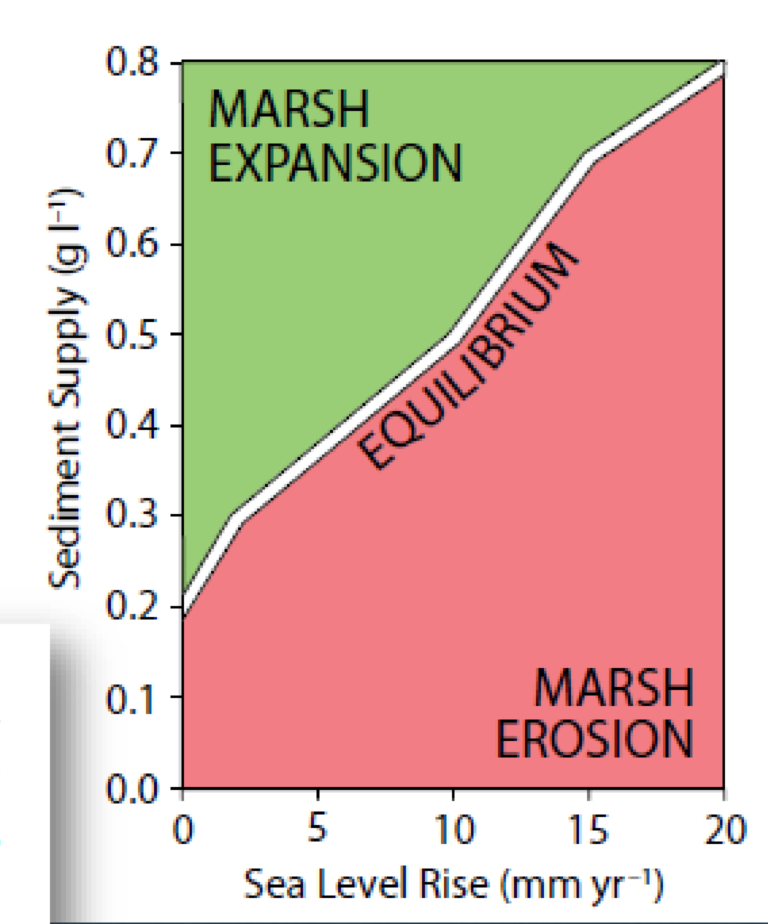
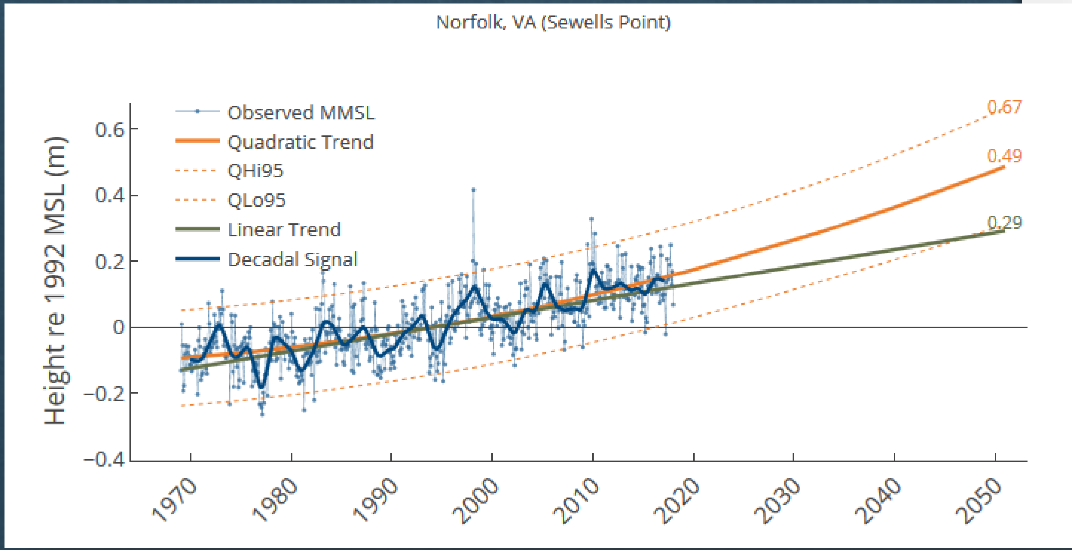
Graph from: Kirwan, M.L. and Guntenspergen, G.R., 2012.. *Journal of Ecology*, *100*(3), pp.764-770.

Inorganic marsh accretion affected by:

- Sediment supply coming from
  - Watershed
  - Adjacent lands (via runoff or tidal waters)
  - Marsh front edge erosion
- Current management goals are to restrict sediment in waters



Fagherazzi et al. 2013. *Oceanography*, *26*(3): 70-77.



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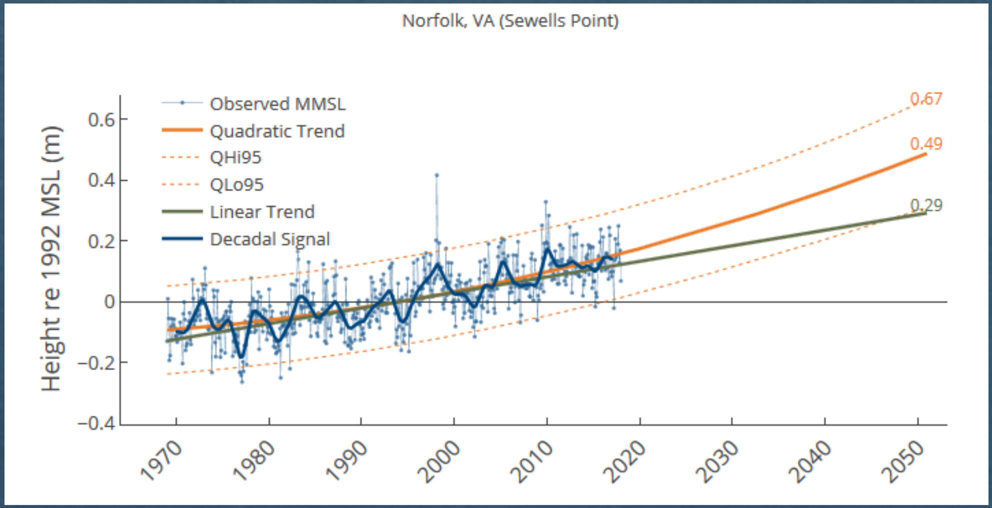
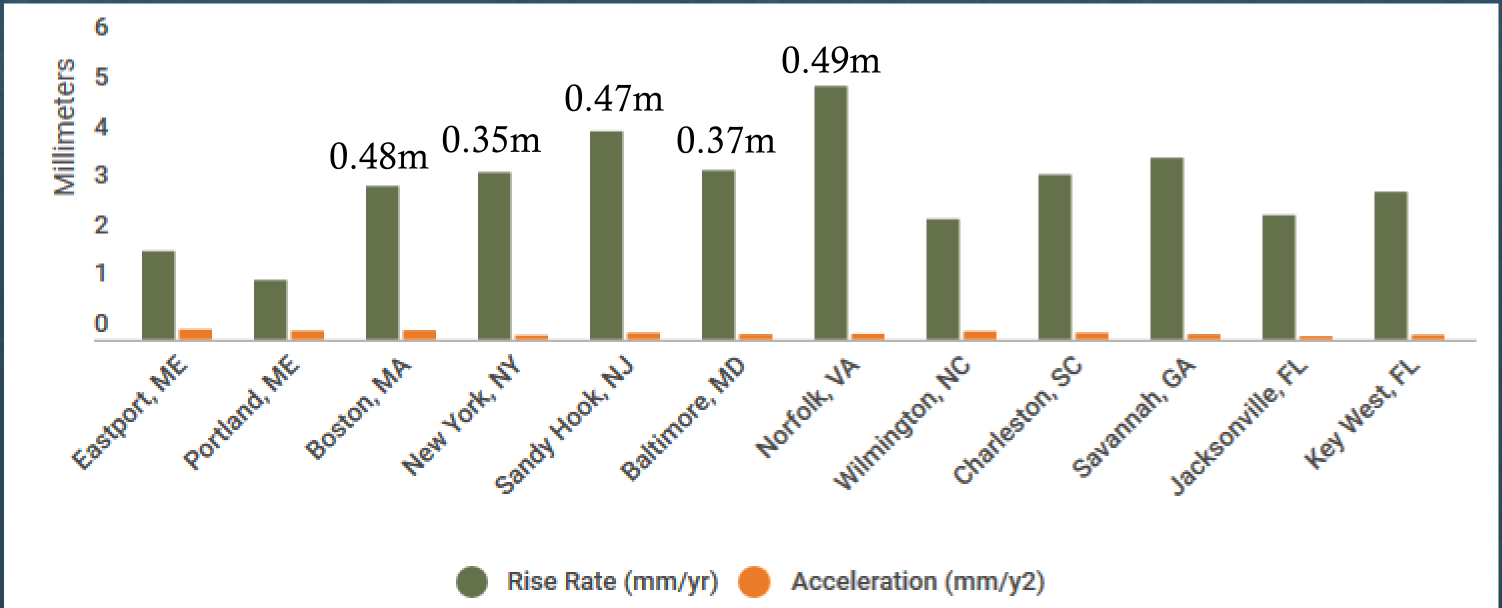
Mid-Atlantic SLR



The average SLR for the Bay :

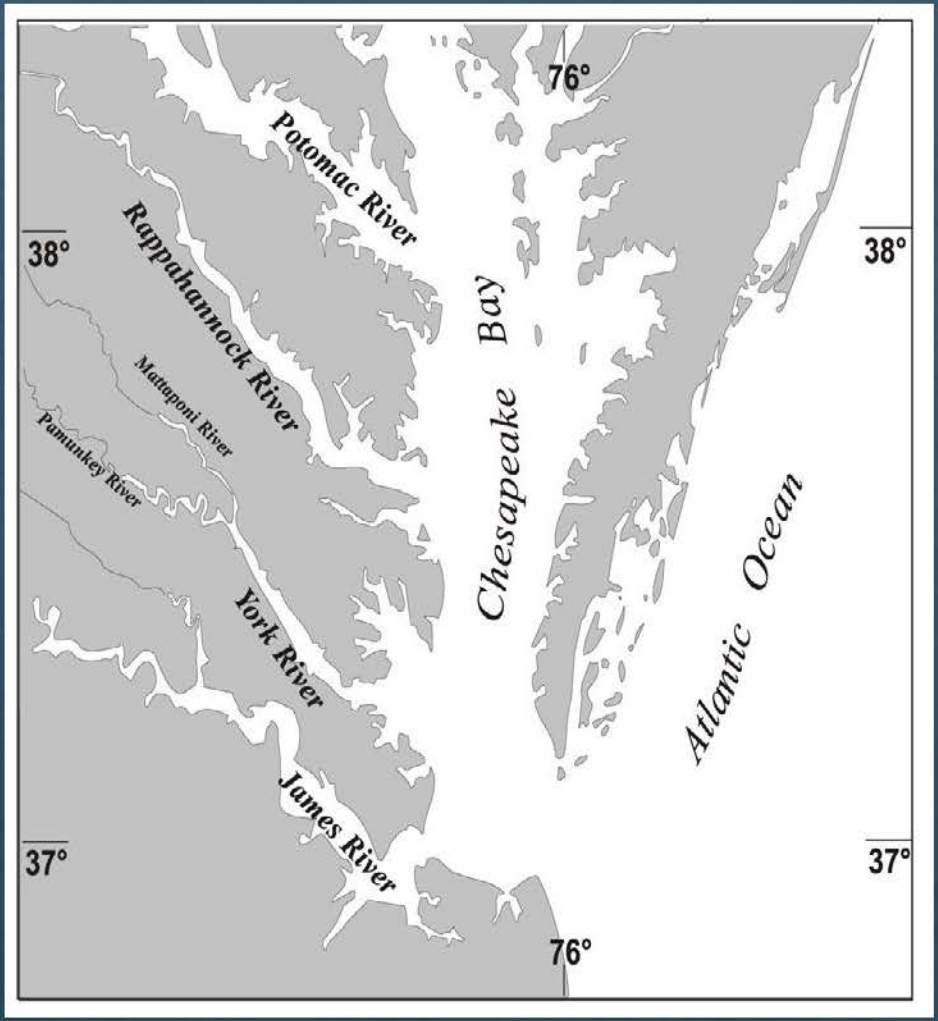
2.5 mm/y for 1953-1983
4.7 mm/y for 1983-2013
5.4 mm/y for 1996-2014

Ezer and Atkinson 2015



http://www.vims.edu/research/products/slrc/compare/east_coast/index.php

Tidal marsh inventories

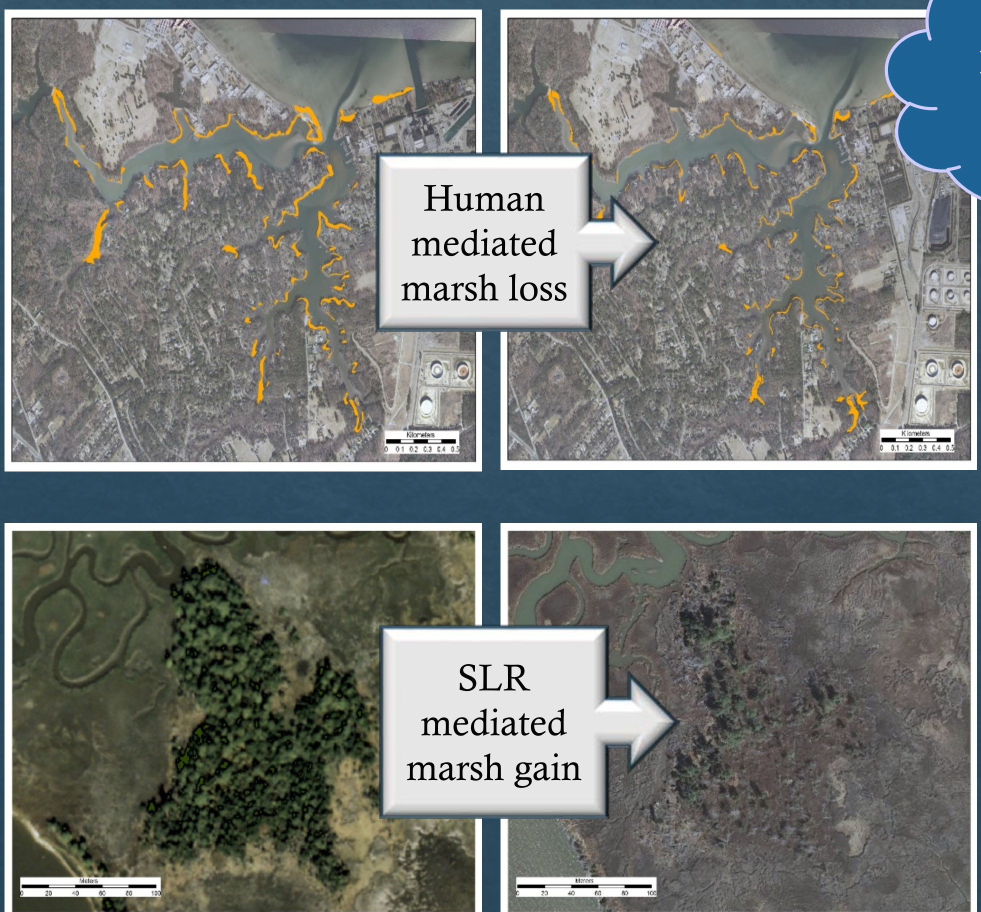


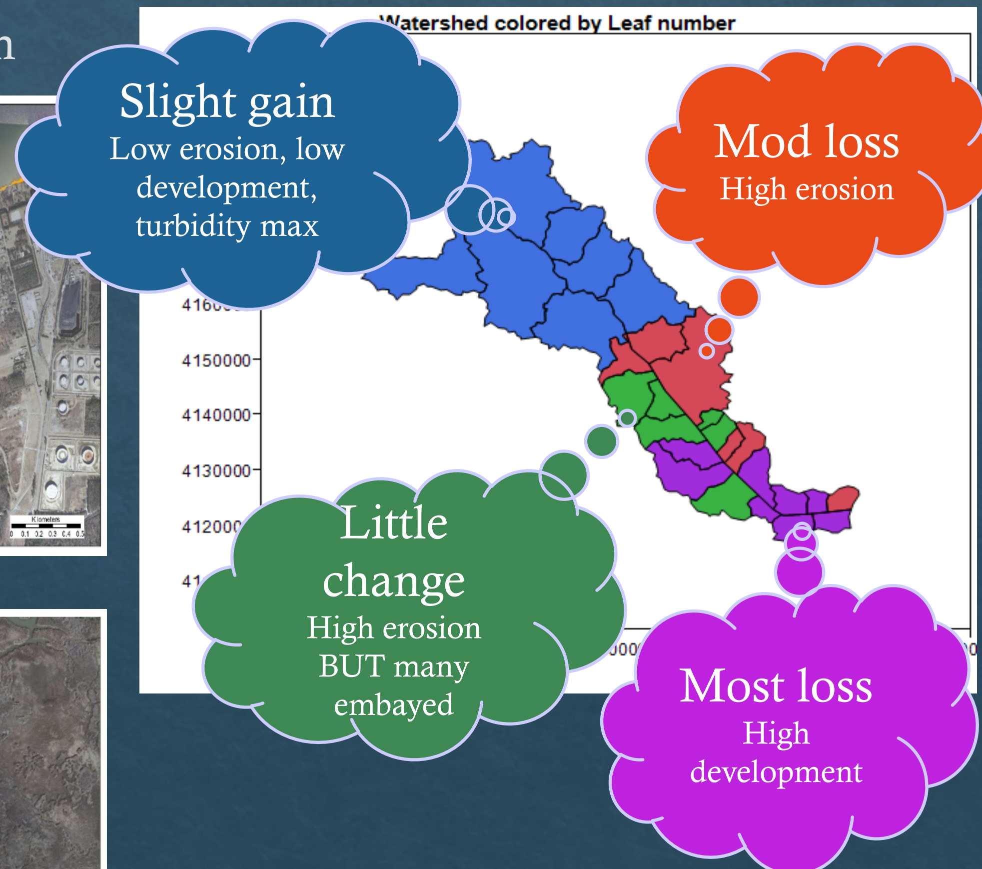
- Survey info:
  - Historic TMIs were surveyed from 1973-1991
  - current TMIs were surveyed from 2010-2018
  - average time between surveys was 32 years
- Plant community comparison:
  - York River = **263** marsh plant species matrices
  - Chesapeake Bay = **17,658** marsh plant communities

Marsh response varies by form as well as setting

Ecologically important fringe marshes are particularly vulnerable. So are marsh islands…

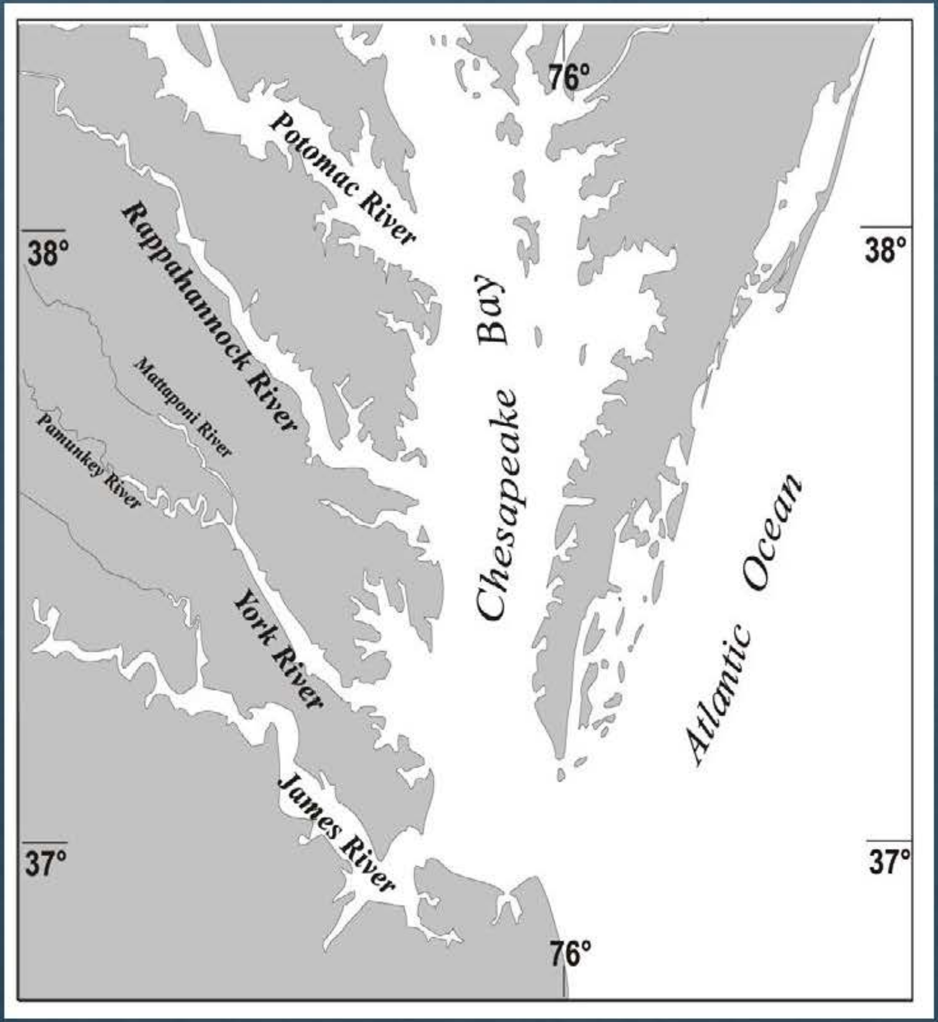
Historic marsh | Current marsh





Mitchell et al. 2017. Ecosystem Health and Sustainability, 3:10, DOI: 10.1080/20964129.2017.1396009

Community shifts



- 51% of marsh plant communities changed
- 18% of marsh communities showed inundation, salinization or invasion
- Increased inundation:
  - many tidal creeks
  - some extensive marshes (York River, Chickahominy River, and Back River)
- Increased salinity
  - upper reaches of tidal creeks
  - riverine transition marshes (James, Mattaponi, Pamunkey and Rappahannock Rivers)

Vulnerable marshes are found

Where human development impedes migration & exacerbates erosion

Where shifts in land use have reduced local sediment supply

Where impeded inlets or excessive subsidence exacerbates RSLR

Marsh change varies by setting and marsh form – fringe marshes appear the least resilient but extensive/island marshes are also of concern

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