Progress on MTMs in the Potomac and James Rivers – Impacts of benthic algae and phosphorus limitations

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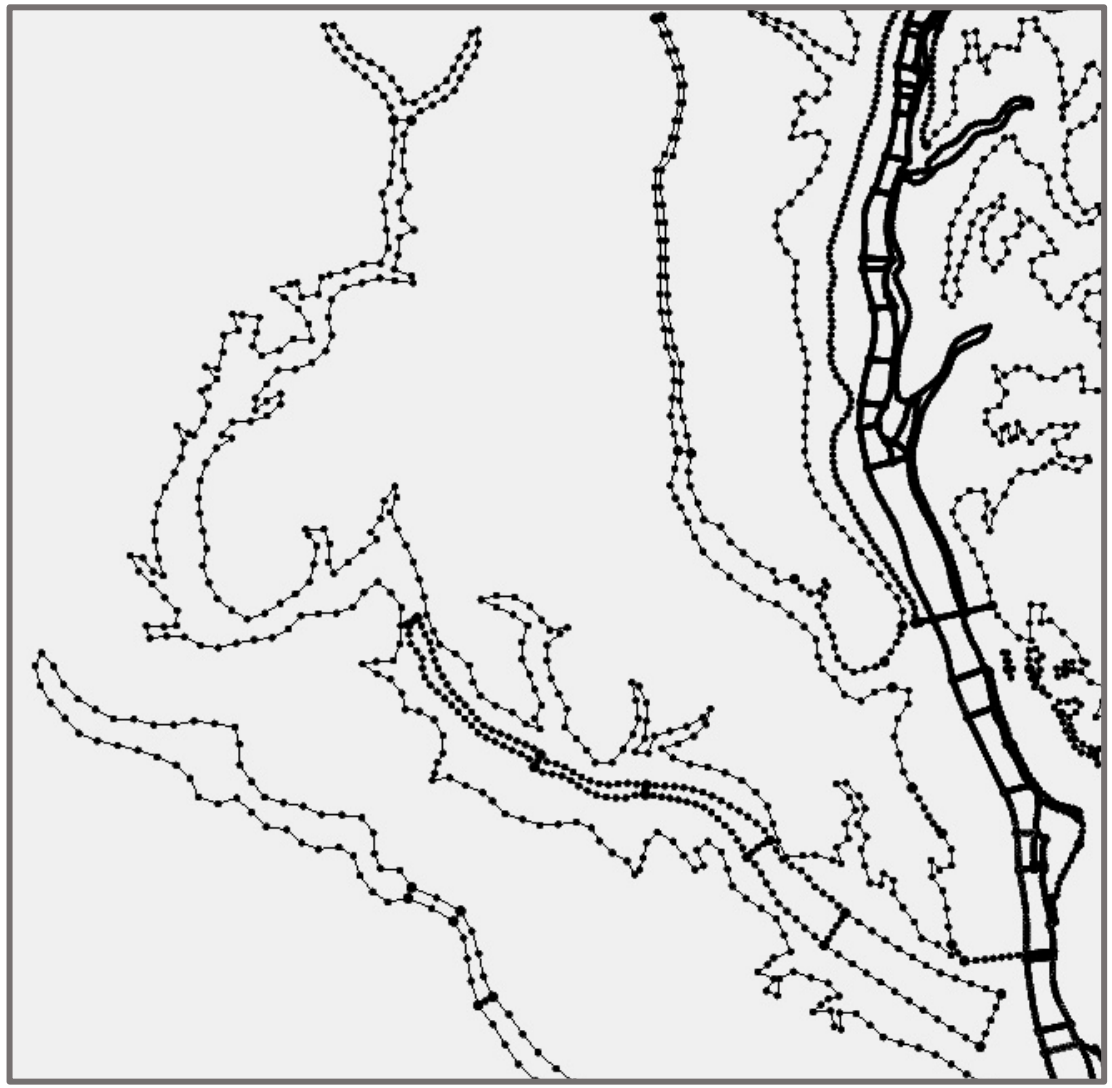
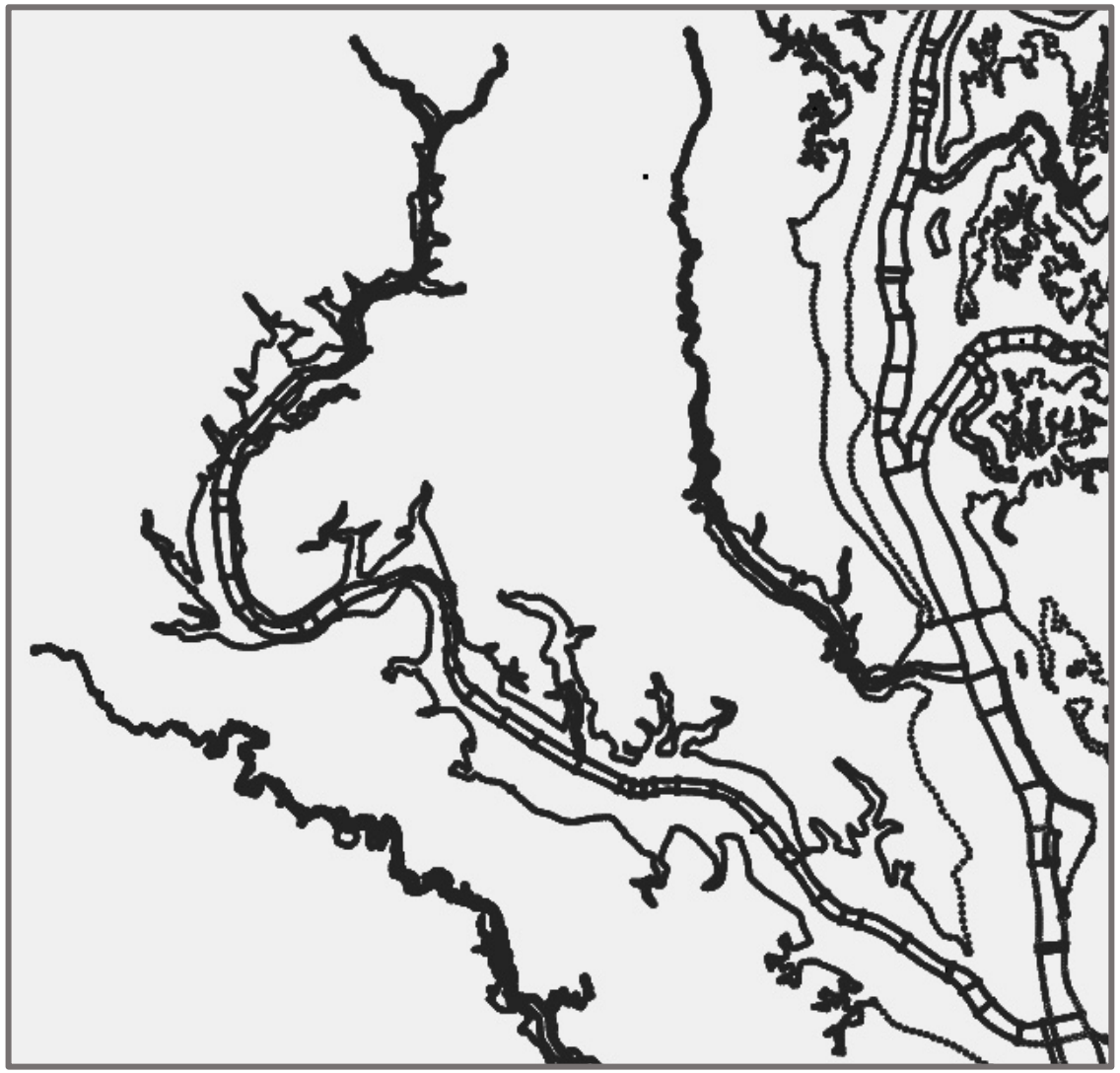
Grid construction screenshots



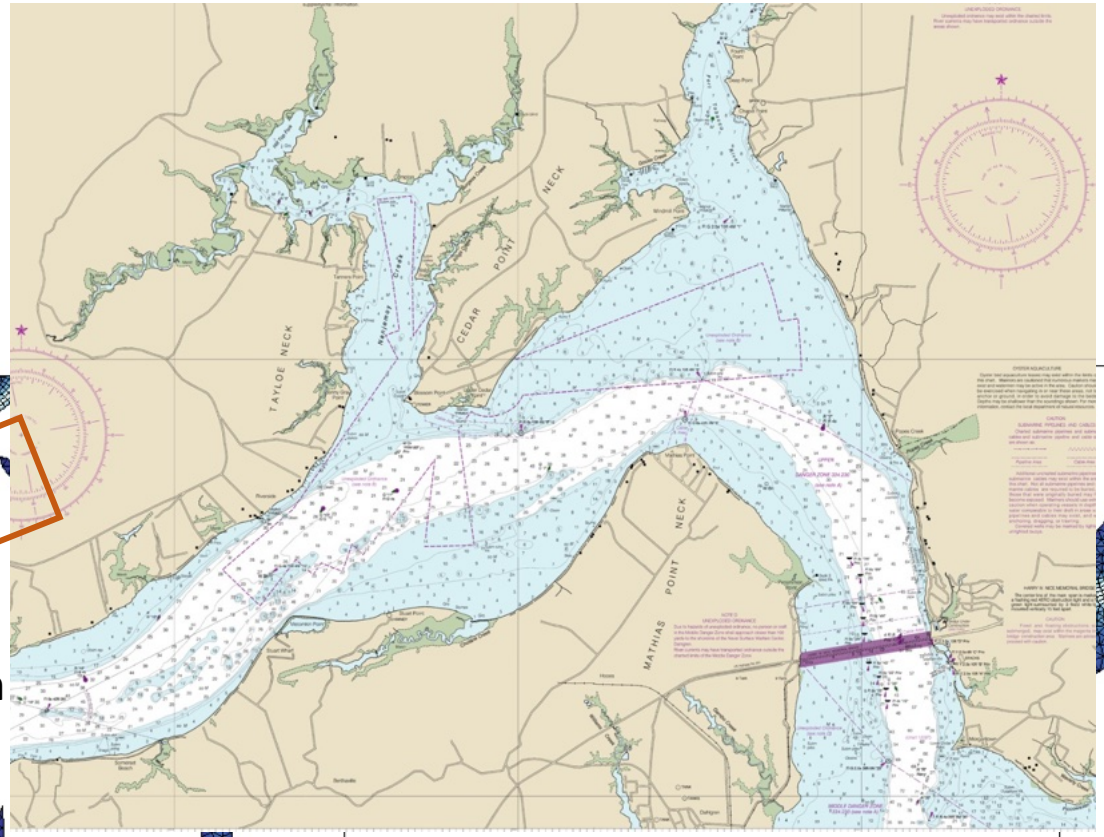
Cai et al. (2020)



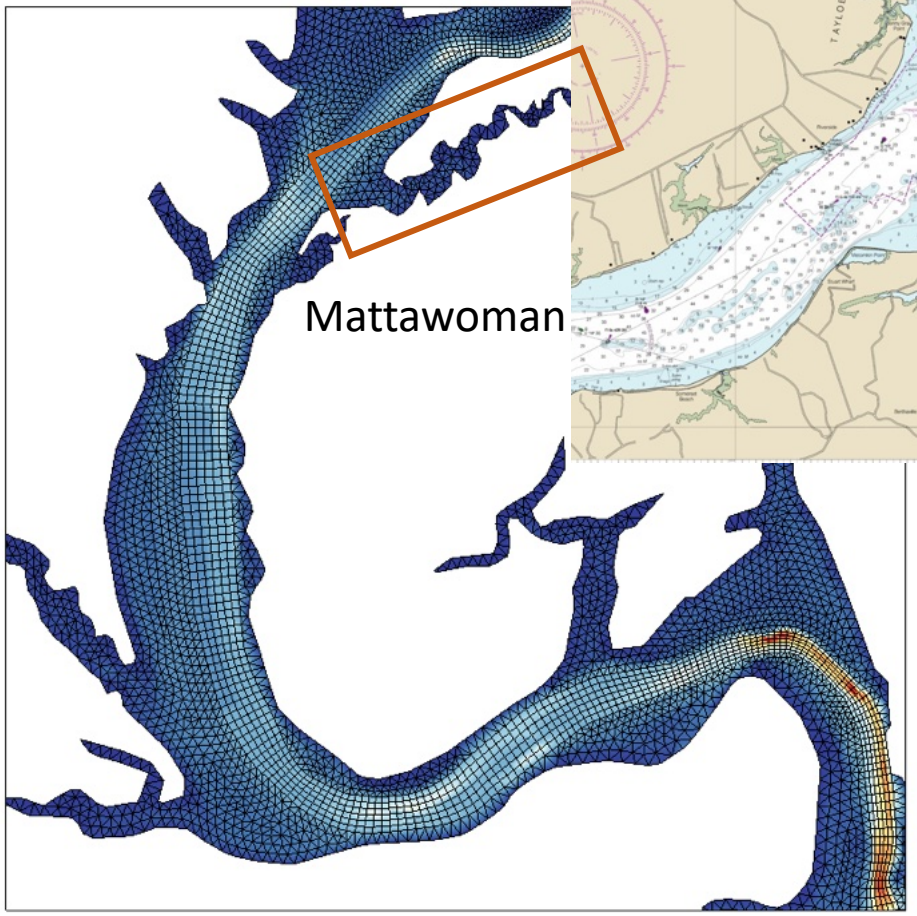
Qin et al. (in prep)

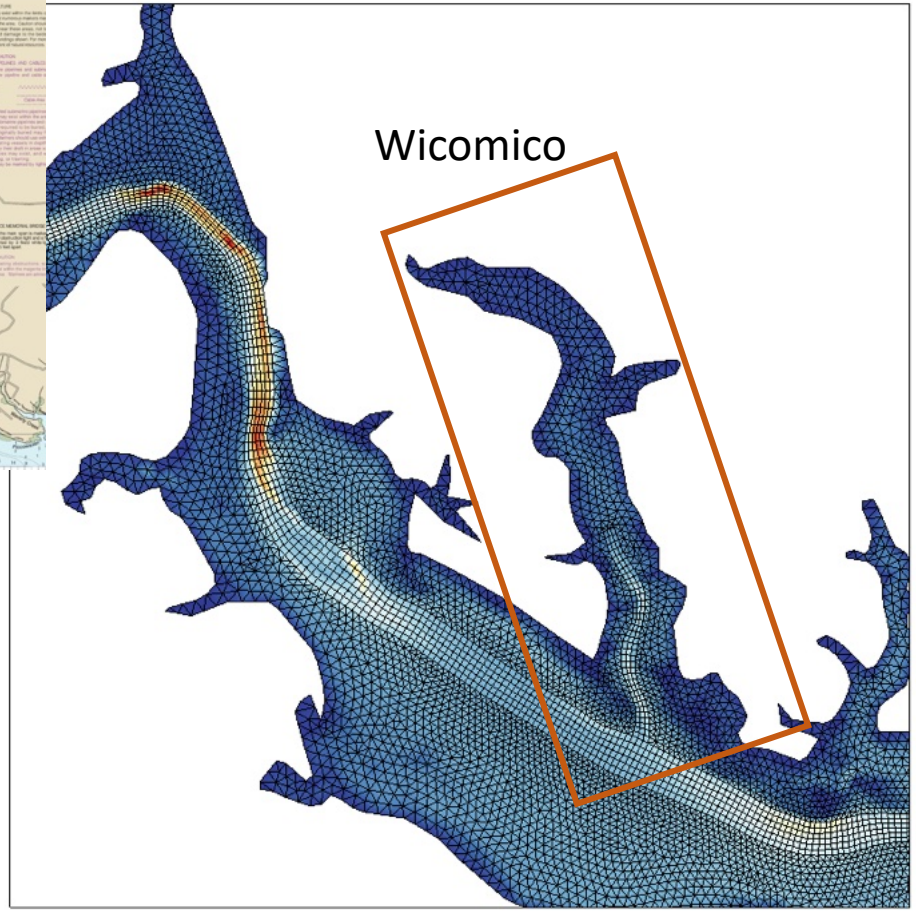
Potomac River horizontal grids

Mid Potomac R.

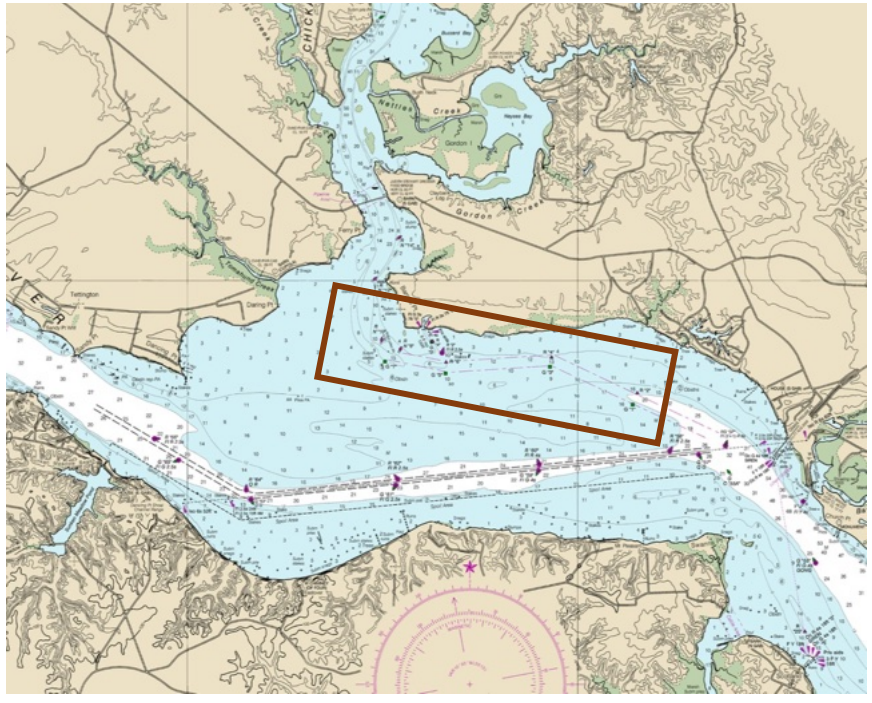


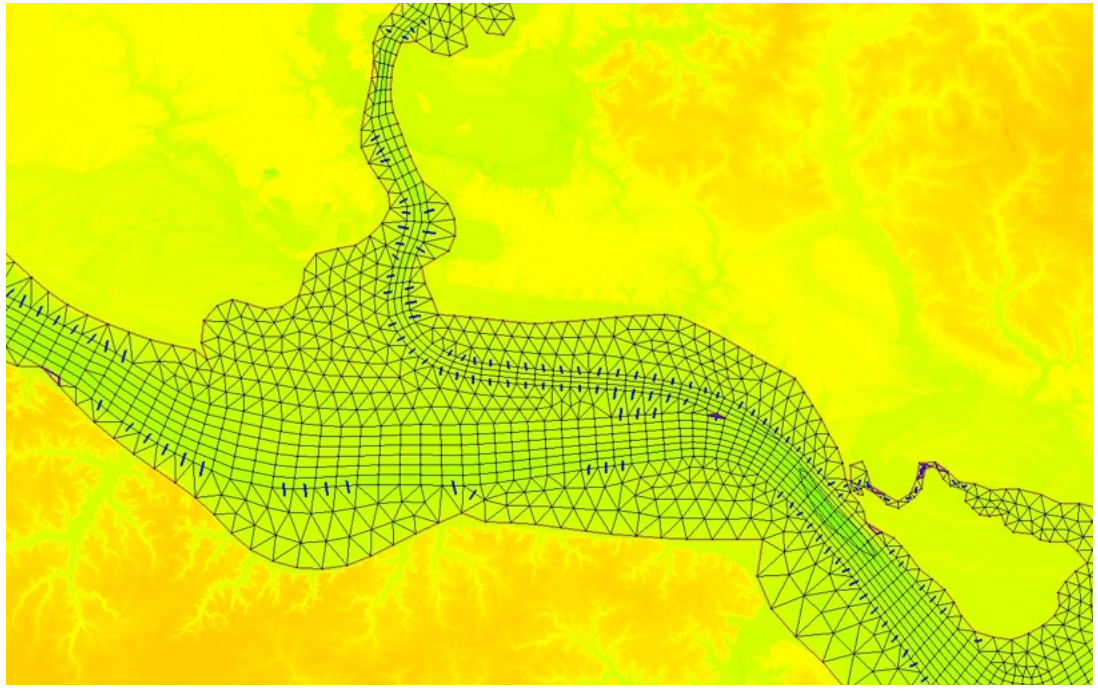
NOAA nautical chart (2021)





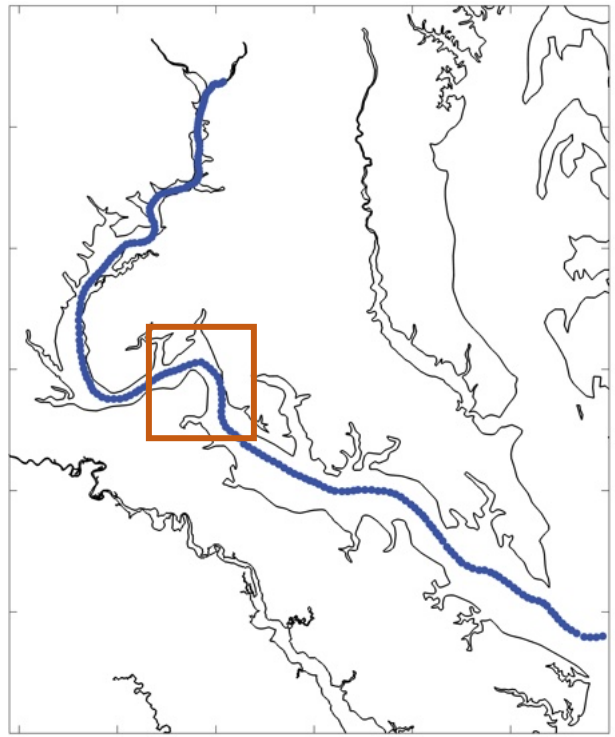
James River horizontal grids

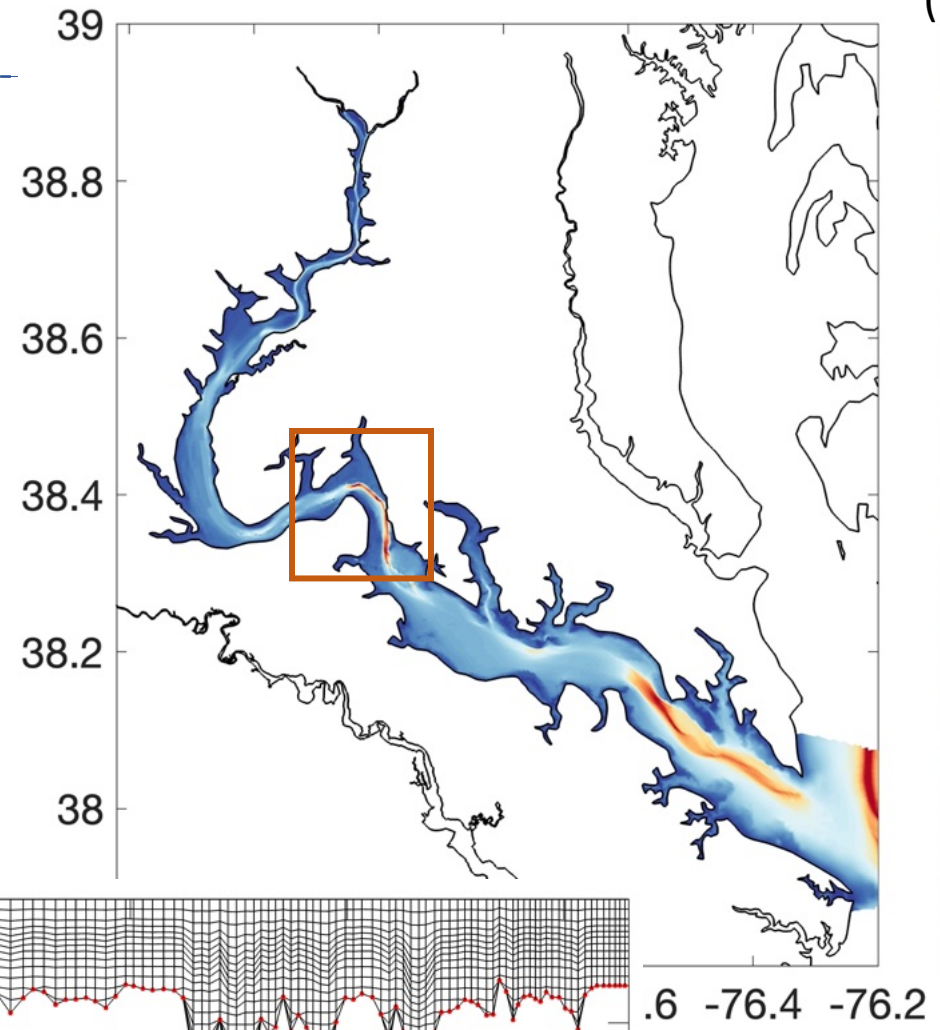


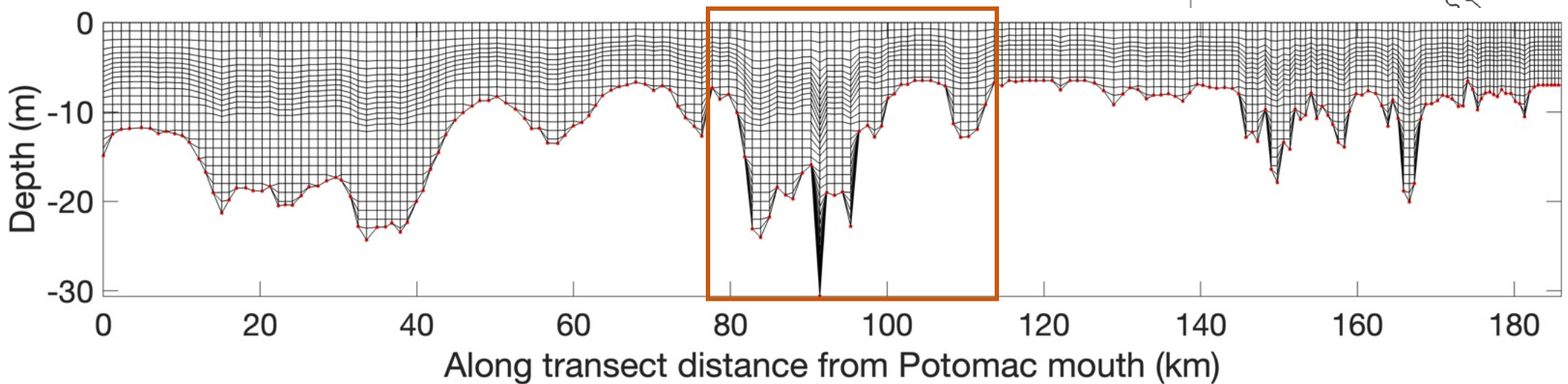


Potomac River vertical grids

- Generally consistent with NOAA nautical chart (2021)
- Overall deeper and wider channel than other tributaries
- Limited amount of bathymetry jump along the channel
- 36 layers at the deepest region

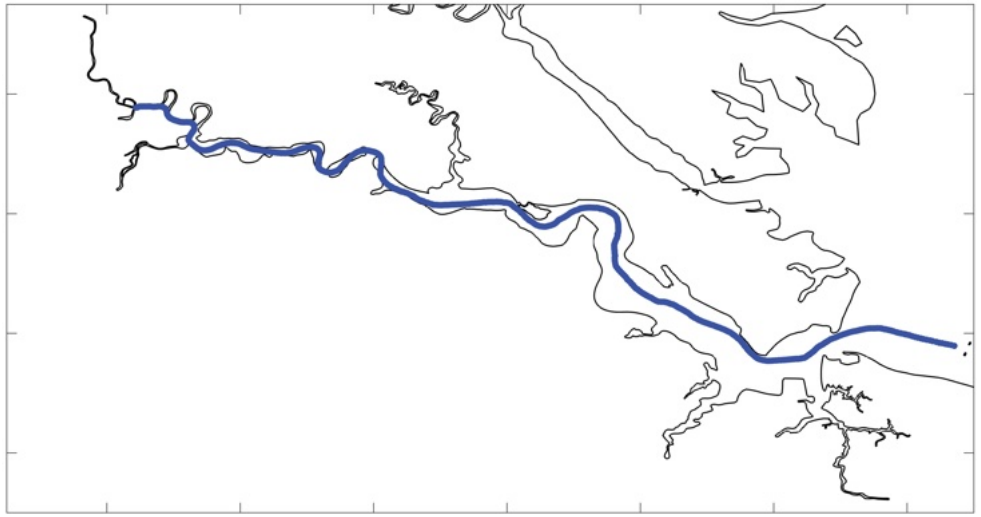


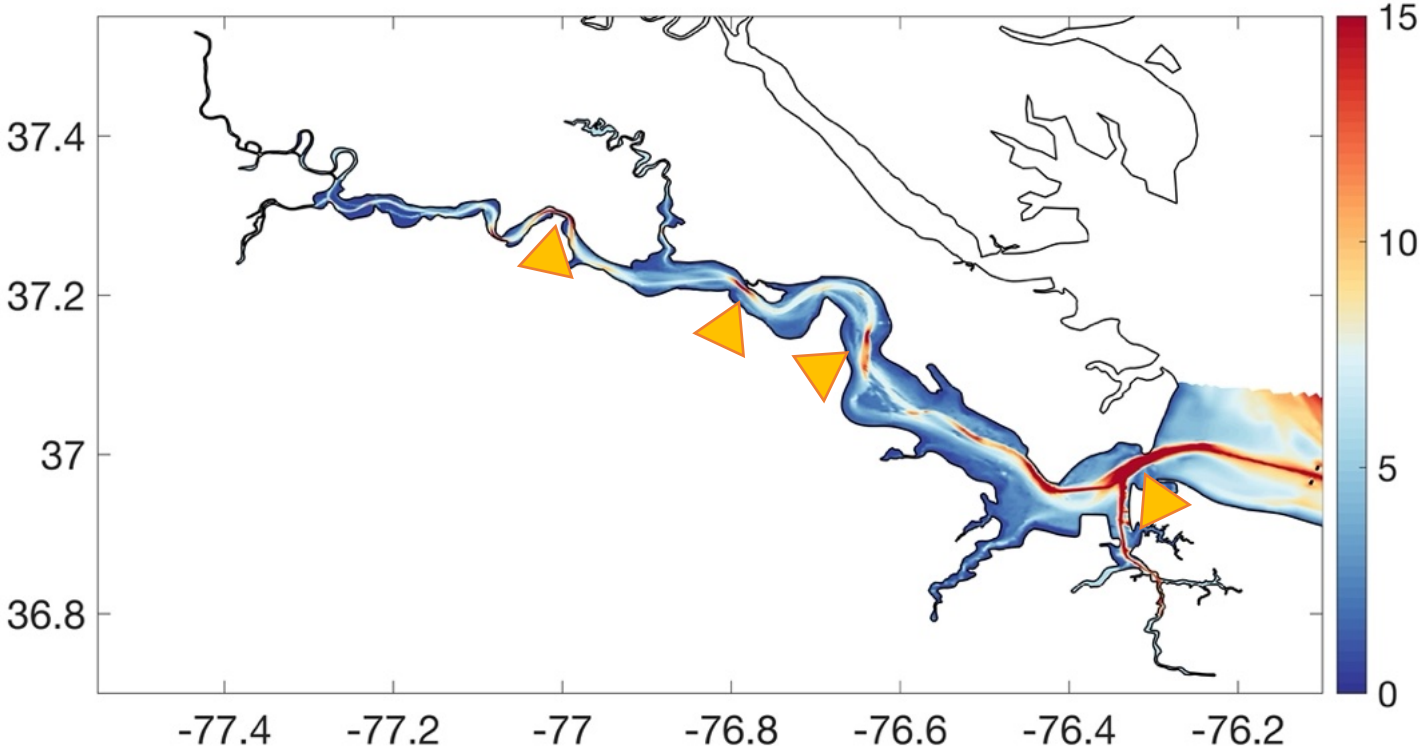




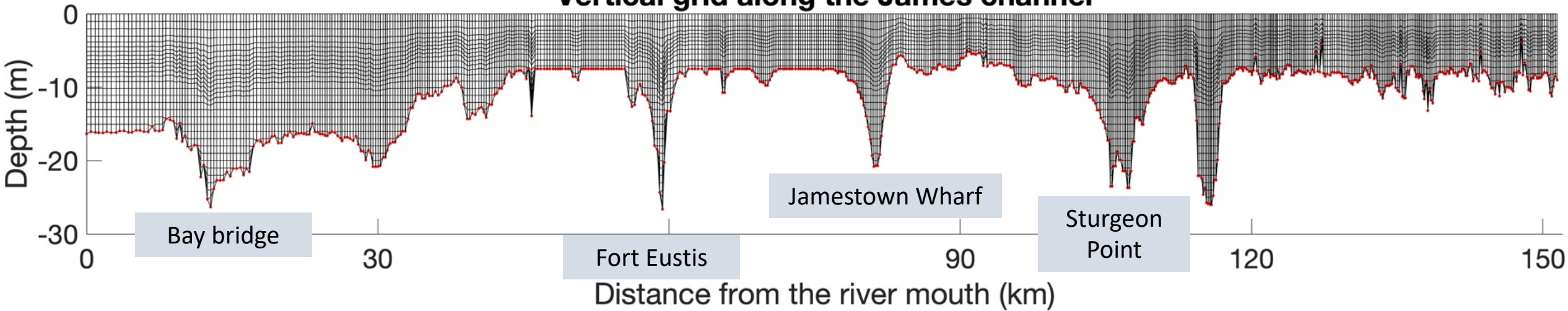
James River vertical grids

- Maximum **32** layers in deep channels
- Minimum one layer for shallow shoals

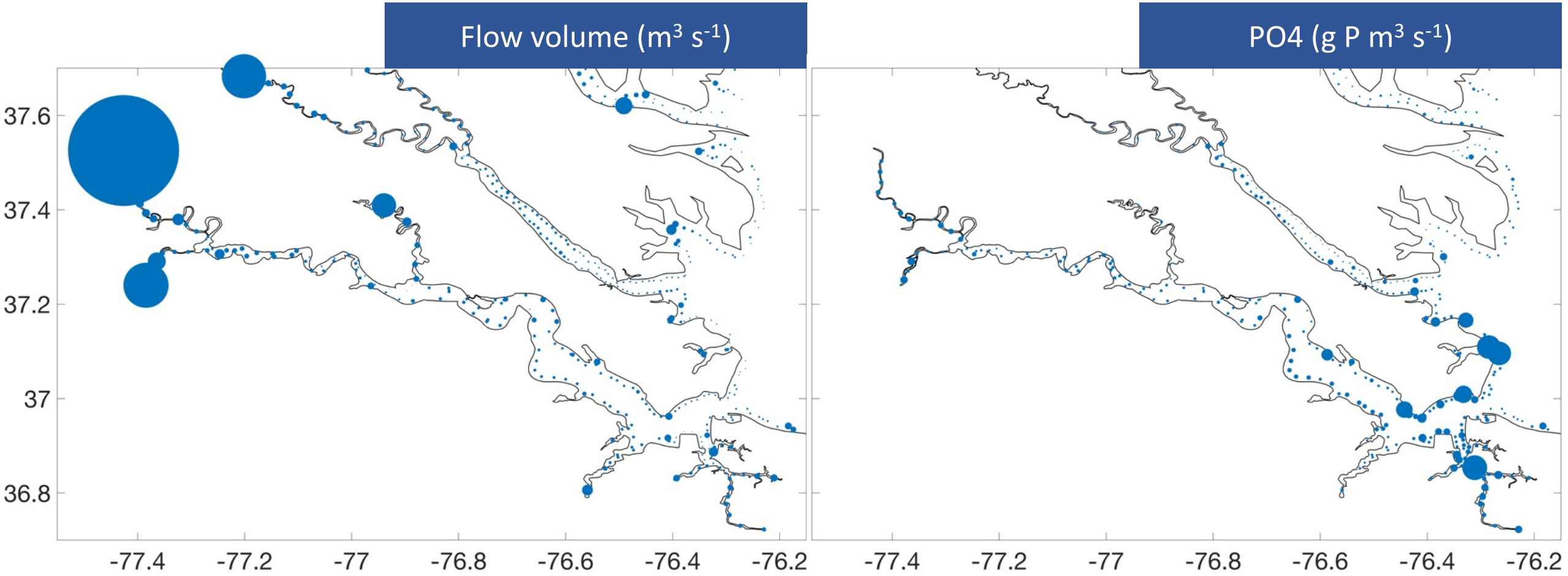




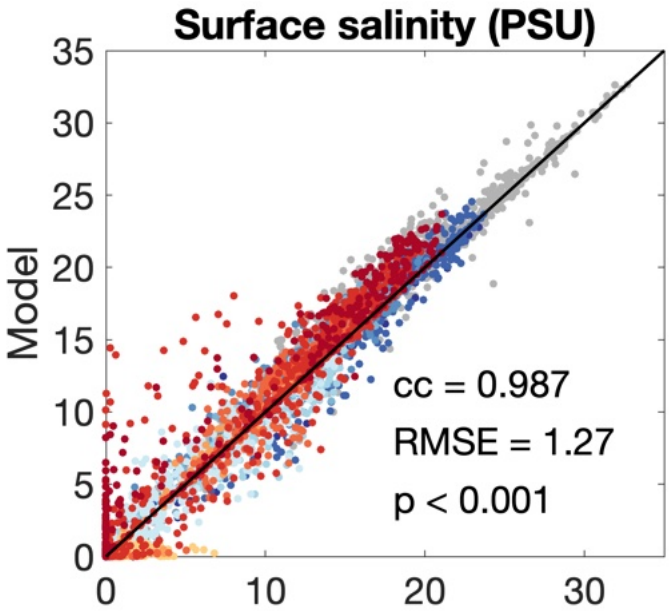
Vertical grid along the James channel

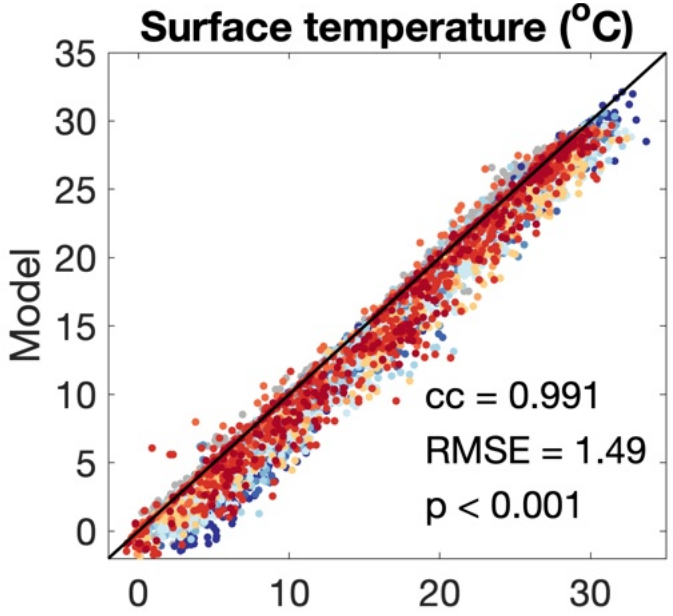


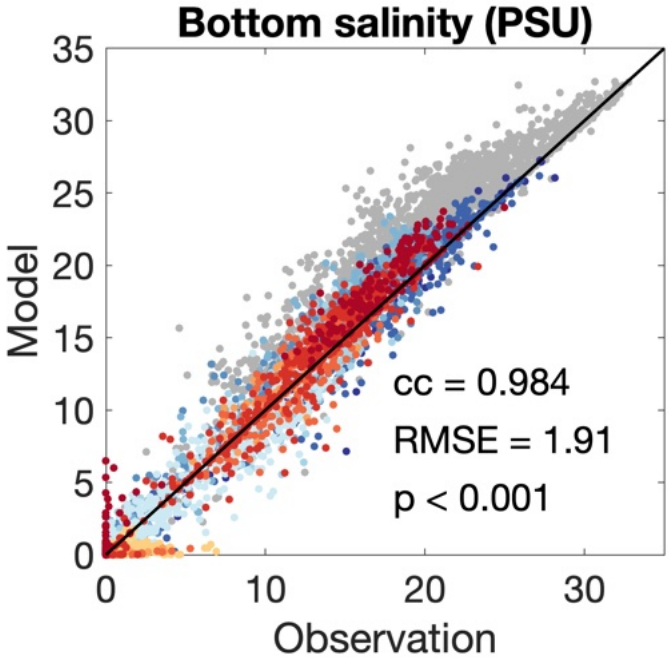
Watershed loading

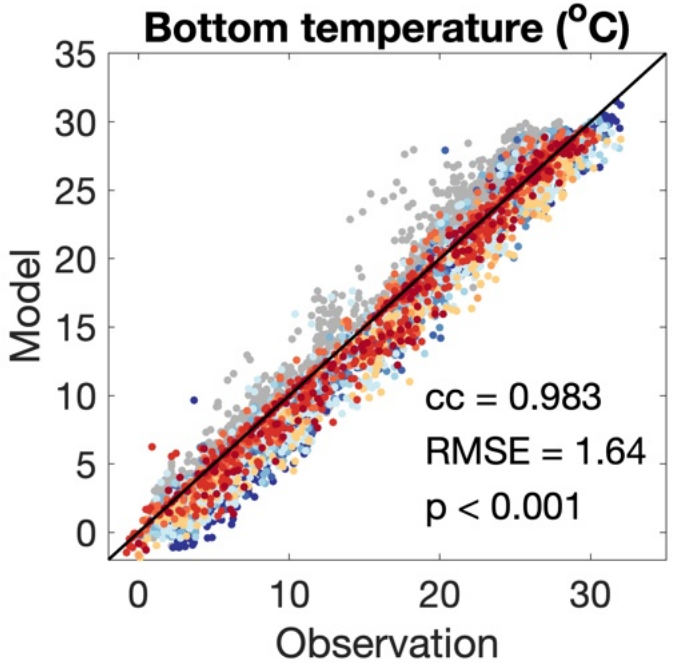


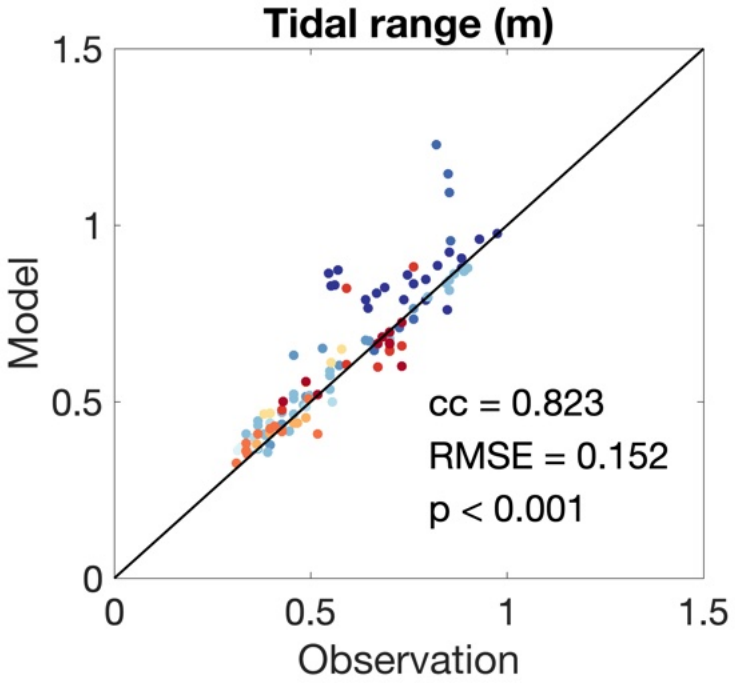
Physical simulations





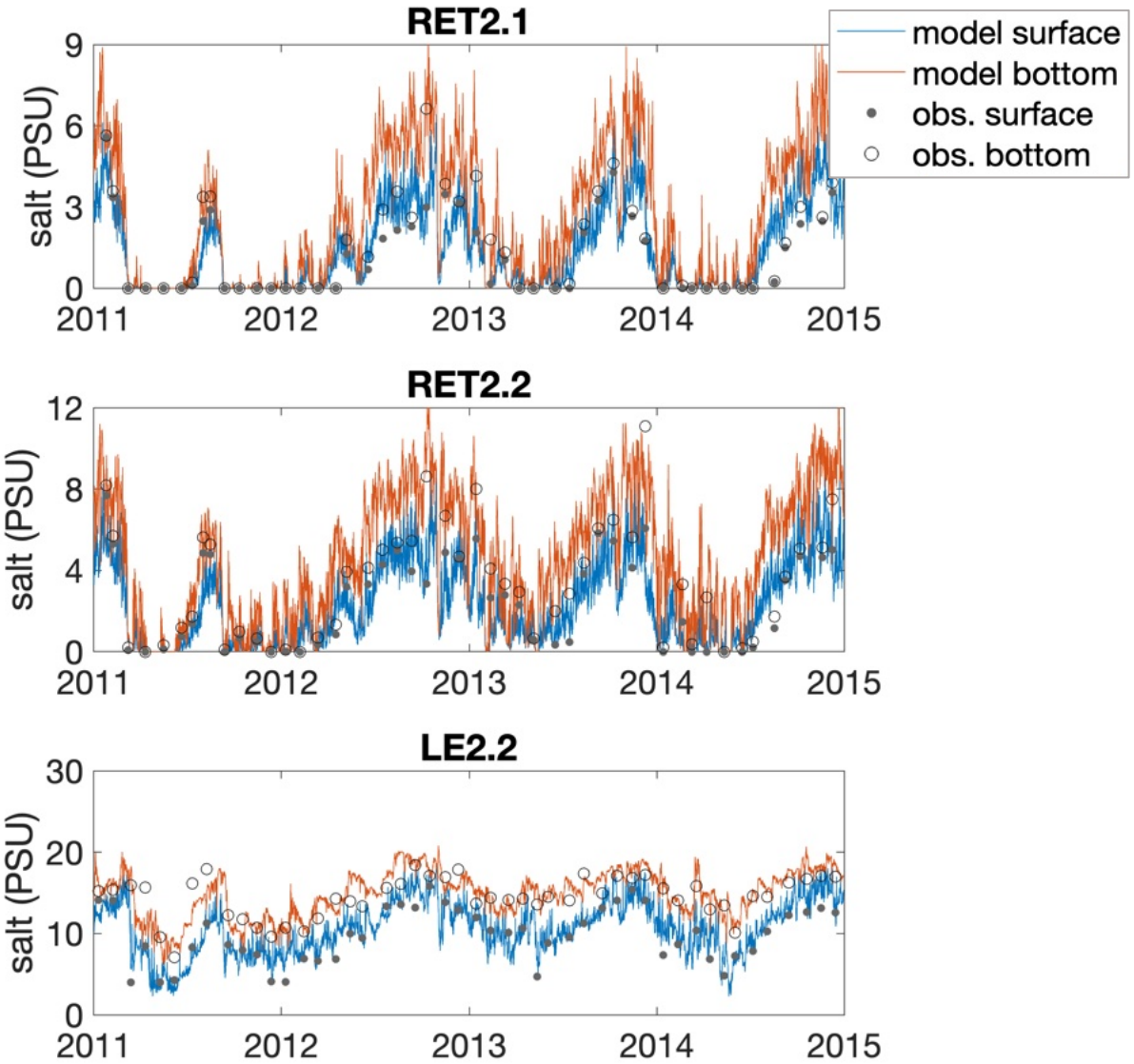


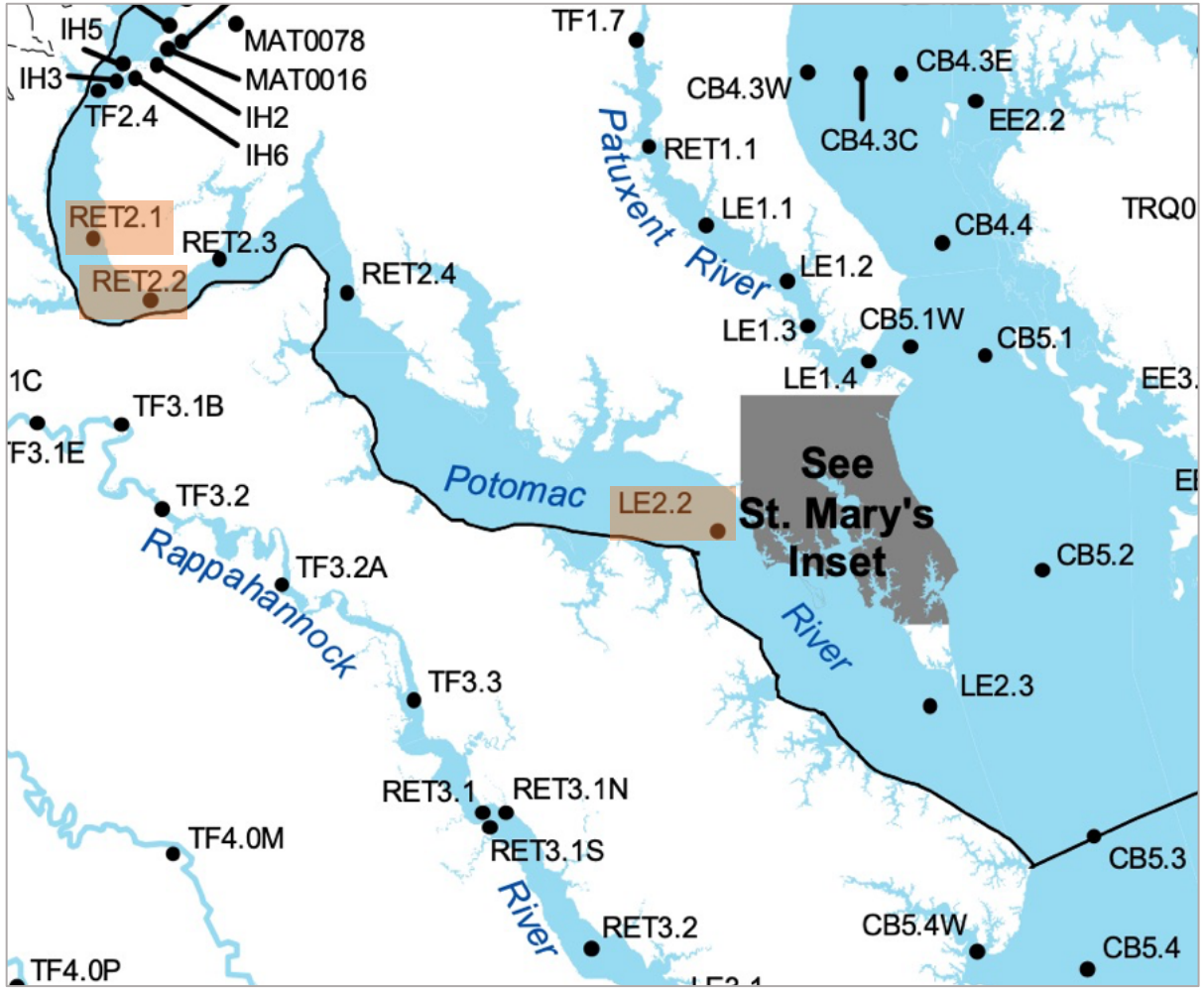




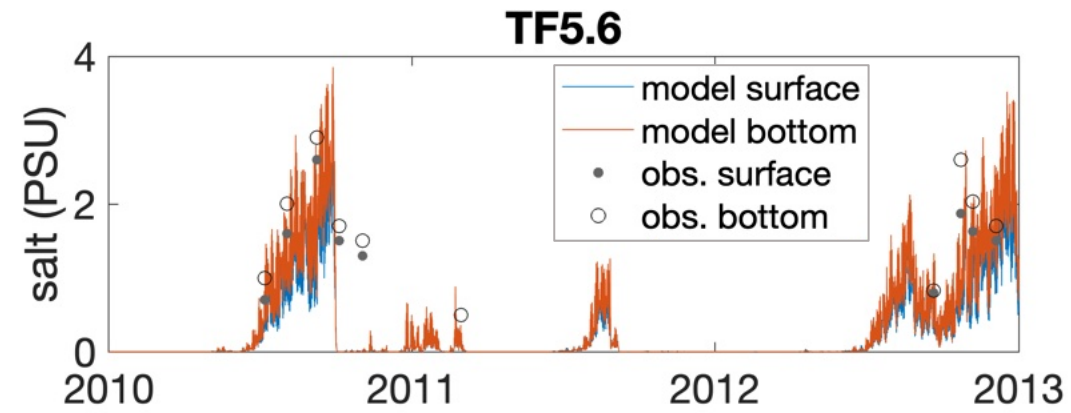
Hydrodynamics: Potomac River

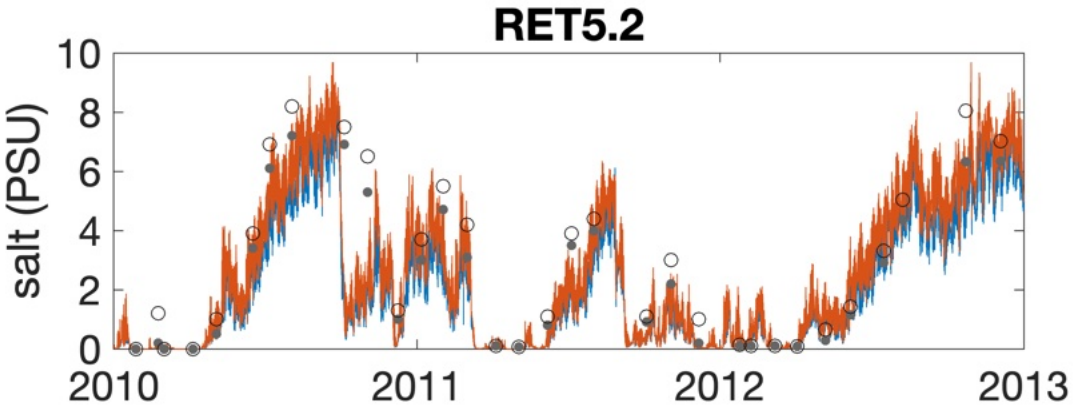
- Well capture of saltwater intrusion distance (to TF2.4)
- Reasonable capture of mid-Potomac stratification

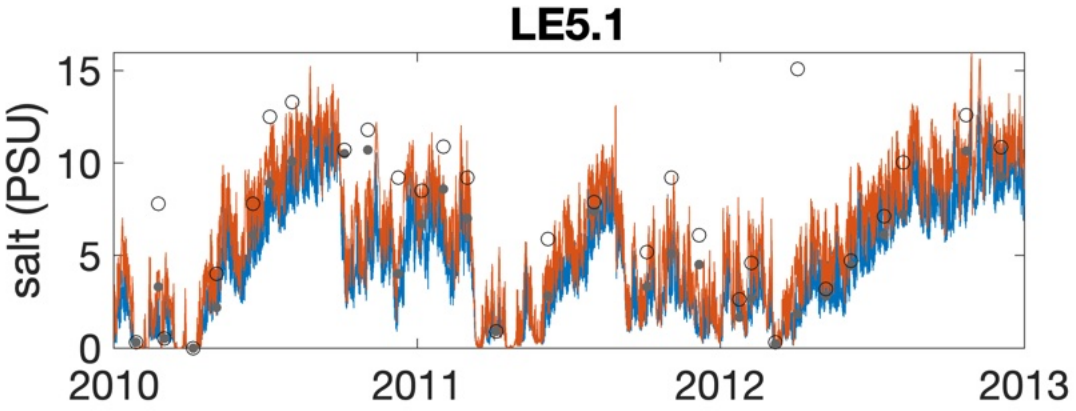


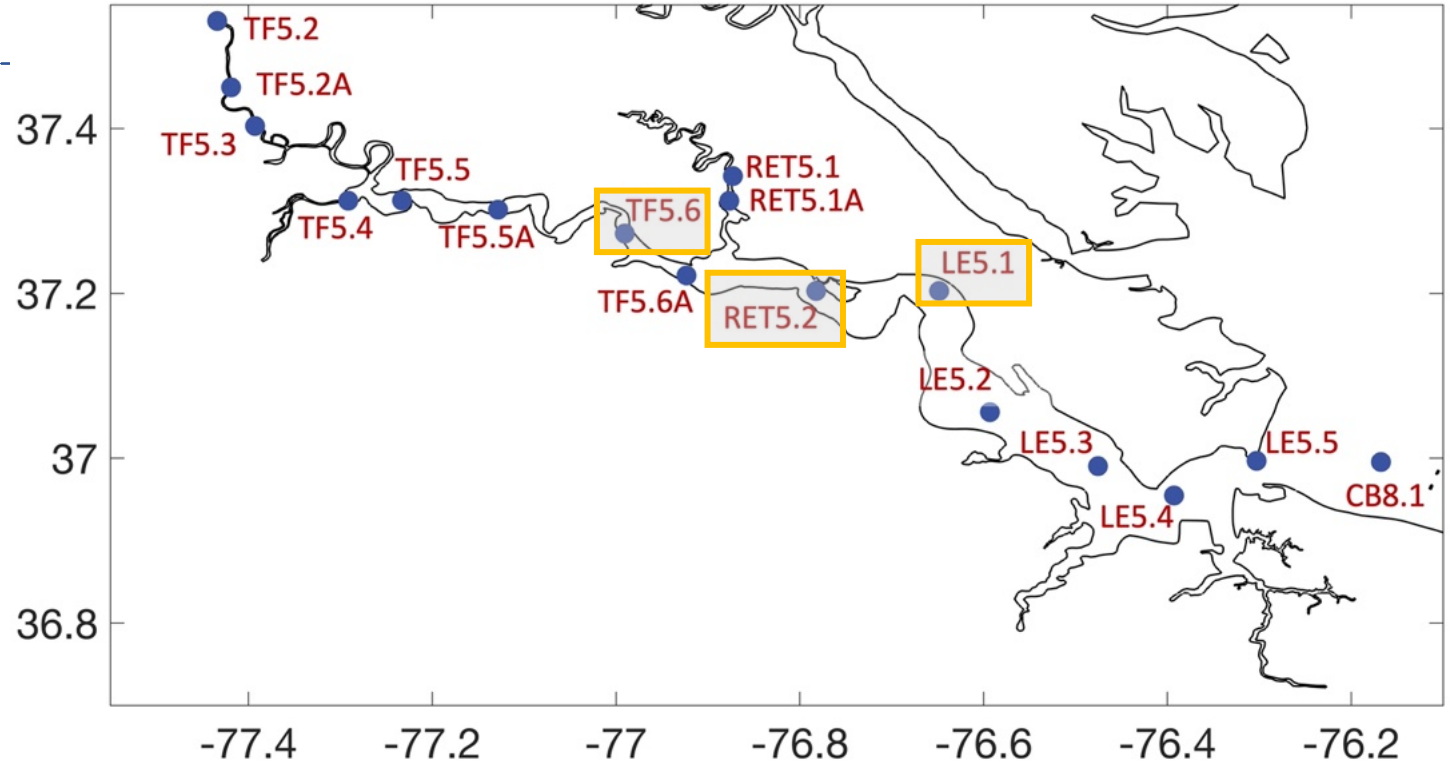


Hydrodynamics: James River









- Overall reasonable saltwater intrusion distance and stratification level
- Reasonable skills along the river cross the polyhaline, mesohaline, oligohaline, and tidal fresh zones.

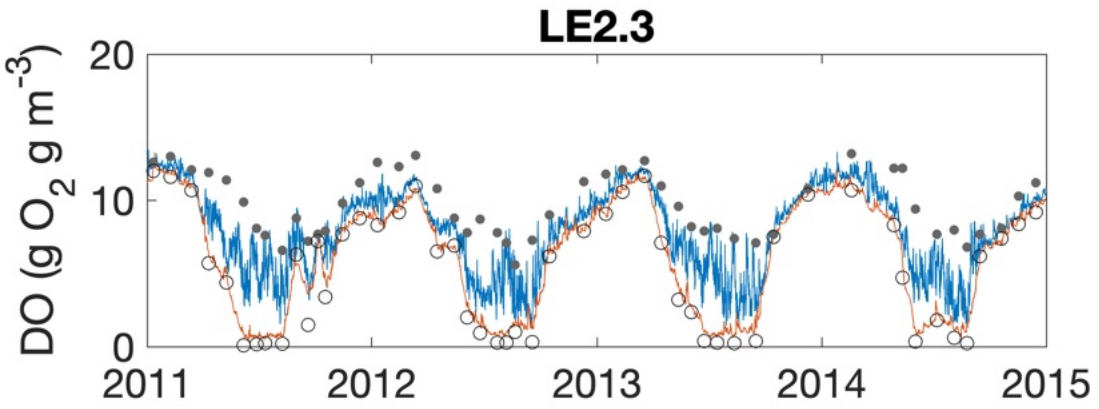
Sensitivity tests on Potomac River model

- Test the importance of sediment phosphorus recycling under hypoxia

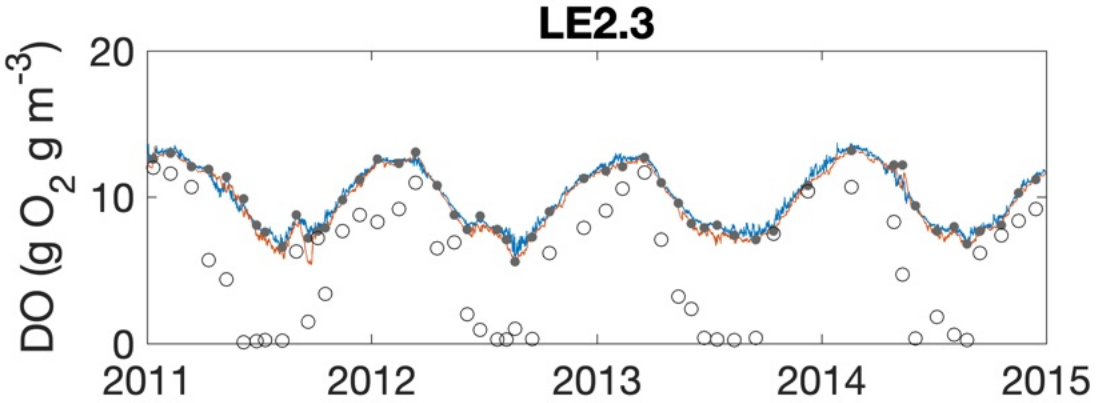
  - Cut-off Potomac domain
  - Identical watershed loading
  - Identical parameter sets
  - Identical boundary condition except oxygen concentrations

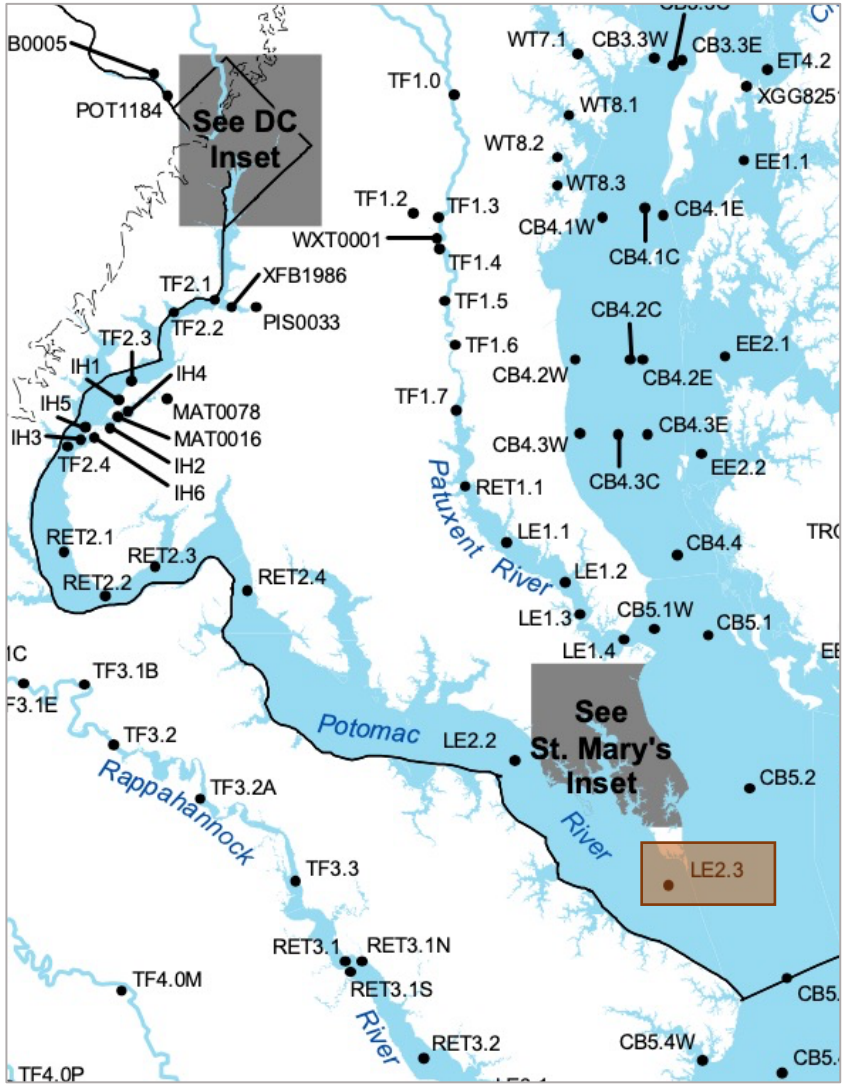
Sensitivity tests – impacts of main Bay hypoxia

Test 1: LE2.3 bottom DO as boundary condition



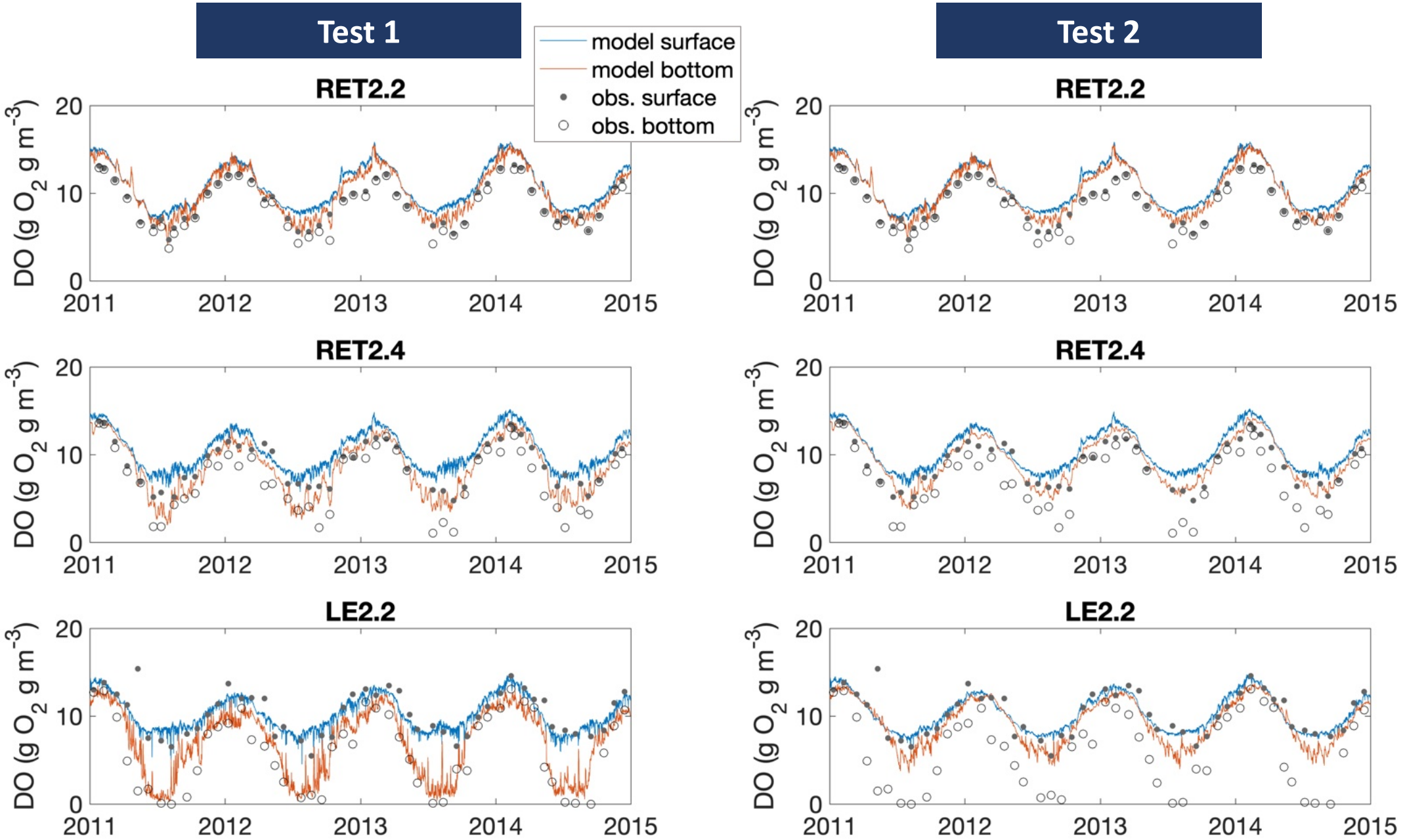
Test 2: LE2.3 surface DO as boundary condition





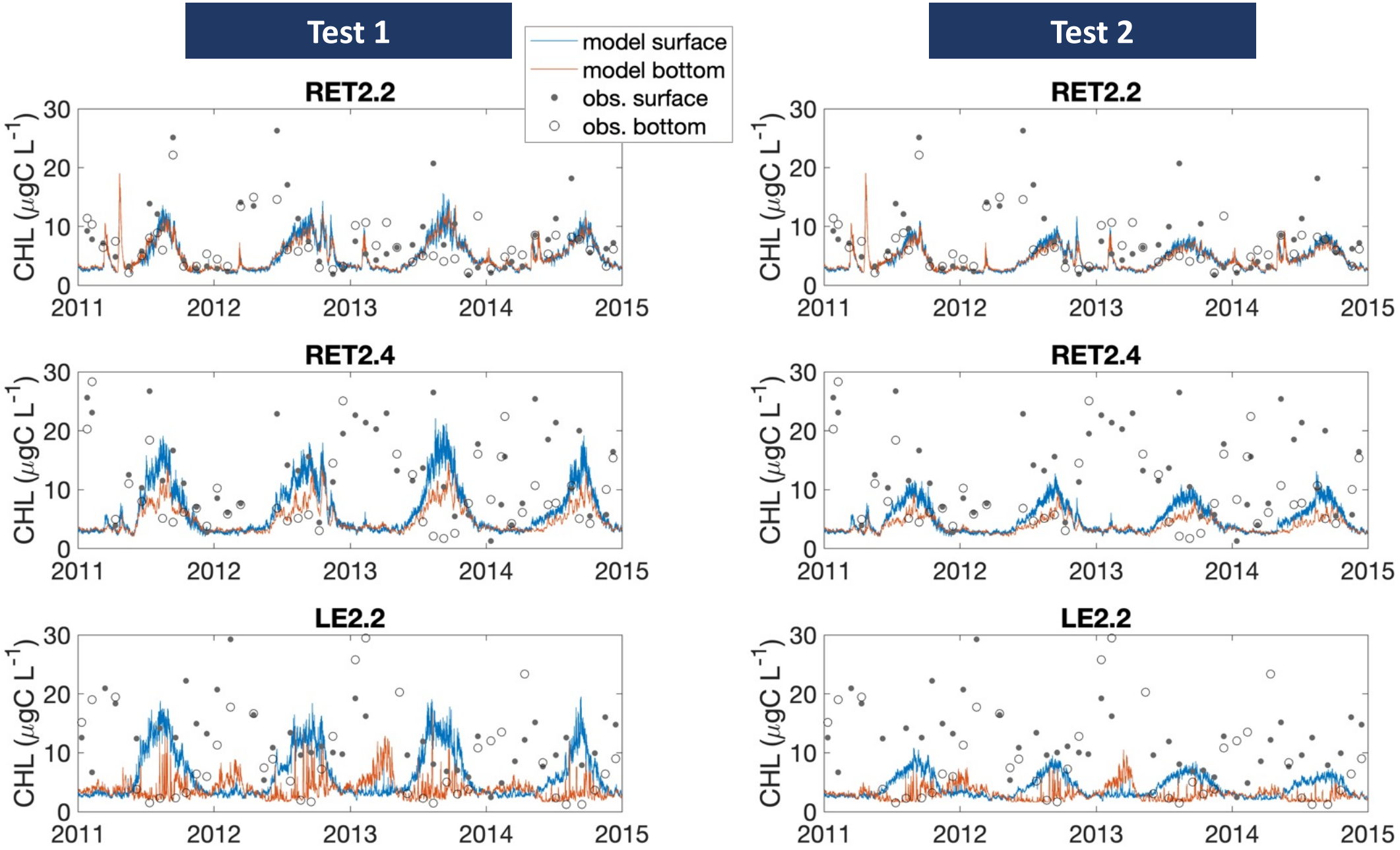
Response of DO

Smaller difference along with less stratification at upper estuary above RET2.1



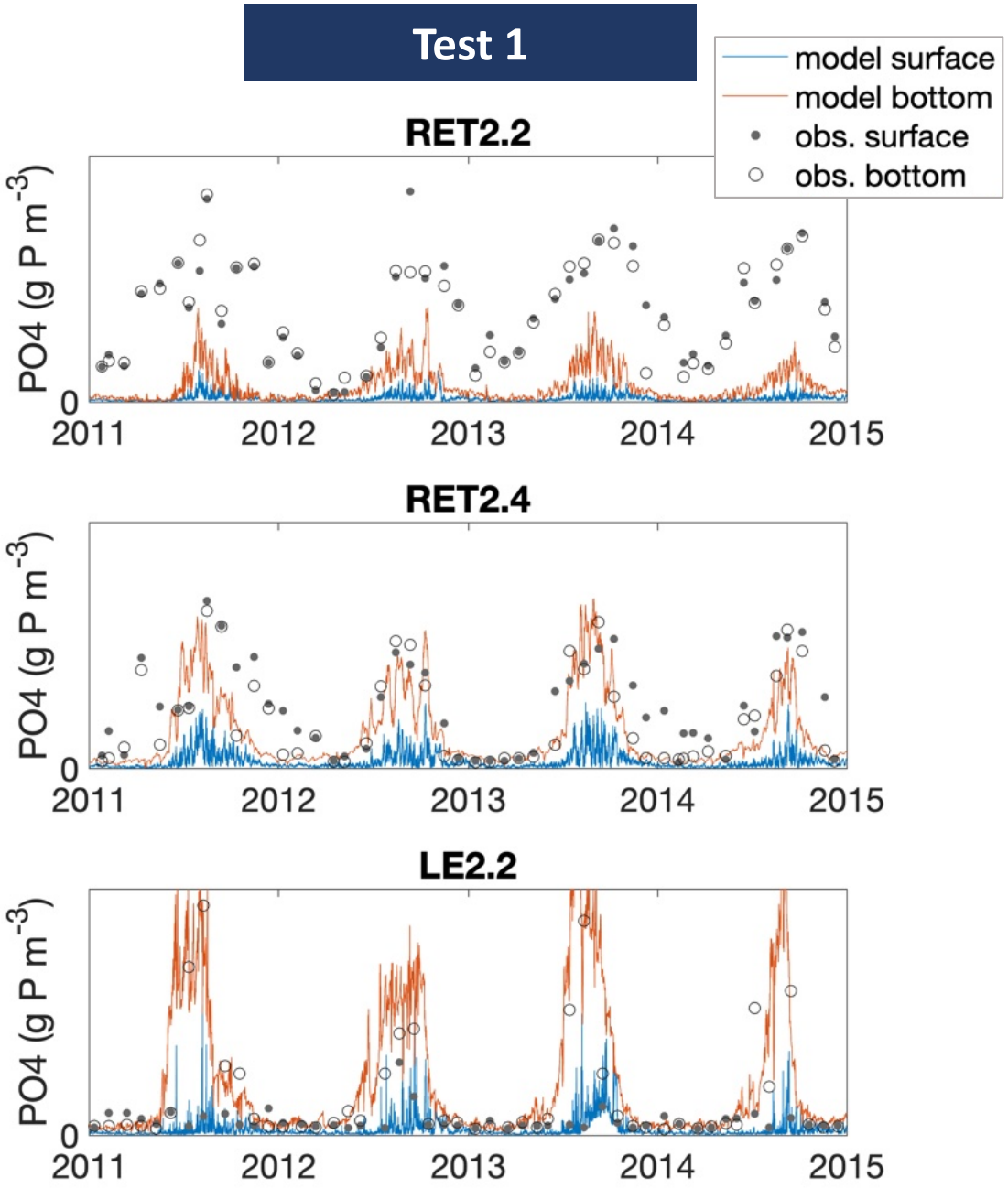
Response of Chl-a

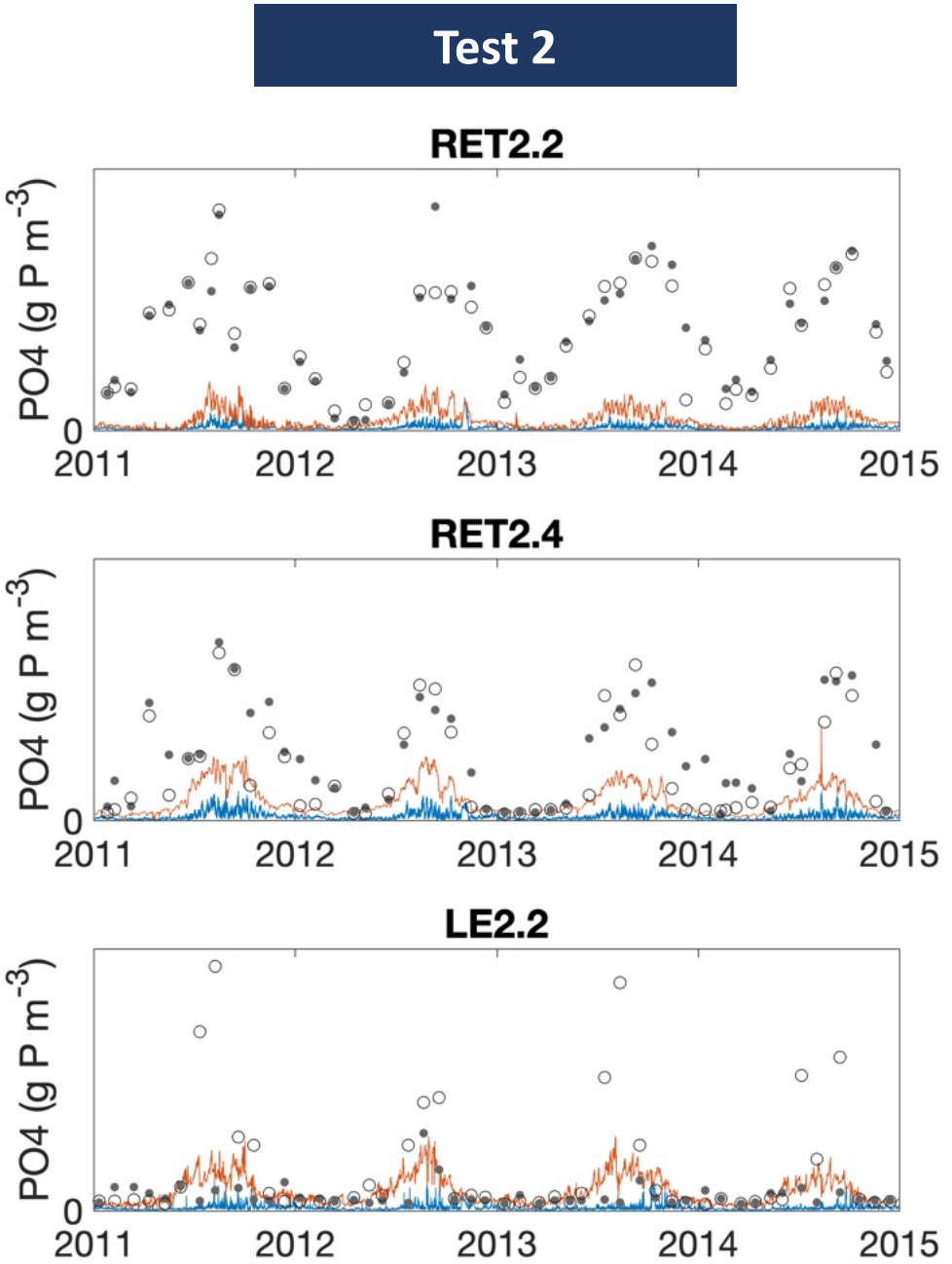
Increased amount of PO4 supports more chl-a and primary production



Response of PO4

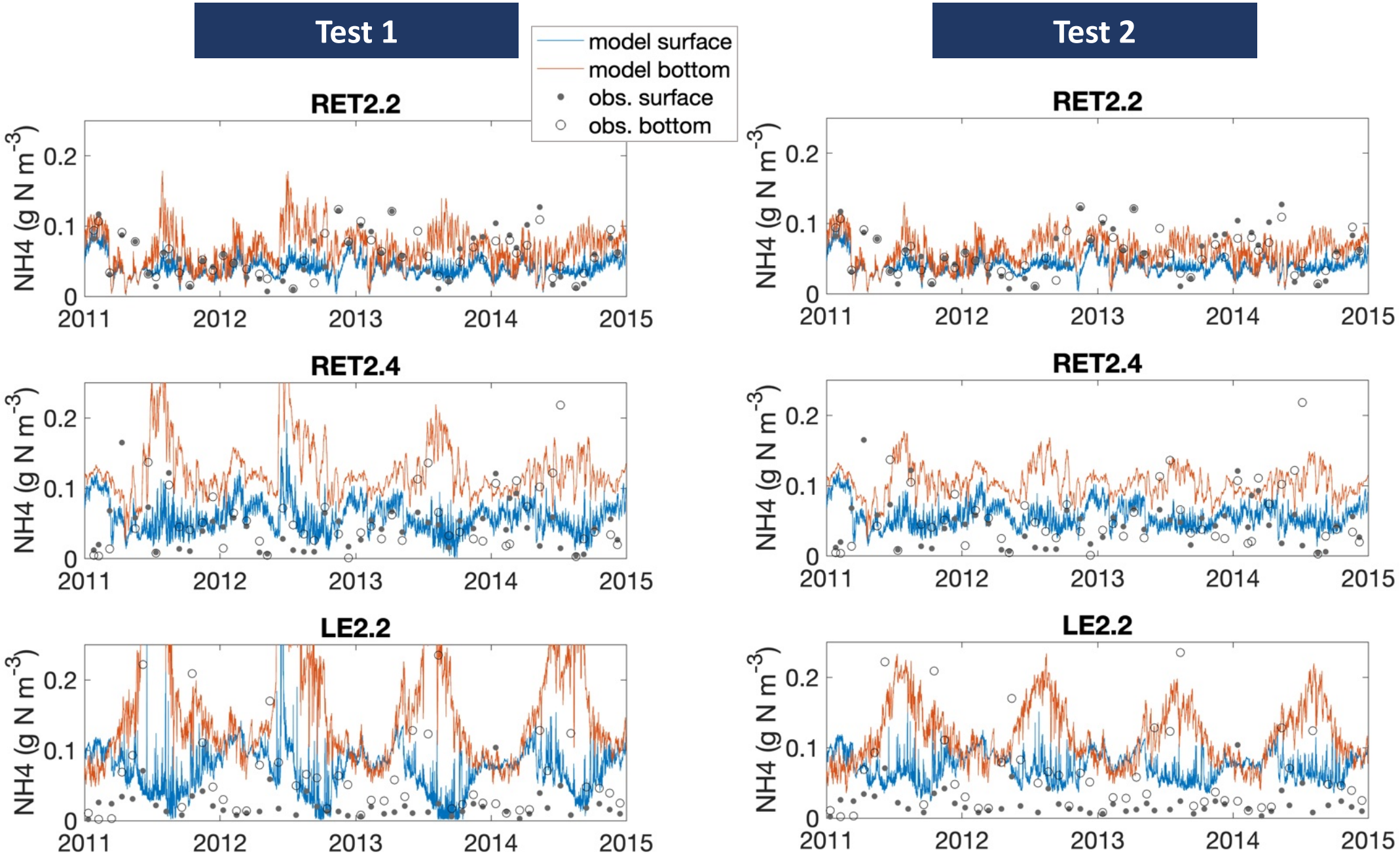
Significant amount of PO4 from bottom release under low-DO condition





Response of NH4

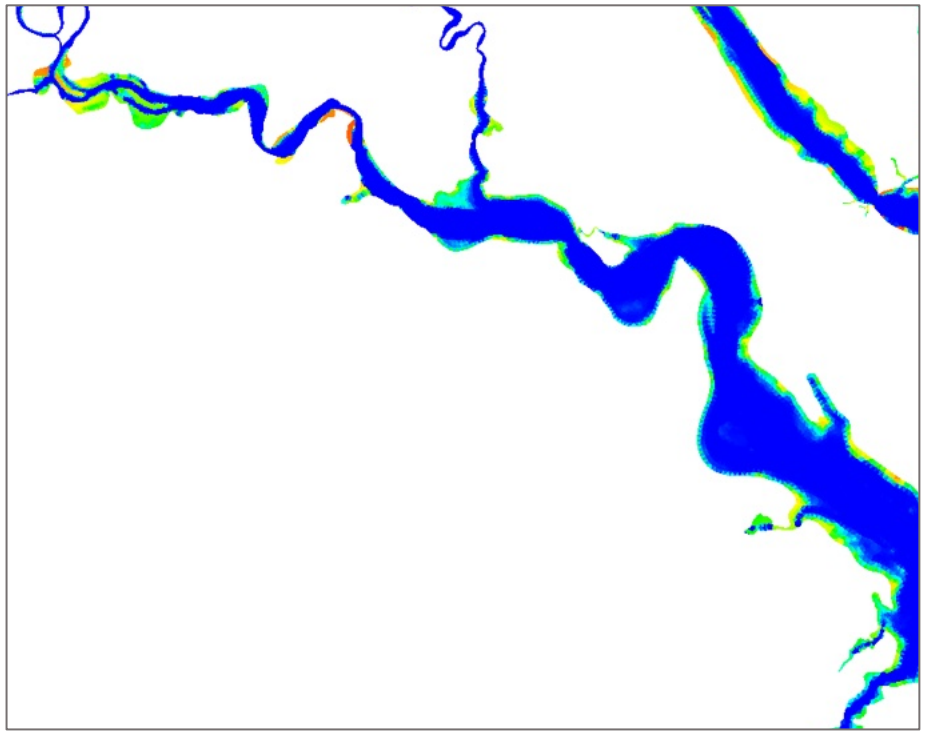
Increased chl-a supports more NH4 recycling



Conclusion 1

- We developed a Potomac-only model.
- This Potomac-only model well repeats the physical simulations.
- We demonstrate the importance of a well-calibrated 3D ICM MBM boundary for Potomac River.
- The hypoxia at lower Potomac is significant for the phosphorus cycling and therefore the primary production.

Sensitivity tests on James River model



Benthic algae

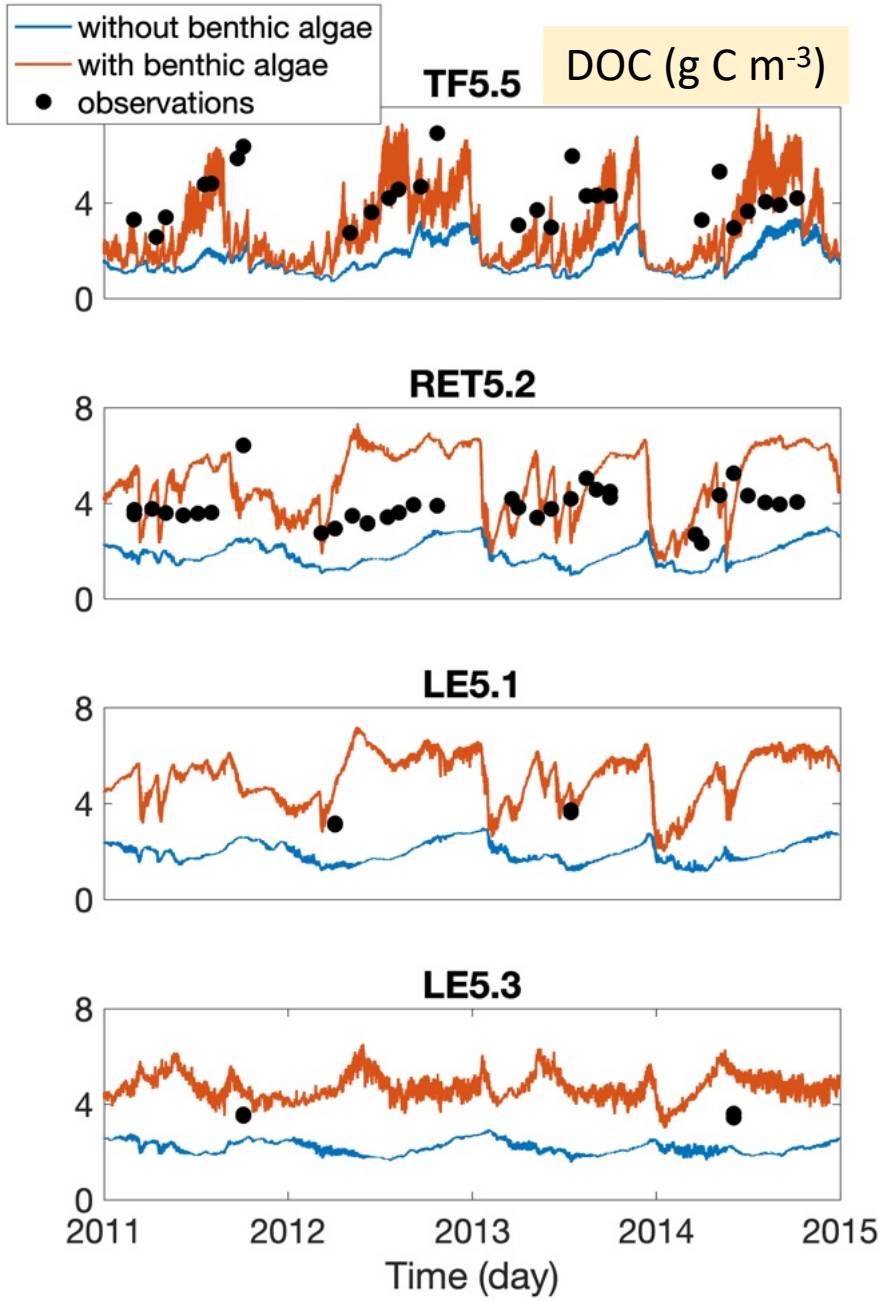
Base

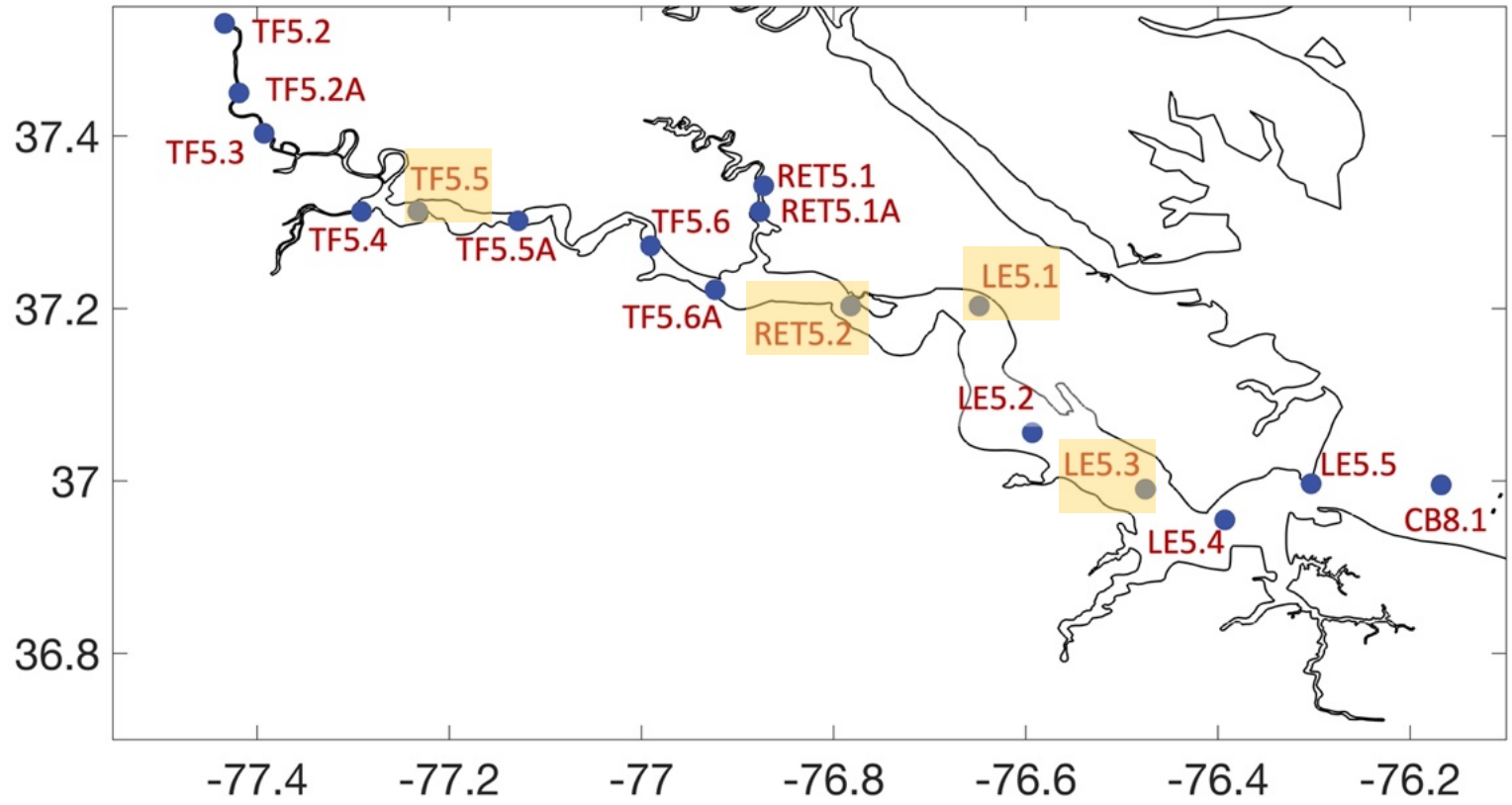
Benthic algae
+ P reduction

P reduction

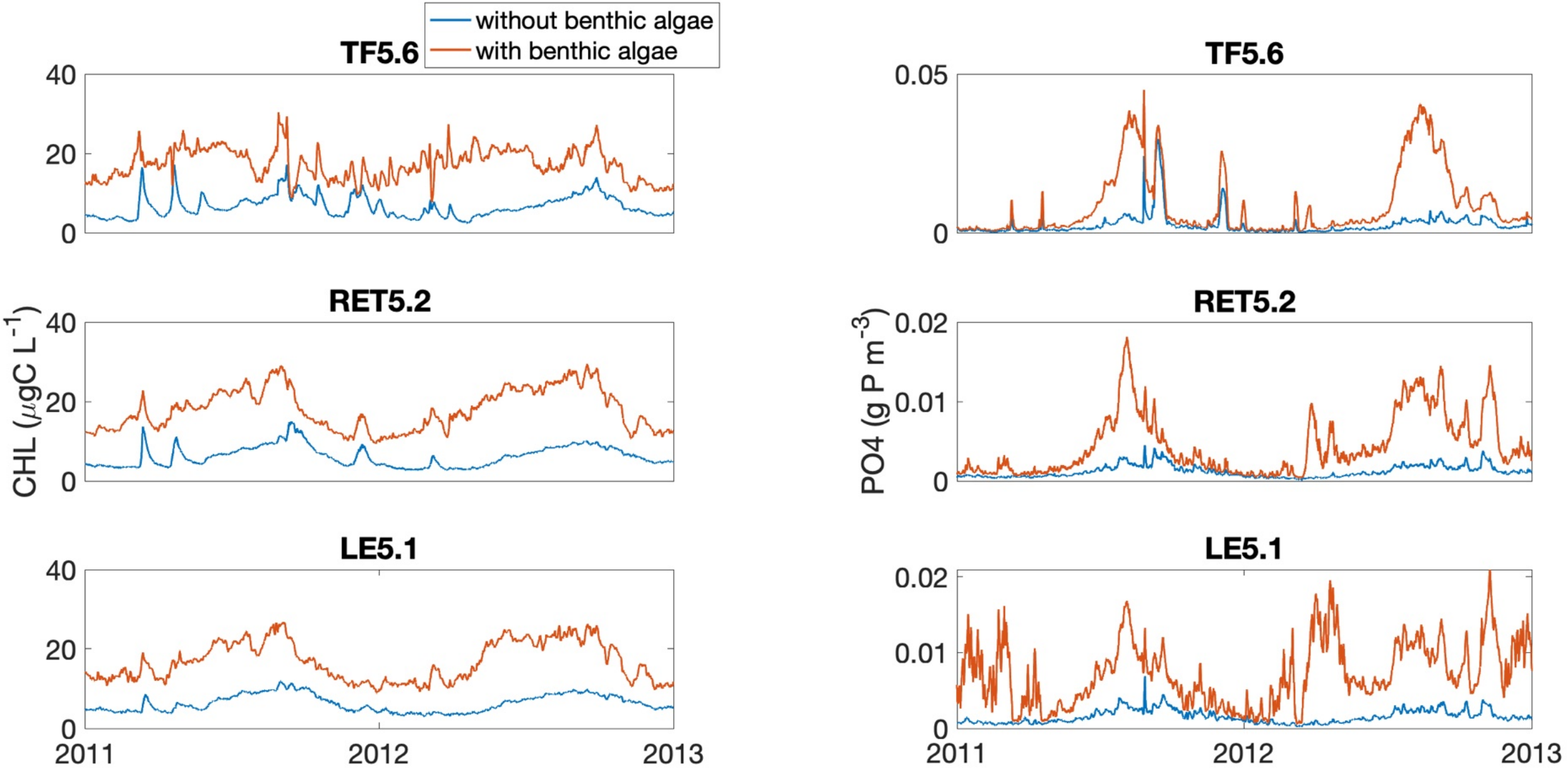
- Test of whole Bay benthic algae
- Test watershed P reduction

Include benthic algae in the Base Scenario?

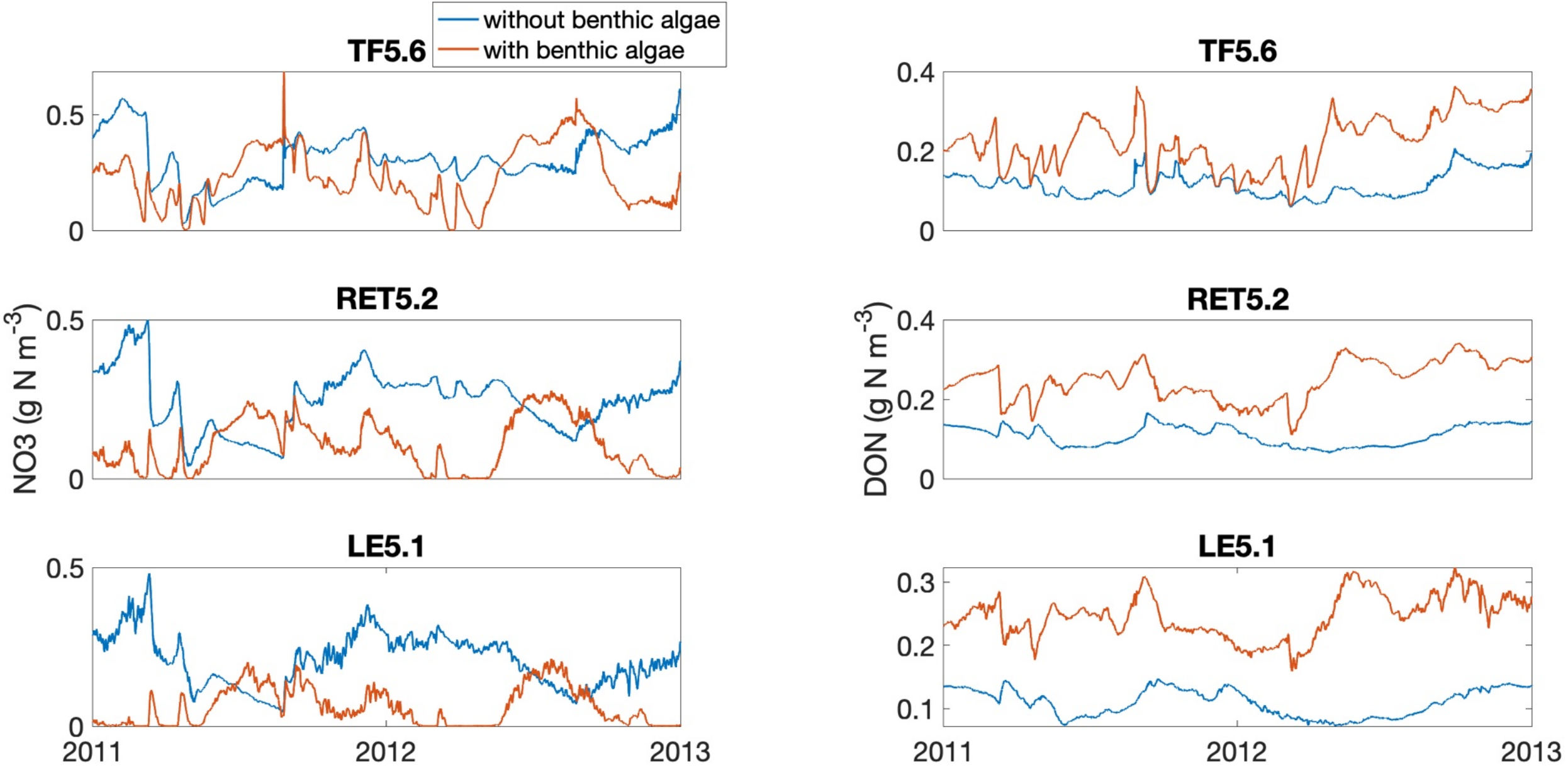




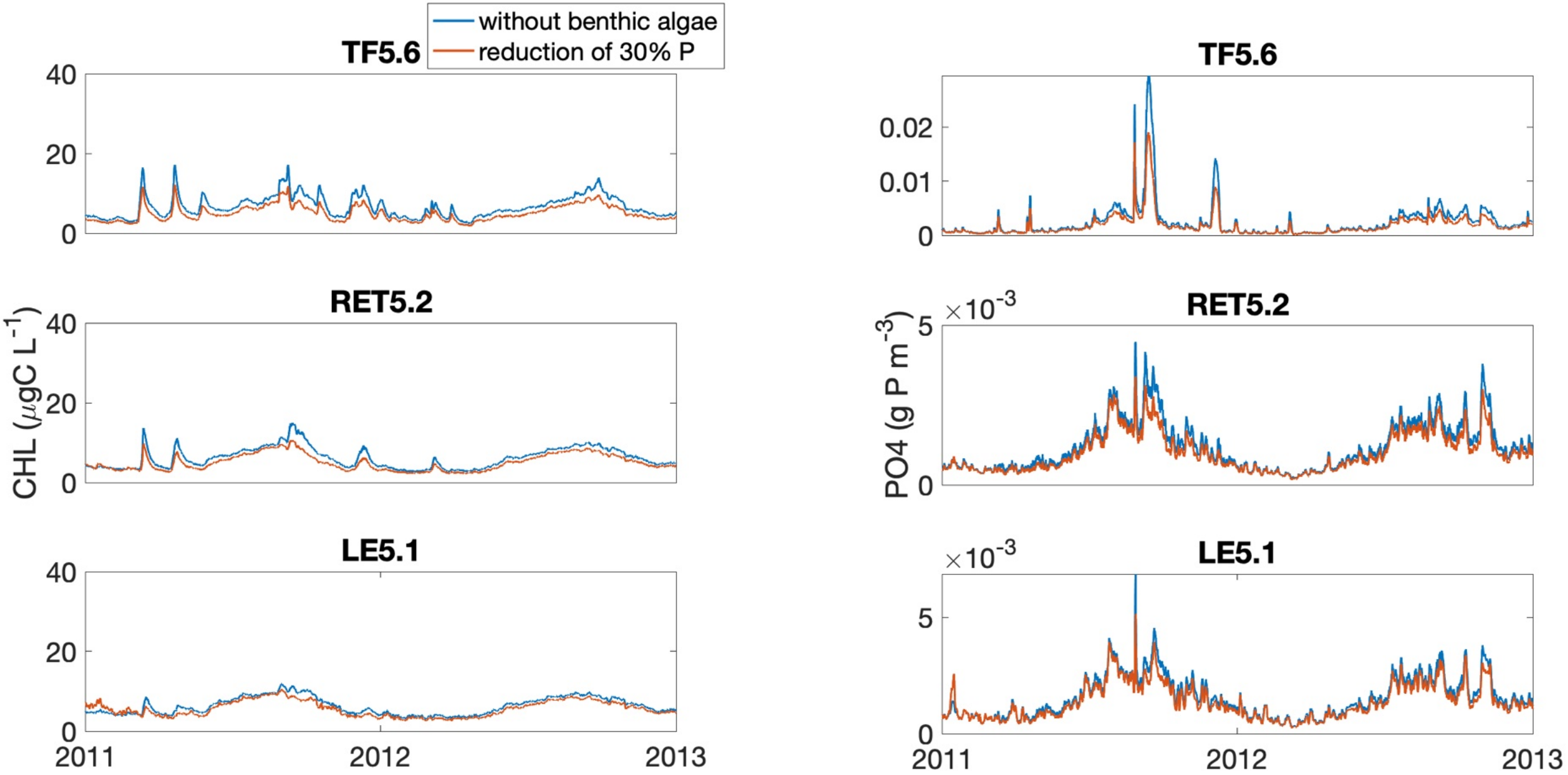
Without vs. with benthic algae



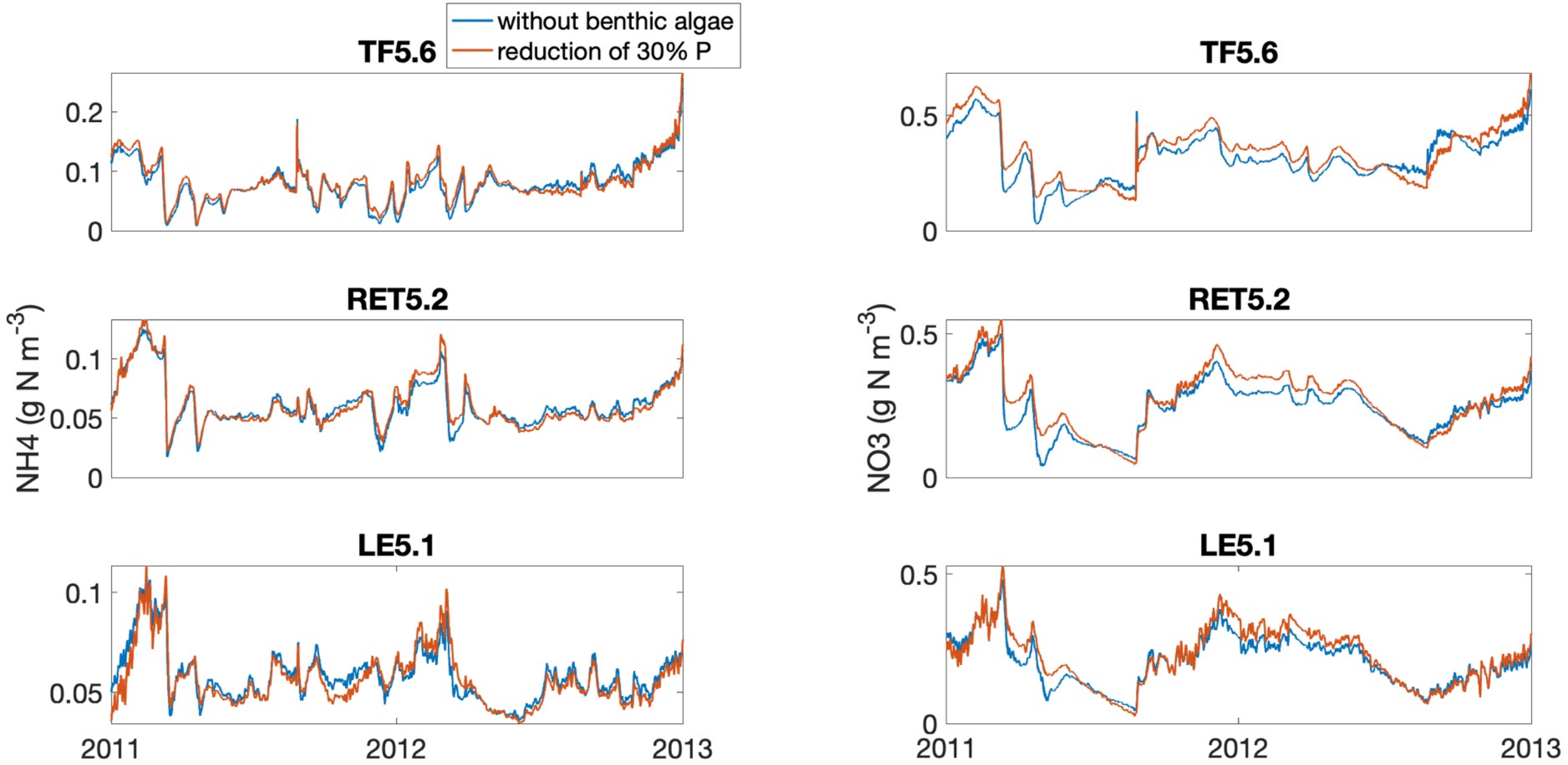
Without vs. with benthic algae



Base vs. P reduction (same trend with benthic algae)

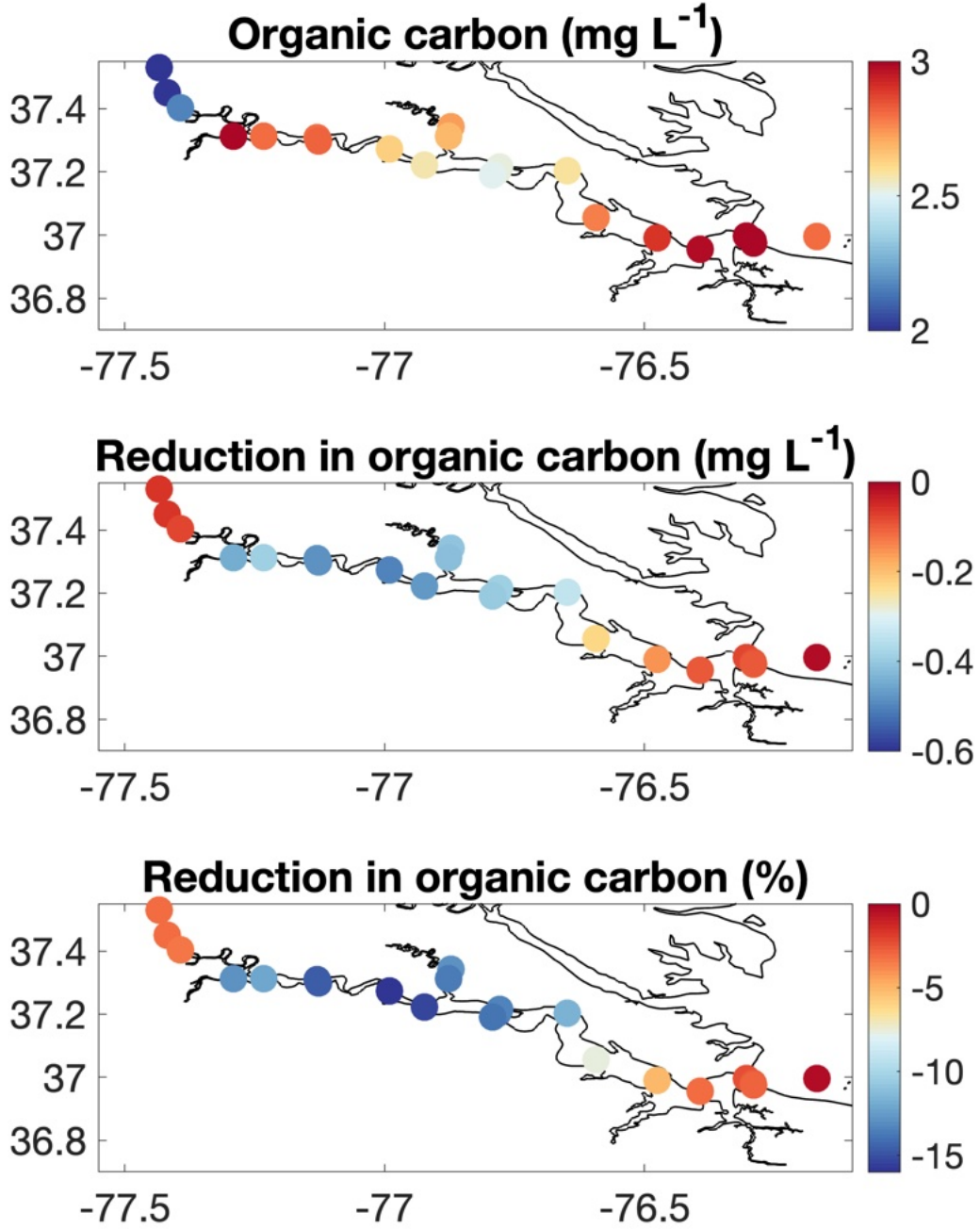


Base vs. P reduction (same trend with benthic algae)



Base vs. P reduction (same trend with benthic algae)

- Less production accumulates in the middle part of James River
- Mid-James response the largest production reduction upon the P reduction of P



Conclusion 2

- We used a James model to test the impacts of benthic algae.
  - Benthic algae tends to enhance nutrient recycling
  - Benthic algae tends to support the water column phytoplankton production
- We tested the responses of the aquatic system to P reduction (30%) w/ and w/o benthic algae.
  - James River production tends to decrease upon the P reduction
  - The response of primary production has spatial variations

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Virginia Institute of Marine Science

Questions?