

Sensitivity Analysis of Sea Level Rise Simulation To the Ocean Open Boundary Specification Using the 2017 CH3D-ICM

STAC WQSTM Peer Review

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and the CBPO Modeling Team



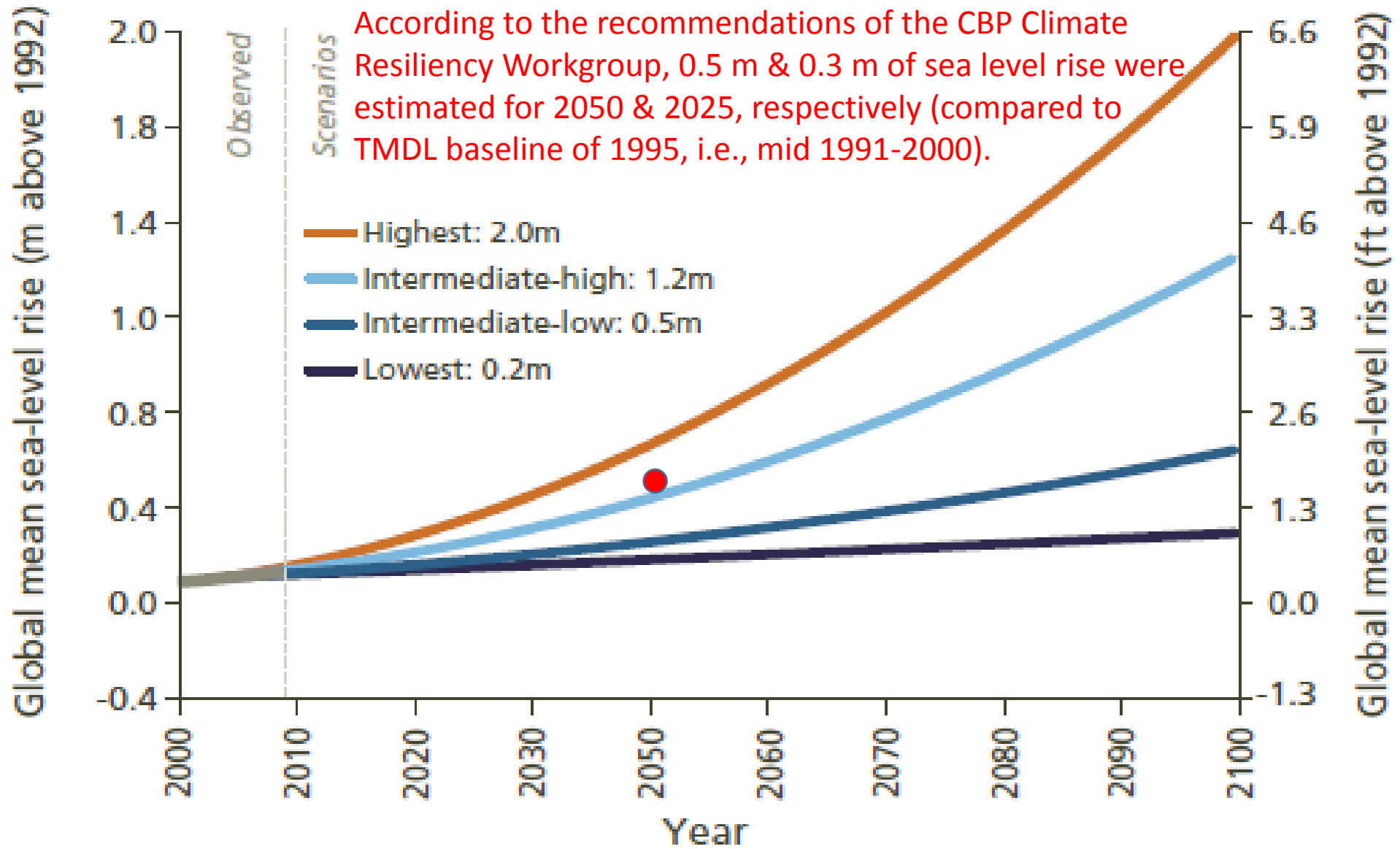
Chesapeake Bay Program
Science, Restoration, Partnership



Overview:

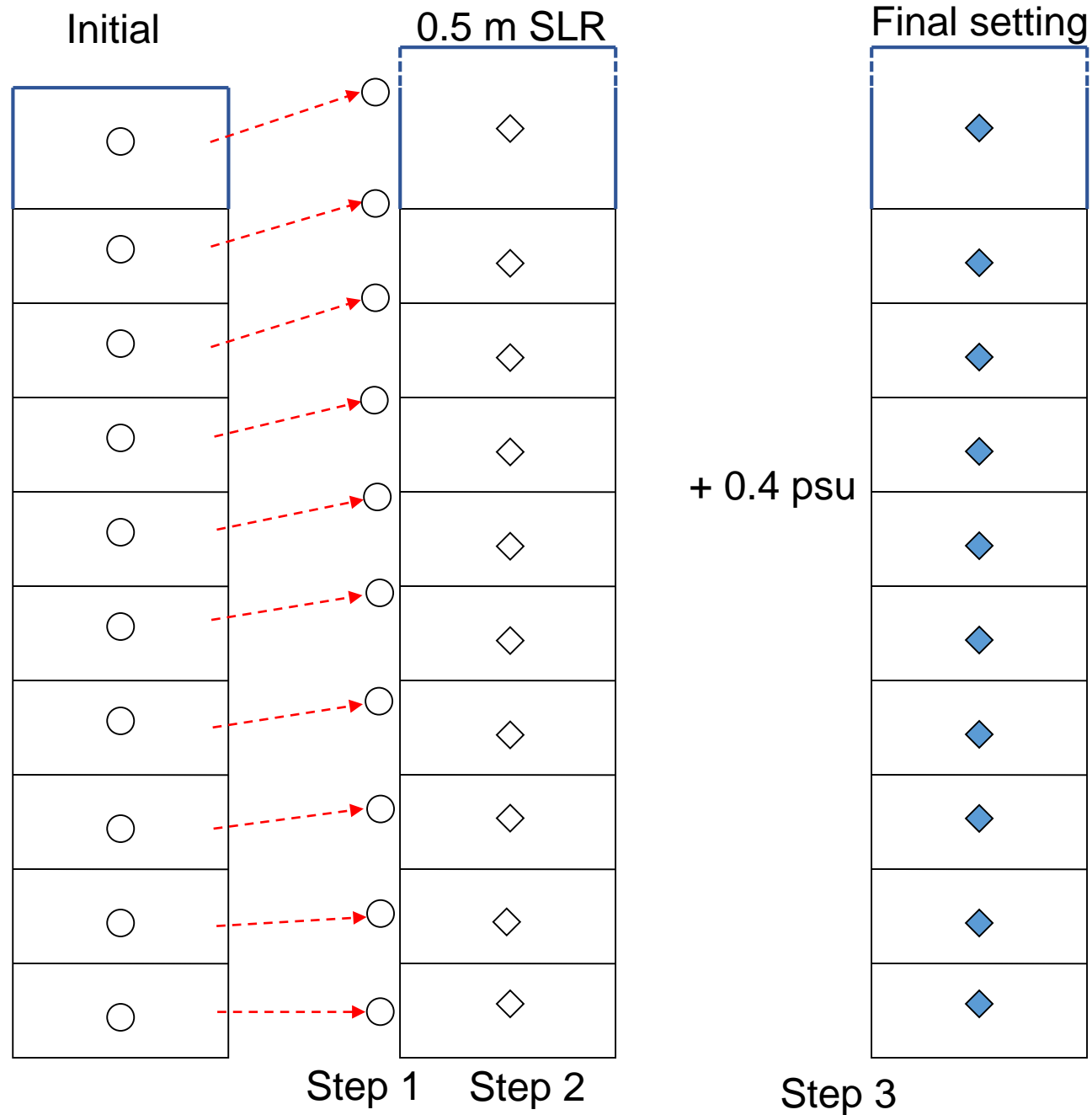
Review the sensitivity scenarios of estuarine circulation with estimated 2050 sea level rise (SLR). The sensitivity scenarios used the 1993-1995 WQSTM simulation period to compare scenarios of 1) Base Case w/ out SLR or boundary salinity increase, 2) SLR only w/out salinity boundary increase, and 3) SLR w/ salinity boundary increase. In the case of both (2) and (3) there is an expectation from theory of an increase in gravitational circulation.

Global mean sea-level rise scenarios



From Parris, A. et al. (2012). *Global Sea Level Rise Scenarios for the United States National Climate Assessment*. NOAA Technical Report OAR CPO-1. National Oceanic and Atmospheric Administration, Silver Spring, Maryland.

Boundary salinity setting



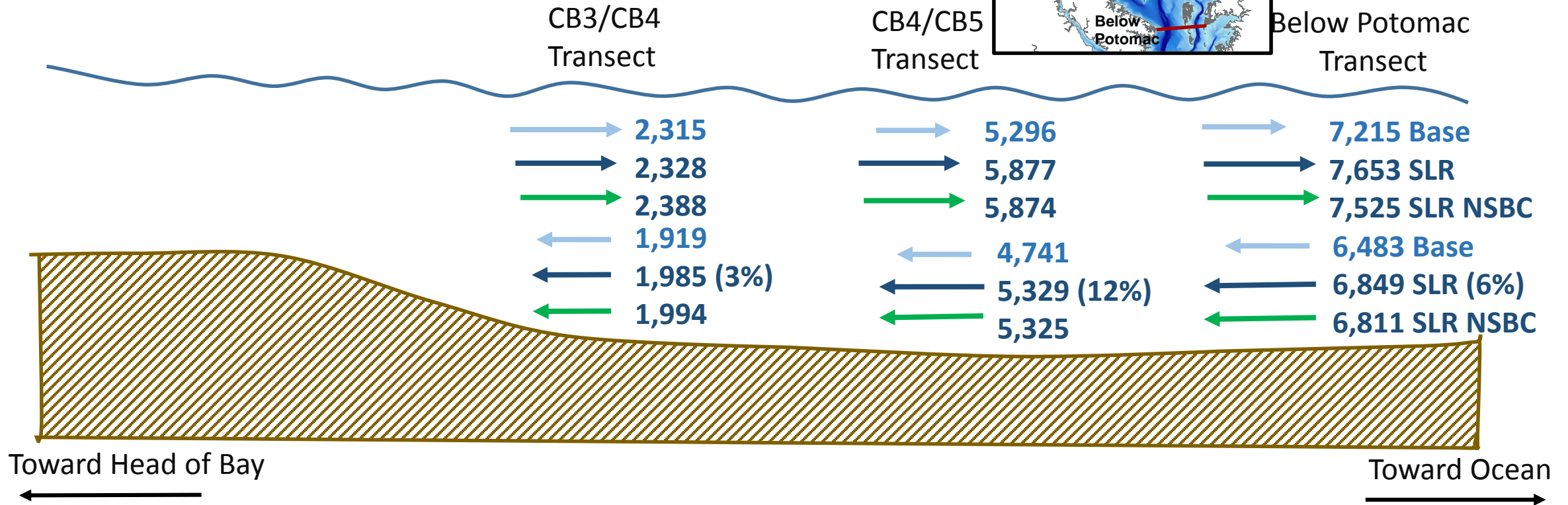
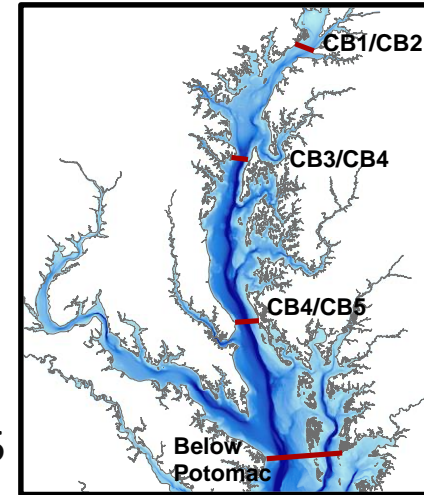
Does salinity adjustment influence water quality simulation and to what extent?



From the Literature: Expectations of the Chesapeake Bay Response to Sea Level Rise:

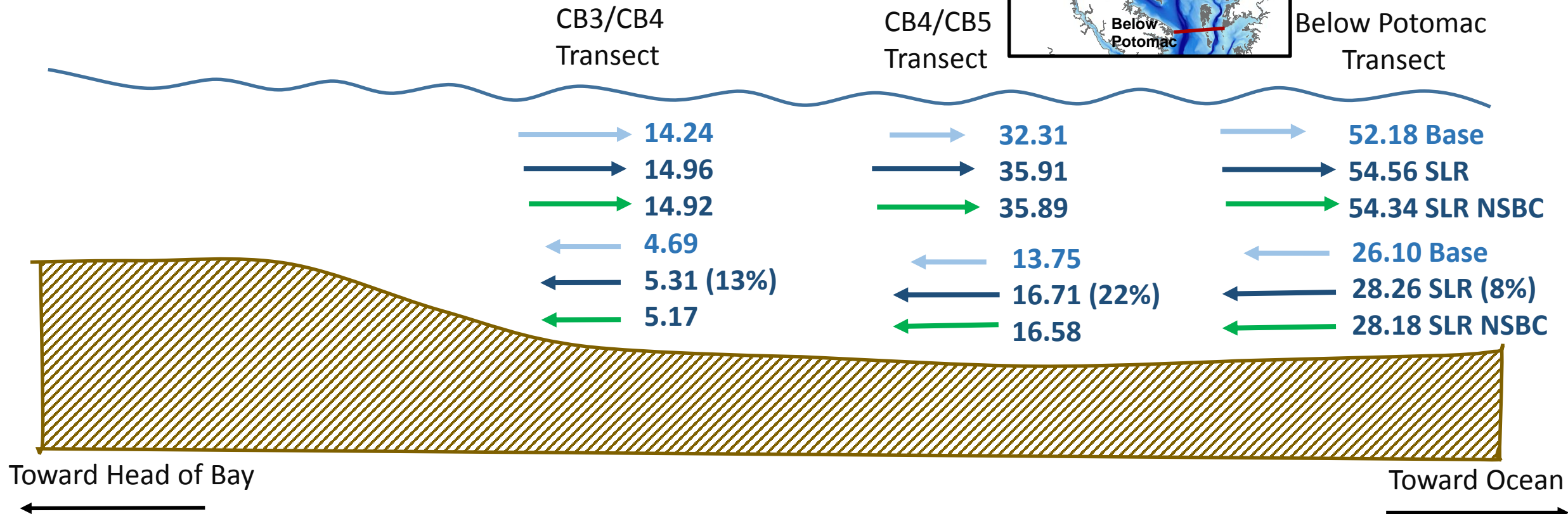
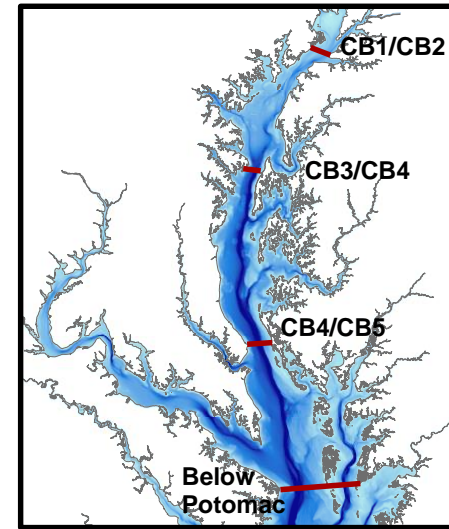
- Increased salinity in Bay
- Increased up-estuary salt intrusion
- Increased vertical mixing (increased tidal currents)
- Changes in stratification
- Increased gravitational circulation
- Increased salinity at ocean boundary

Cross-transect water fluxes (m^3/s) Base case versus sea level rise (SLR) of 0.5m. Summer 1993-1995



Base = Beta 4 WQSTM, SLR = 0.5m representing relative Chesapeake sea level rise from 1995 to 2050. Units in mean m^3/s for summer (Jun-Sept) 1993 to 1995; NSBC: No Salt Boundary Change.

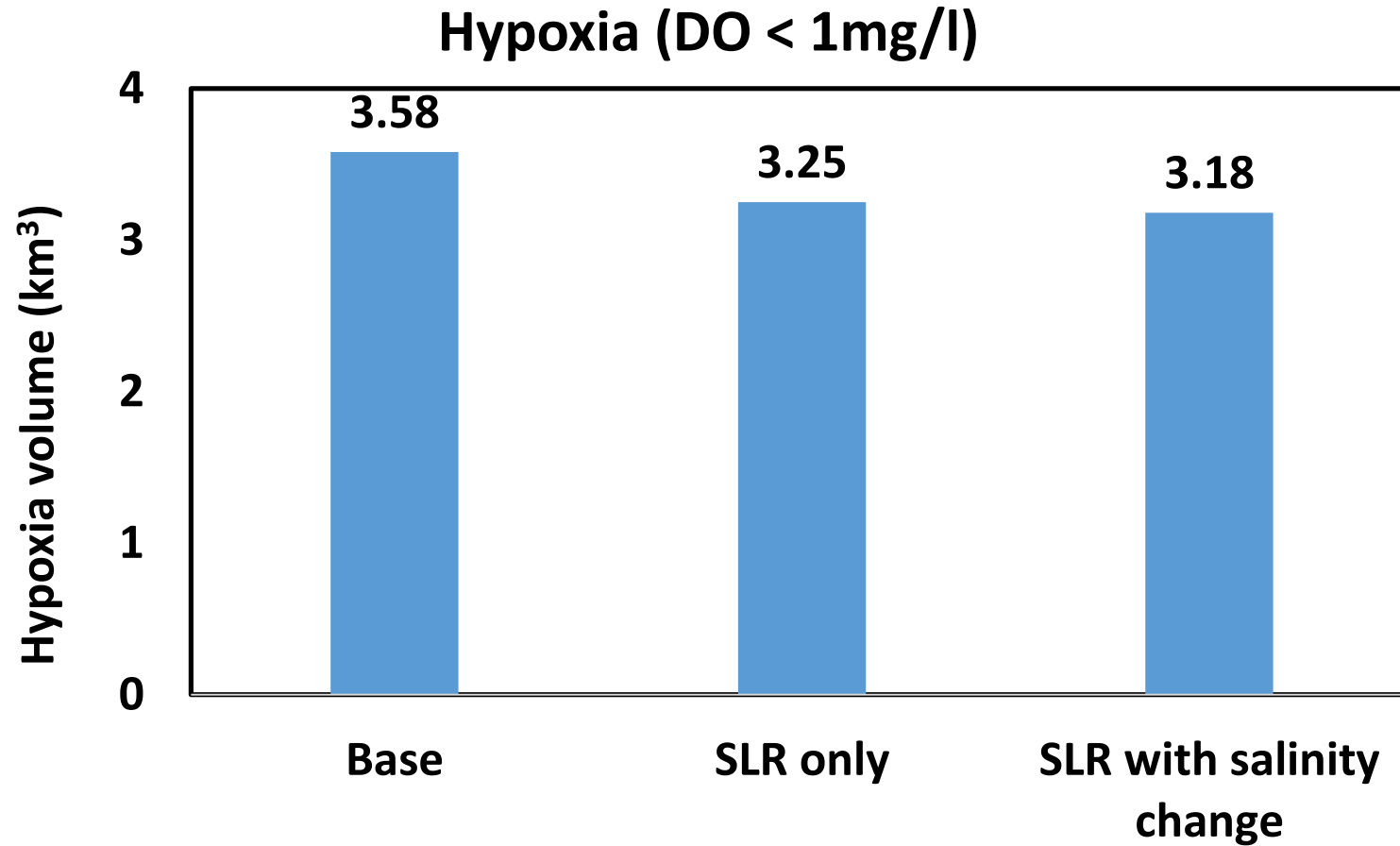
Cross-transect DO fluxes (kg/s) Base case versus sea level rise (SLR) of 0.5m. Summer 1993-1995



Base = Beta 4 WQSTM, SLR = 0.5m representing relative Chesapeake sea level rise from 1995 to 2050. Units in mean kg DO per second (kg/s) for summer (Jun-Sept) 1993 to 1995; NSBC: No Salt Boundary Change.



Sea level rise 2050 (0.5m) with open boundary salinity change (SLR) and SRL without open boundary salinity change

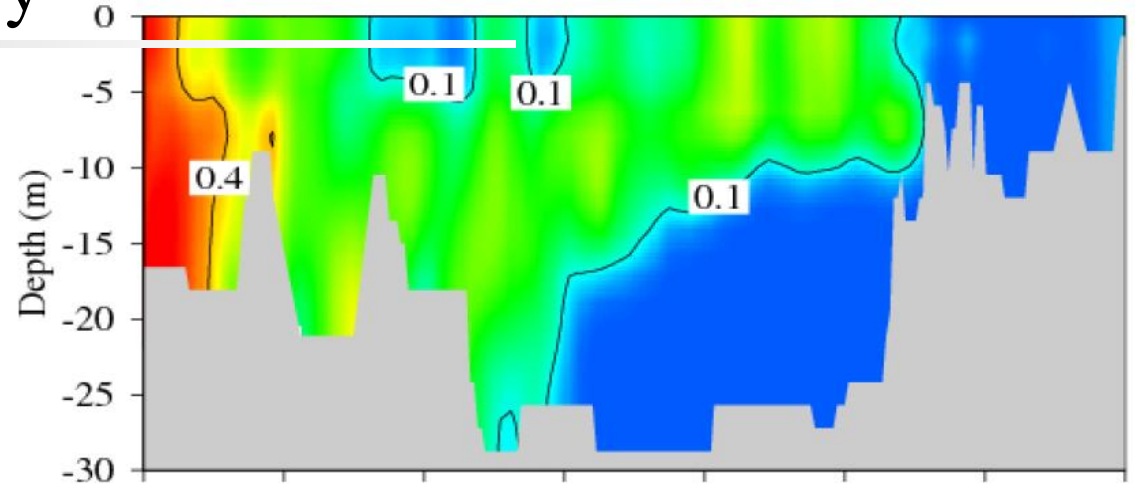




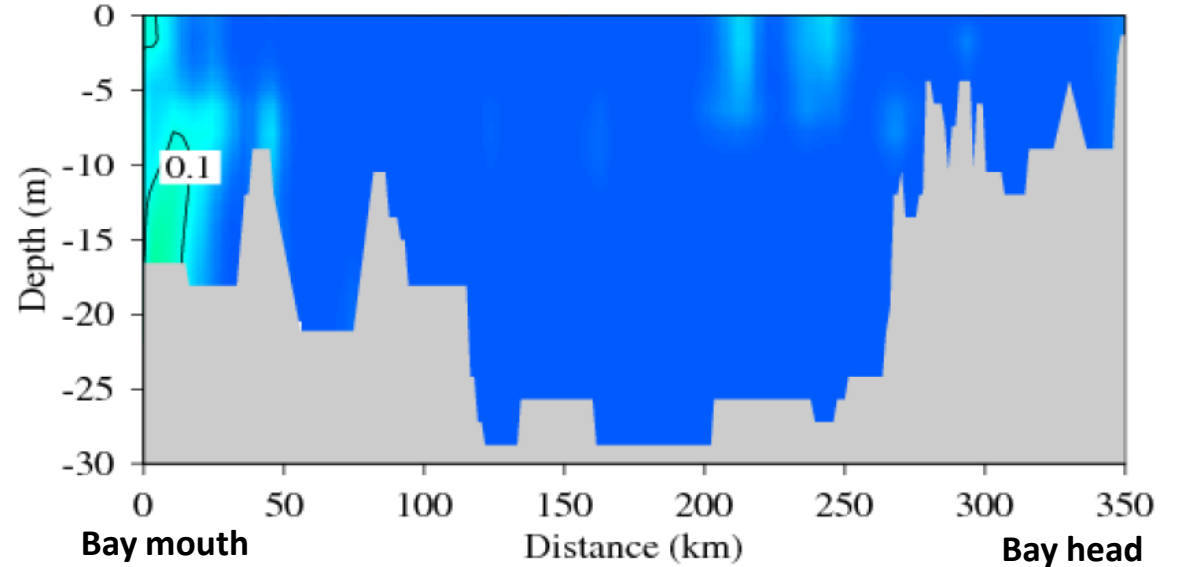
Salinity Distribution in the Chesapeake With and With Out 0.4 psu Salinity Change At Ocean Boundary

Distribution of salinity difference between sea level rise scenarios with and without salinity adjustment at the open boundary and the base case (1994 summer).

With salinity adjustment



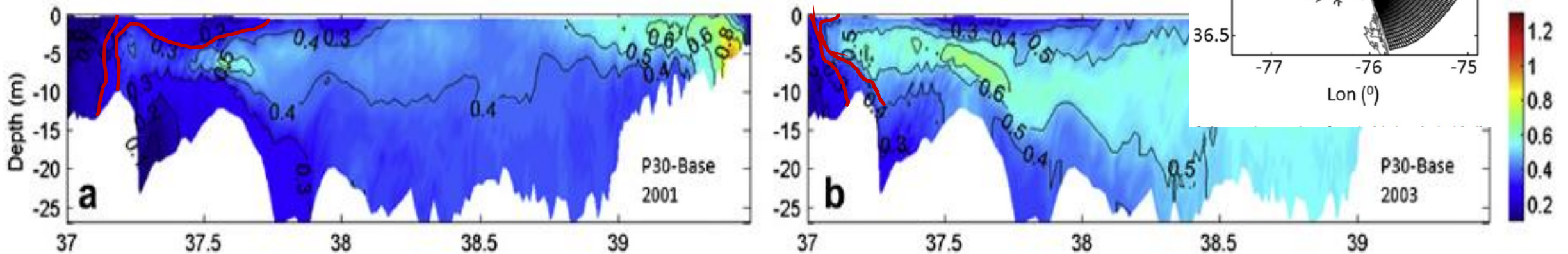
Without salinity adjustment





Origins of the 0.4 ppt Ocean Boundary Condition

Model estimates of delta June average salinity in 2001 (dry year) and 2003 (wet year) relative to base calibration under conditions of a 0.3 m sea level rise.



“The mean salinity at the Bay mouth would increase with rising sea level, which could alter the along-Bay pressure gradient. Meanwhile, the water depth in the Bay also increases. These changes will result in the variations of gravitational circulation. According to the classical estuarine circulation theorygiven a sea-level rise of 1.0 m, [in Chesapeake Bay] gravitational circulation will increase by a factor of 1.5.”

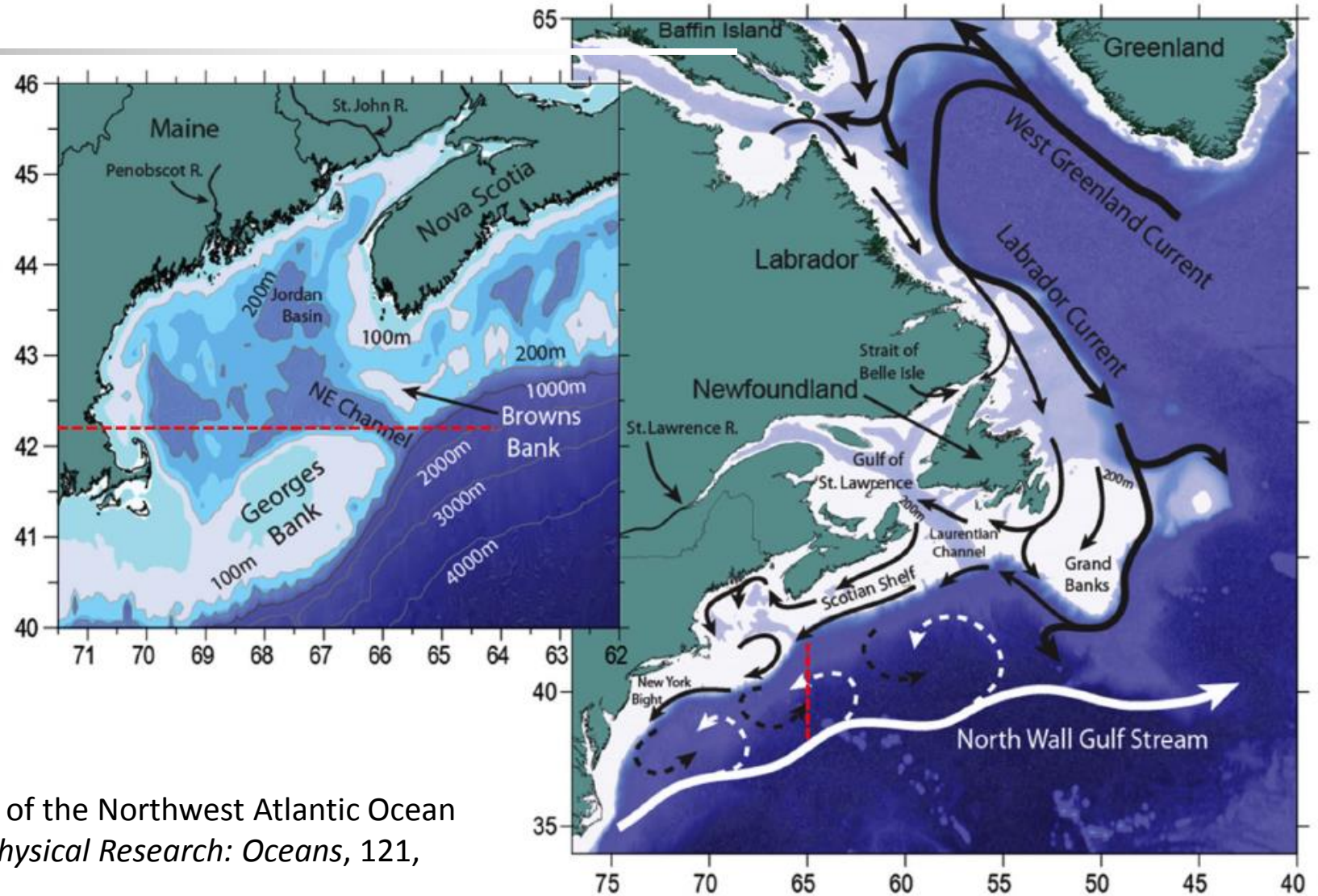
Hong and Shen, *Estuarine, Coastal and Shelf Science* 104-105 (2012) 33-45 (page 40)



Bringing us to...why?

“Northwest Atlantic Ocean and Labrador Sea bathymetry and major current systems. Black arrows are colder, fresher water associated with the Labrador Current. White arrows are warmer, saltier water associated with the Gulf Stream. Dashed arrows indicate mixing of waters (not currents) in the Slope sea. Inset shows location of the Northeast Channel (NEC; sill depth ca. 220 m) where a mix of these Slope and Shelf Waters enter the Gulf of Maine.”

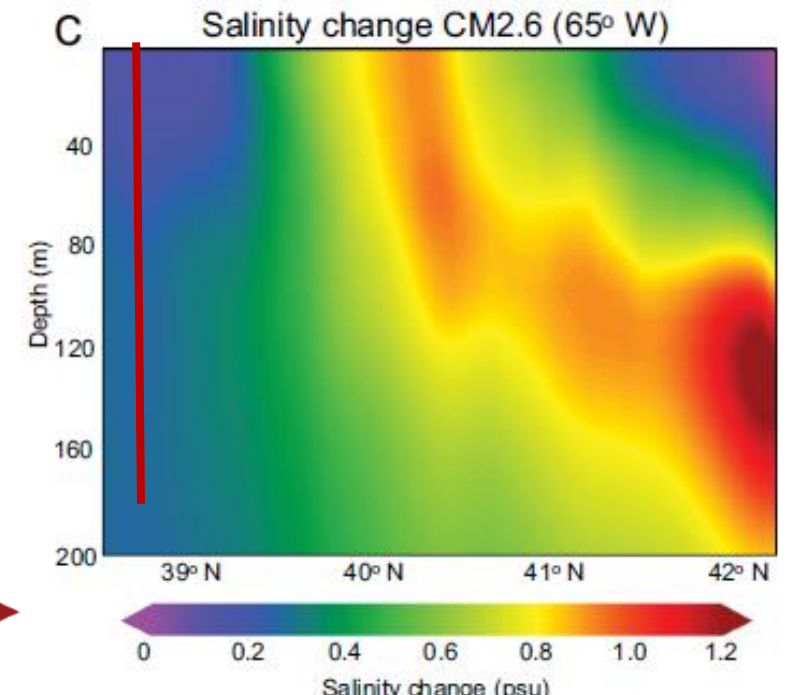
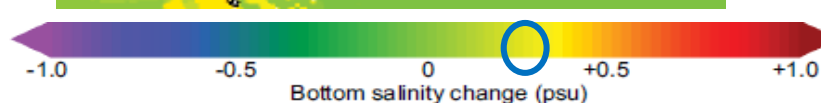
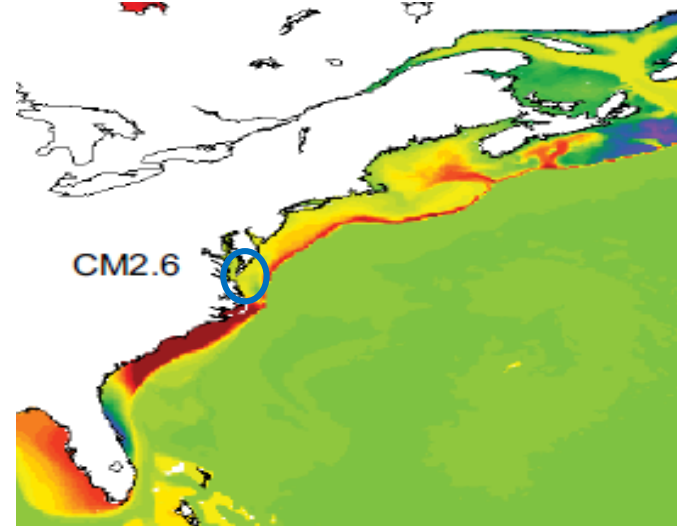
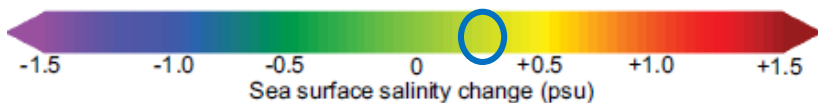
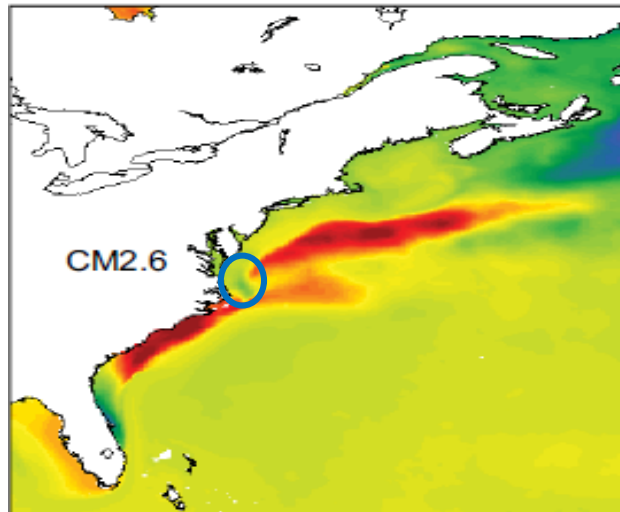
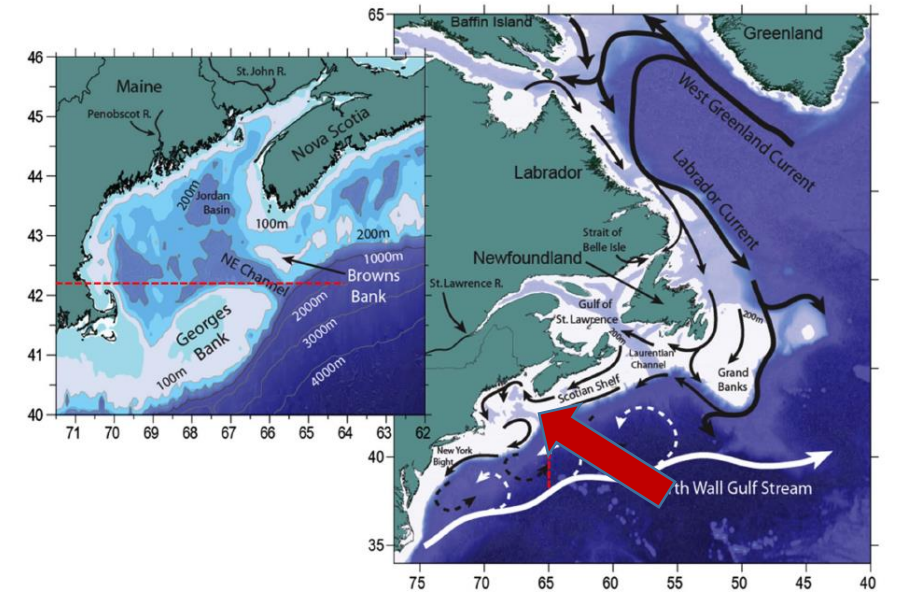
Saba, V. S., et al. (2016), Enhanced warming of the Northwest Atlantic Ocean under climate change, *AGU Journal of Geophysical Research: Oceans*, 121, 118–132, doi:10.1002/2015JC011346.



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“Examining the ocean change in CM2.6* in more detail, we find an enhanced warming and a more substantial increase in salinity in not only the surface waters of the Northwest Atlantic Ocean but also in the bottom waters of the Northwest Atlantic Shelf. The increase in both temperature and salinity is associated with a northerly shift of the Gulf Stream, a retreat of the Labrador Current, and the replacement of cold Labrador Slope Water by warm Atlantic Temperate Slope Water along the Shelf Slope. This water mass replacement leads to a higher proportion of warmer and saltier Atlantic Temperate Slope Water entering the Shelf via the Northeast Channel.”

CM2.6 is a climate model from NOAA Geophysical Fluid Dynamic Laboratory w/ a highly spatially resolved ocean simulation.





Conclusions:

- **Sea level rise (SLR) is estimated to be a major influence in increased gravitational circulation in the Chesapeake.**
- **Increased salinity at the ocean boundary condition also increases gravitational circulation in the Chesapeake.**
- **The 0.4 ppt salinity adjustment at the ocean boundary is consistent with literature and provides a better simulation of the salinity distribution within the Chesapeake under estimated 2050 SLR conditions.**