Estuary Dissolved Oxygen Model Enhancements

Water Quality Advisory Committee Meeting

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Zoom

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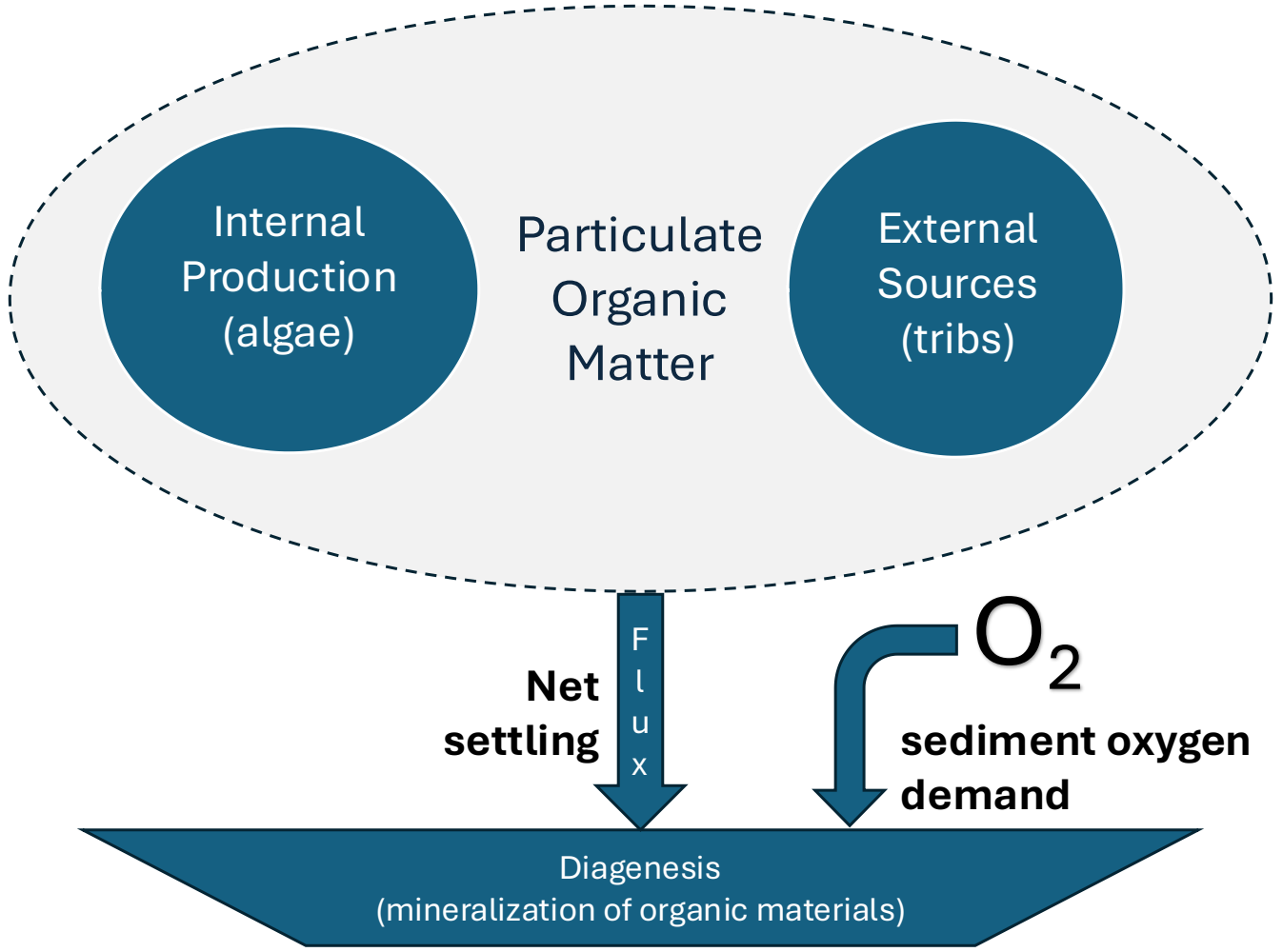
Model Improvement Goals

- Couple WQ model with sediment diagenesis
- Predict daily DO throughout frequency distribution



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How does DRBC intend to use the model?

- Long term predictions of average daily dissolved oxygen under various load scenarios
- Provide technical basis for States to implement new DO criteria
  - Criteria expressed as seasonal DO saturation percentile
  - Model needs to calculate the change in average daily DOSAT as a function of effluent ammonia, CBOD, and DO
- Gain insight into causes of SOD and whether it is expected to change in the future

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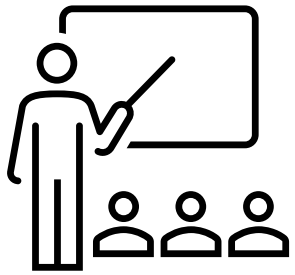
What have we changed?

How did we do?



What have we learned?

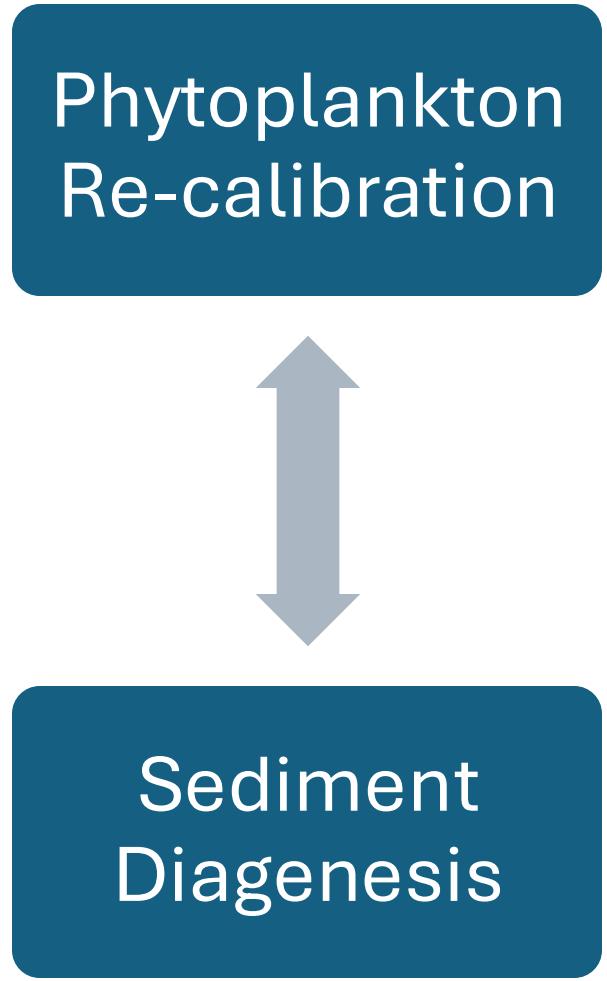
What Have We Changed?

Phyto Re-calibration

- Light Function
- Kinetics
- Salinity Boundary Conditions

Dynamic Sediment Diagenesis

- Updated POC loads
- Kinetics



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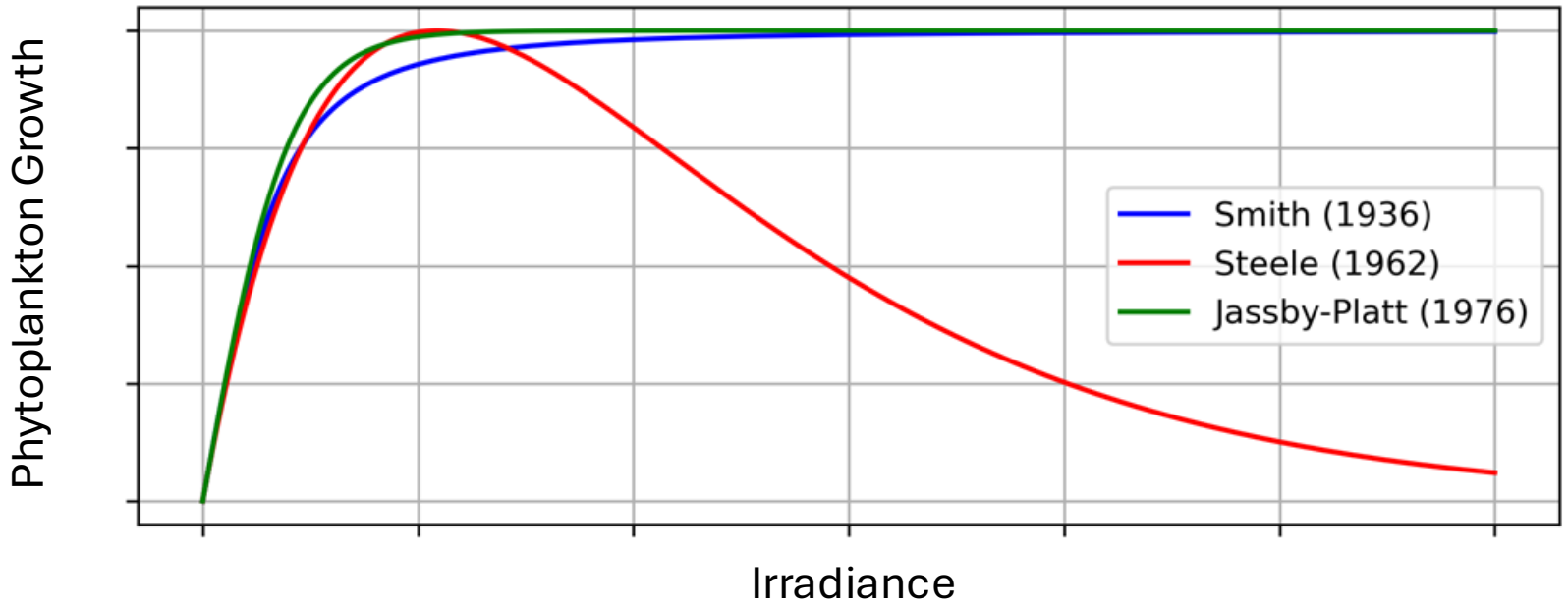
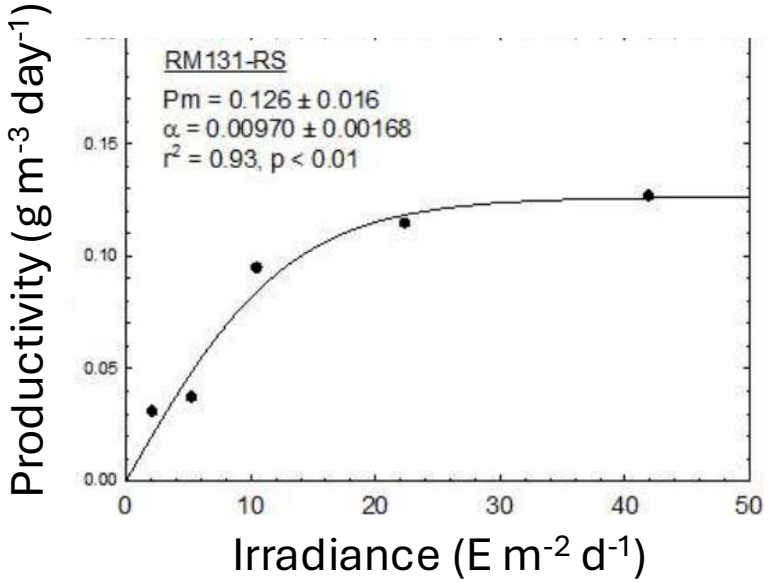
The model better captures phytoplankton response to light

- **Switch from Steele to Smith Light Fxn (used in CBM)**





According to Fisher and Gustafson (2019; 2020), freshwater phyto in the tidal river do not exhibit signs of photoinhibition, likely because light, not nutrients, is the major limitation to growth

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Phytoplankton kinetics were derived from data

Growth Kinetics

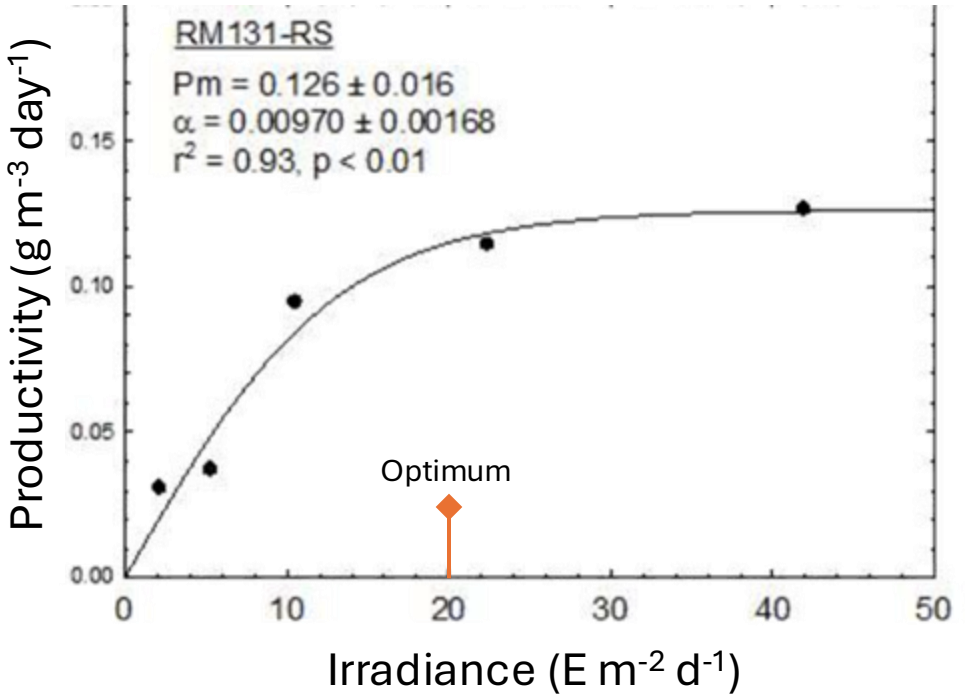
- Adjusted optimal light, photosynthetic rate, optimal temperature, silica limitation

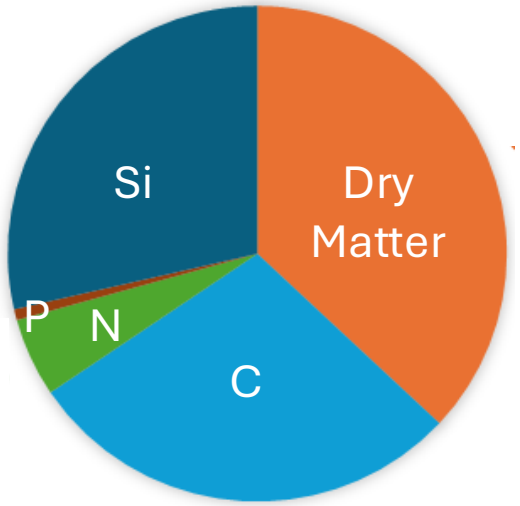
Loss Kinetics

- Adjusted death and respiration rates, along with salinity toxicity

Silica & Salinity Representation

- Refined diatom stoichiometry
- Correct Si BCs from SiO_2 to Si
- Update ocean nutrient BCs
- Update Salinity BCs





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The model now more accurately captures salinity dynamics upstream

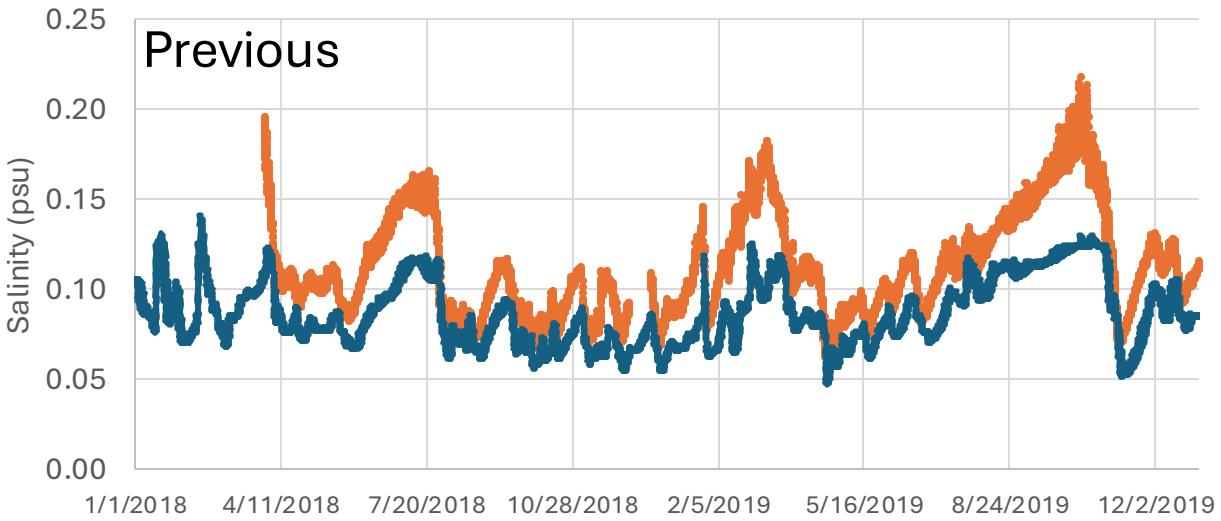
Salinity from point dischargers

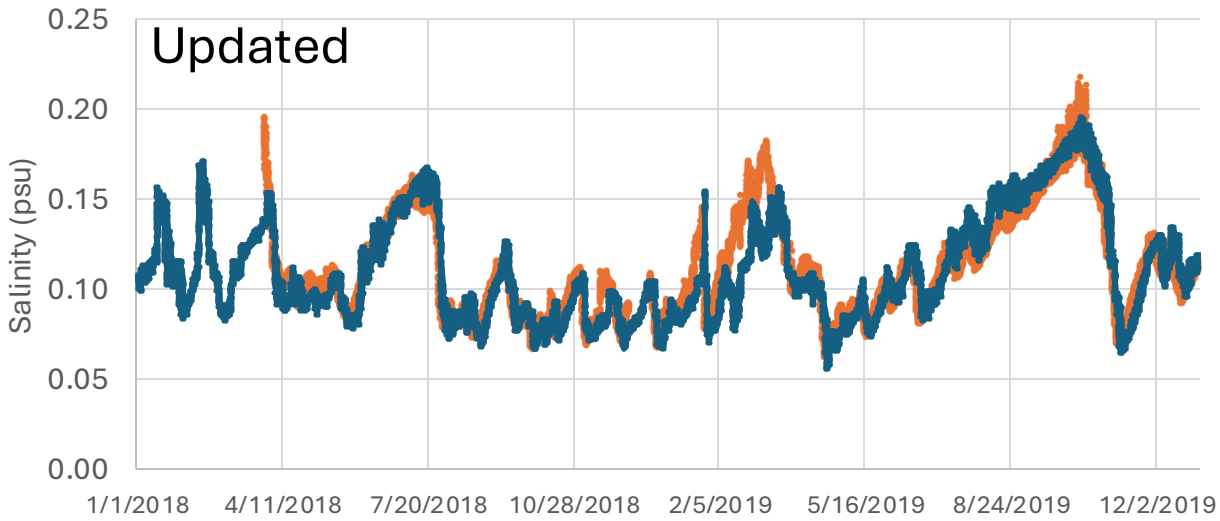
- Previous: zero
- Updated: spatial and temporal constants

Salinity at tributary boundaries

- Previous: Use Trenton/Schuylkill
- Updated: Tribs U/S of Schuylkill use DRBC data

Ben Franklin Bridge (RM 100.1)

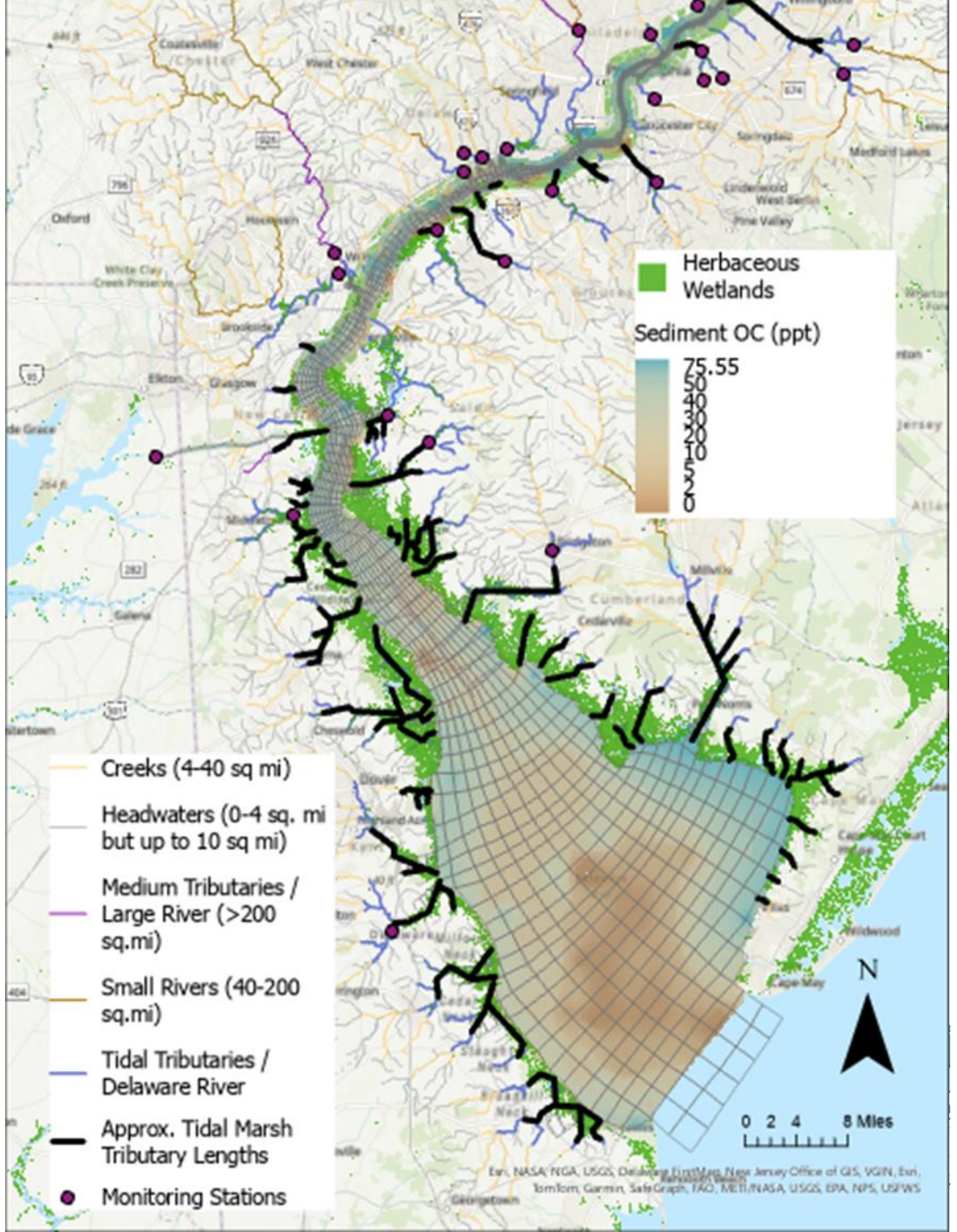




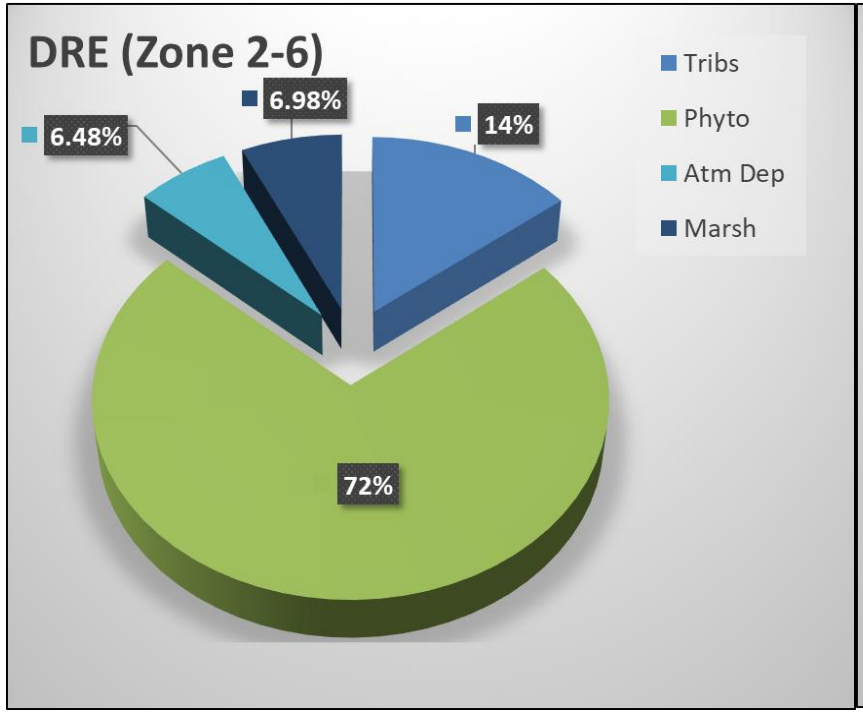
Salinity - Data Salinity - Model

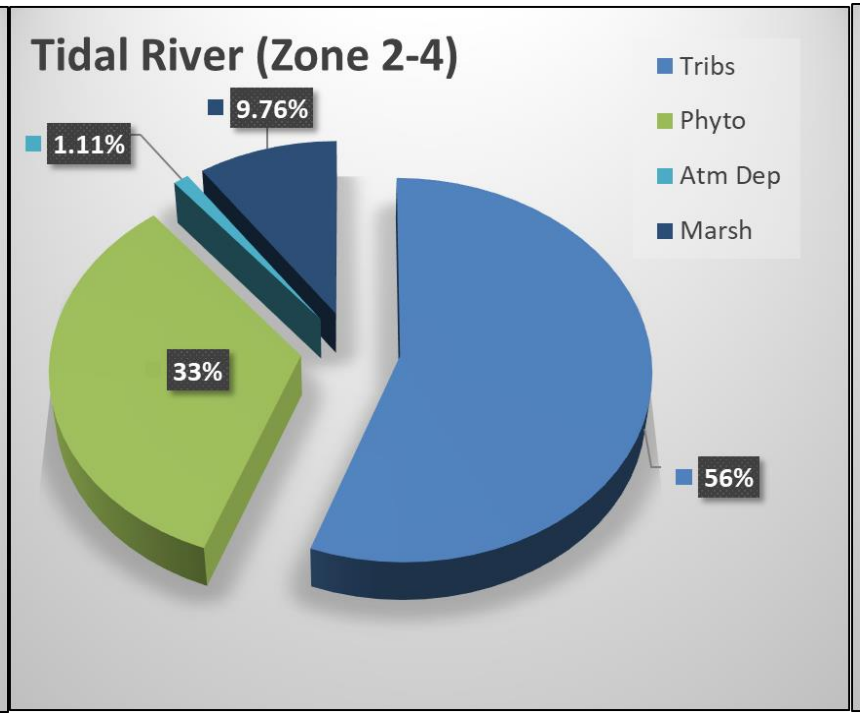
DRBC developed the first comprehensive budget for carbon in the estuary

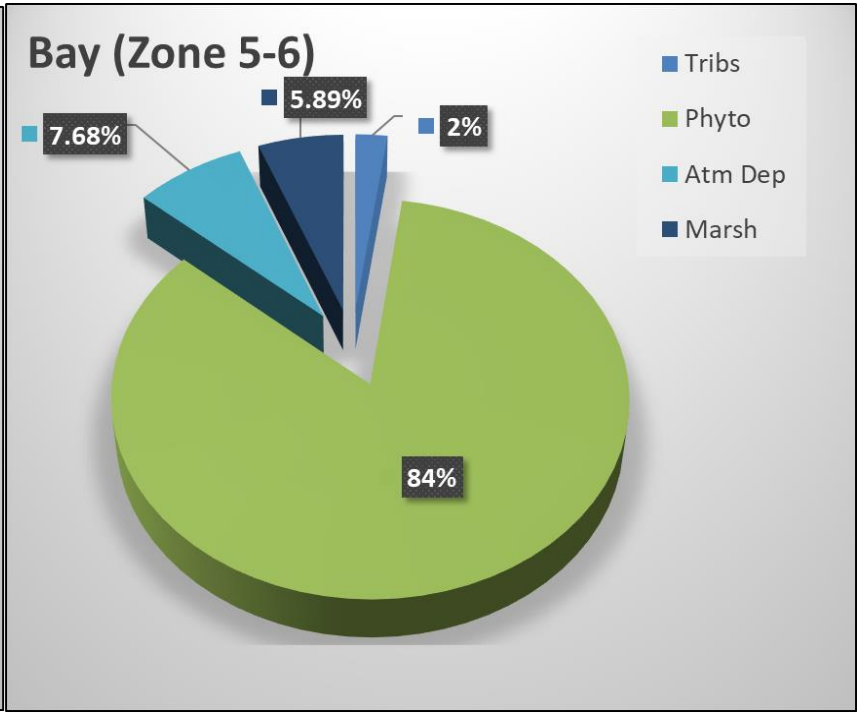
- Updated Tributary Loads
- Marsh Organic Loads
- Atmospheric Deposition
- Internal Loads



The origin of estuarine carbon varies by WQ Zone







In the bay, most POC is from internal algal production (due to the size of the bay!)

In the tidal river, external production is the primary source of POC

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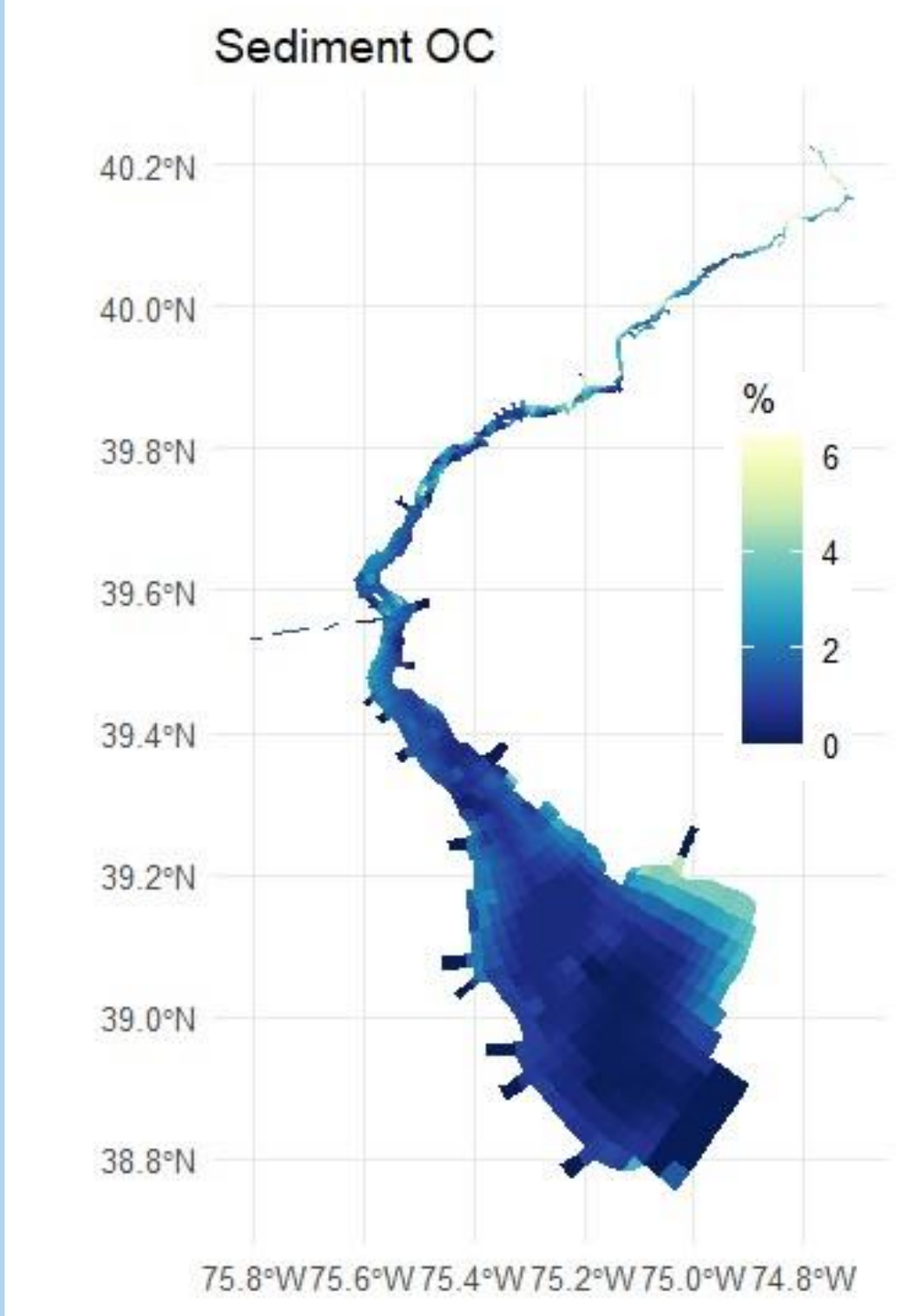
DRBC coupled sediment diagenesis with its water column model

- Implemented Di Toro's diagenesis model in WASP
- Developed spatially varying net settling rates for POM

TOC (%wt)	Net Settling Velocity	# Segments
0 – 1%	0.125 m/d	448
1 – 2%	0.25 m/d	583
2 – 3%	0.5 m/d	431
> 3%	1.0 m/d	414

- Performed relatively minor calibration of sediment diagenesis model
  - Calibrated P Sorption
  - Reset labile and recalcitrant fractions of settled POC



How did we do?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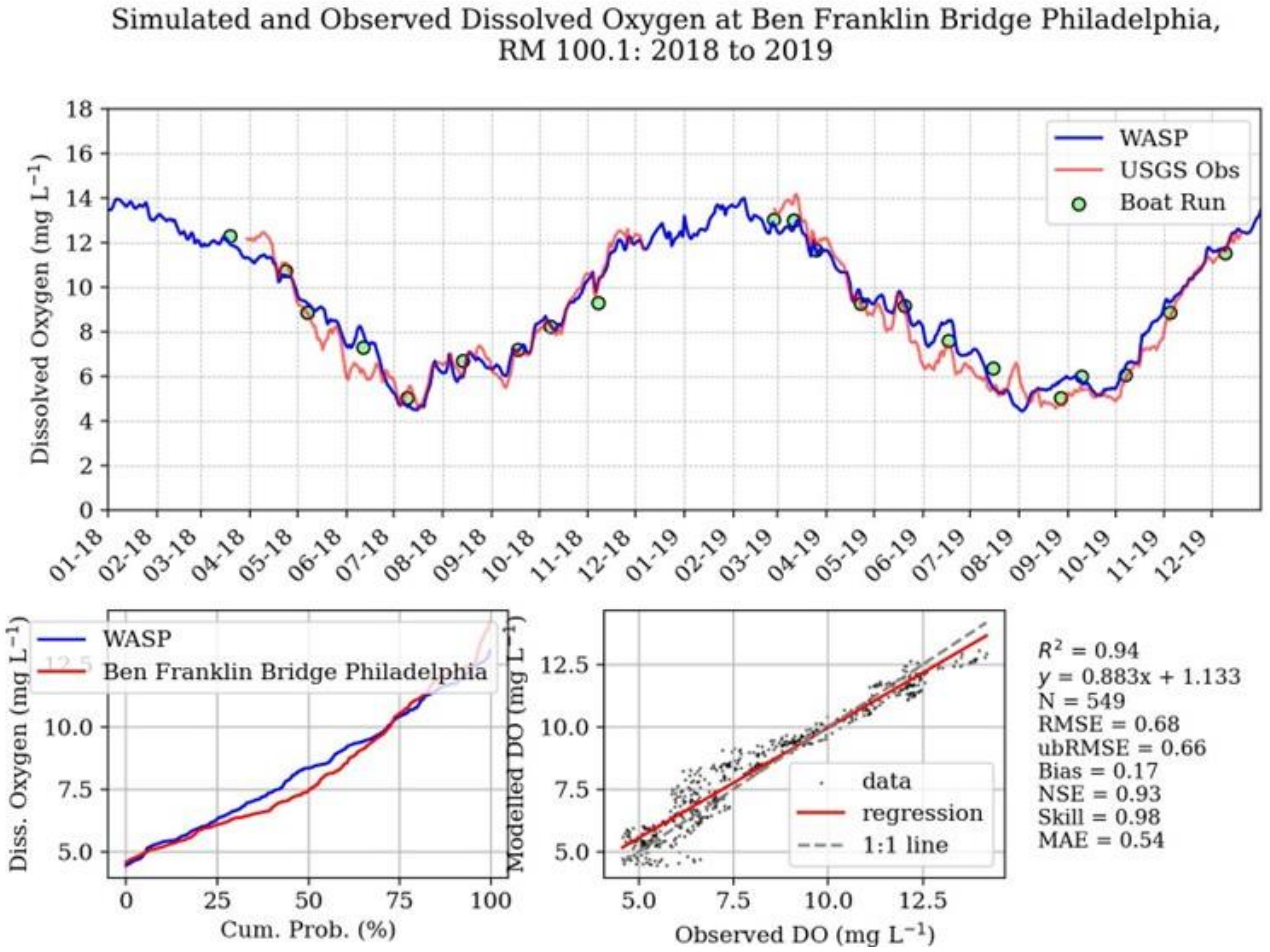
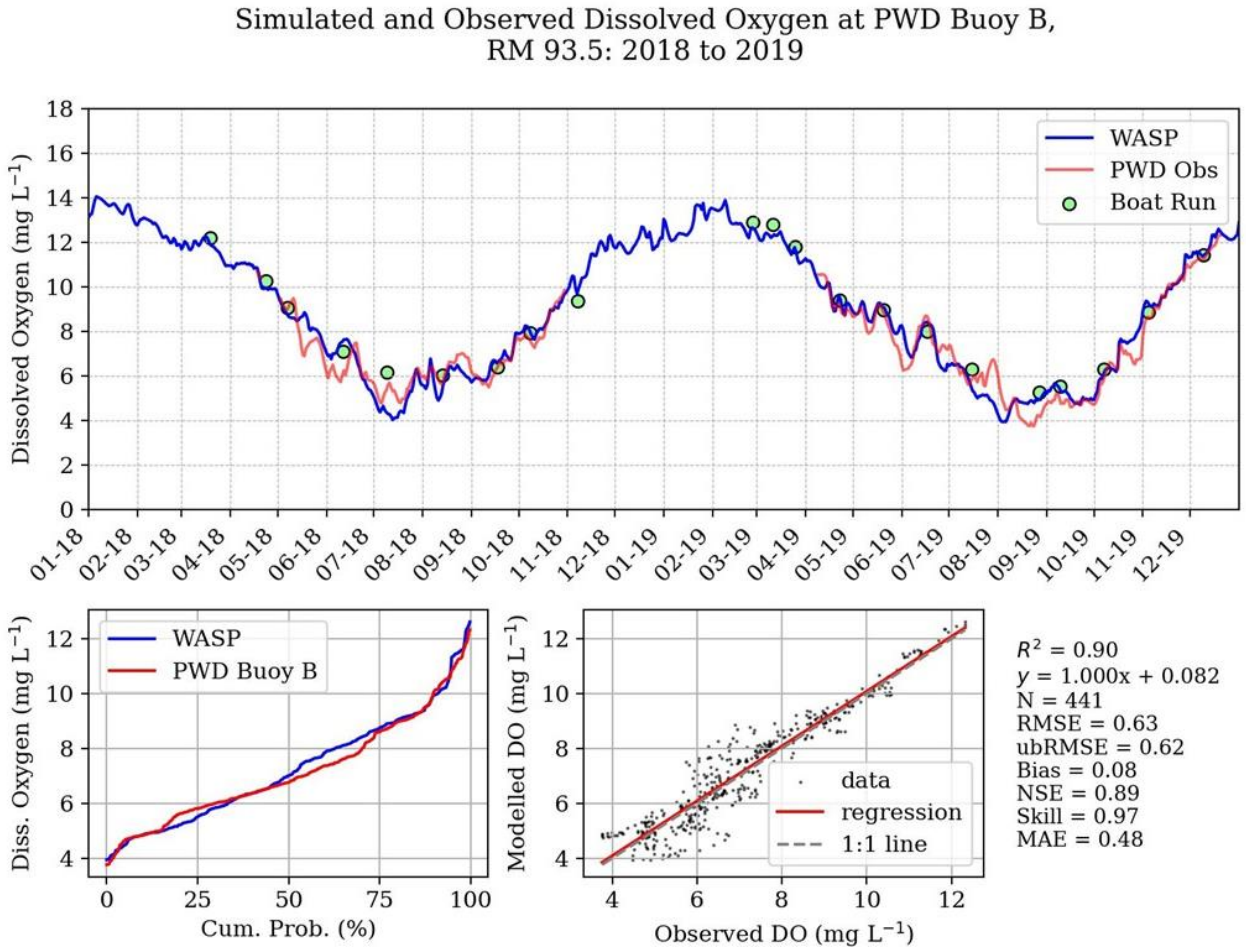
The model remains highly accurate for DO prediction





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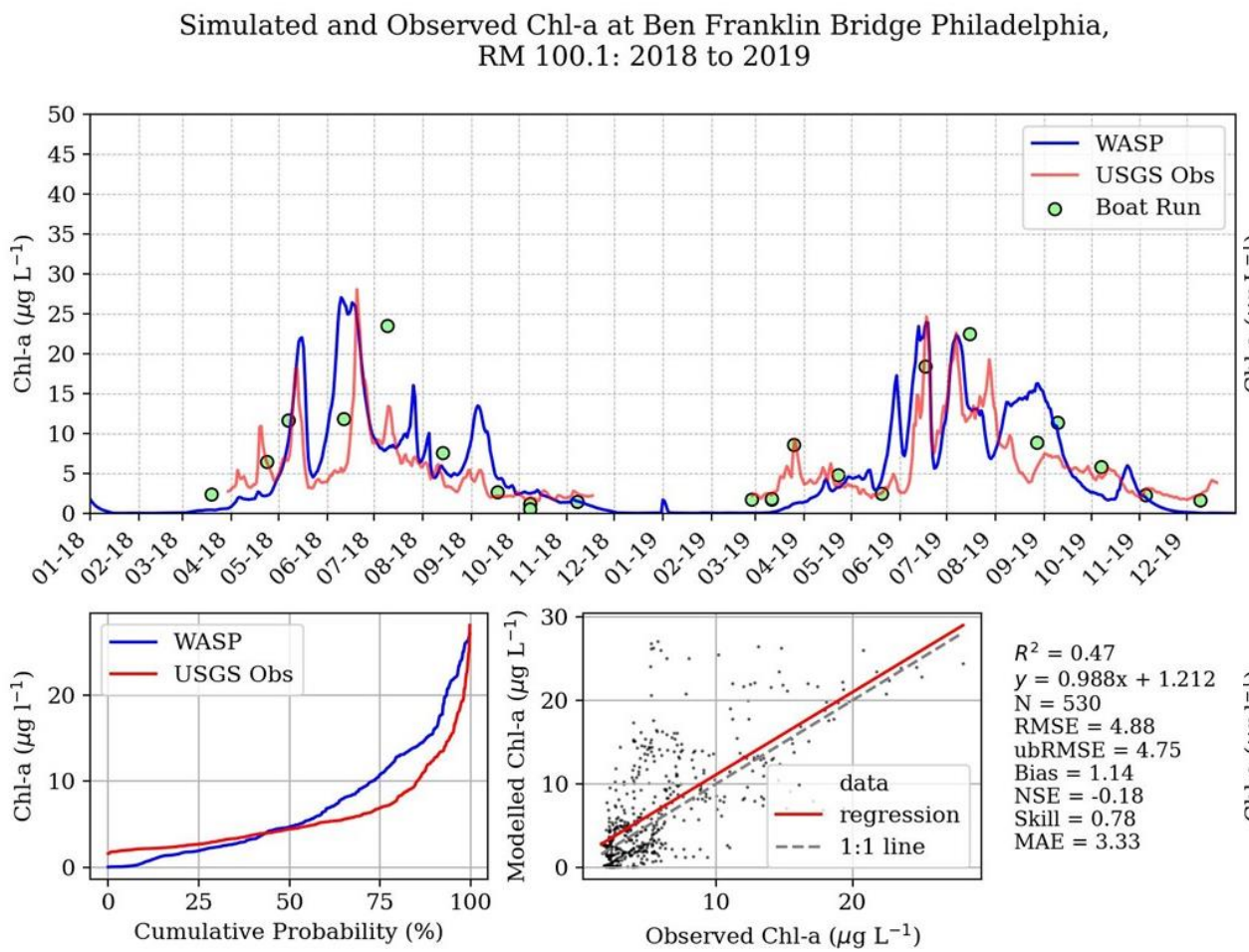
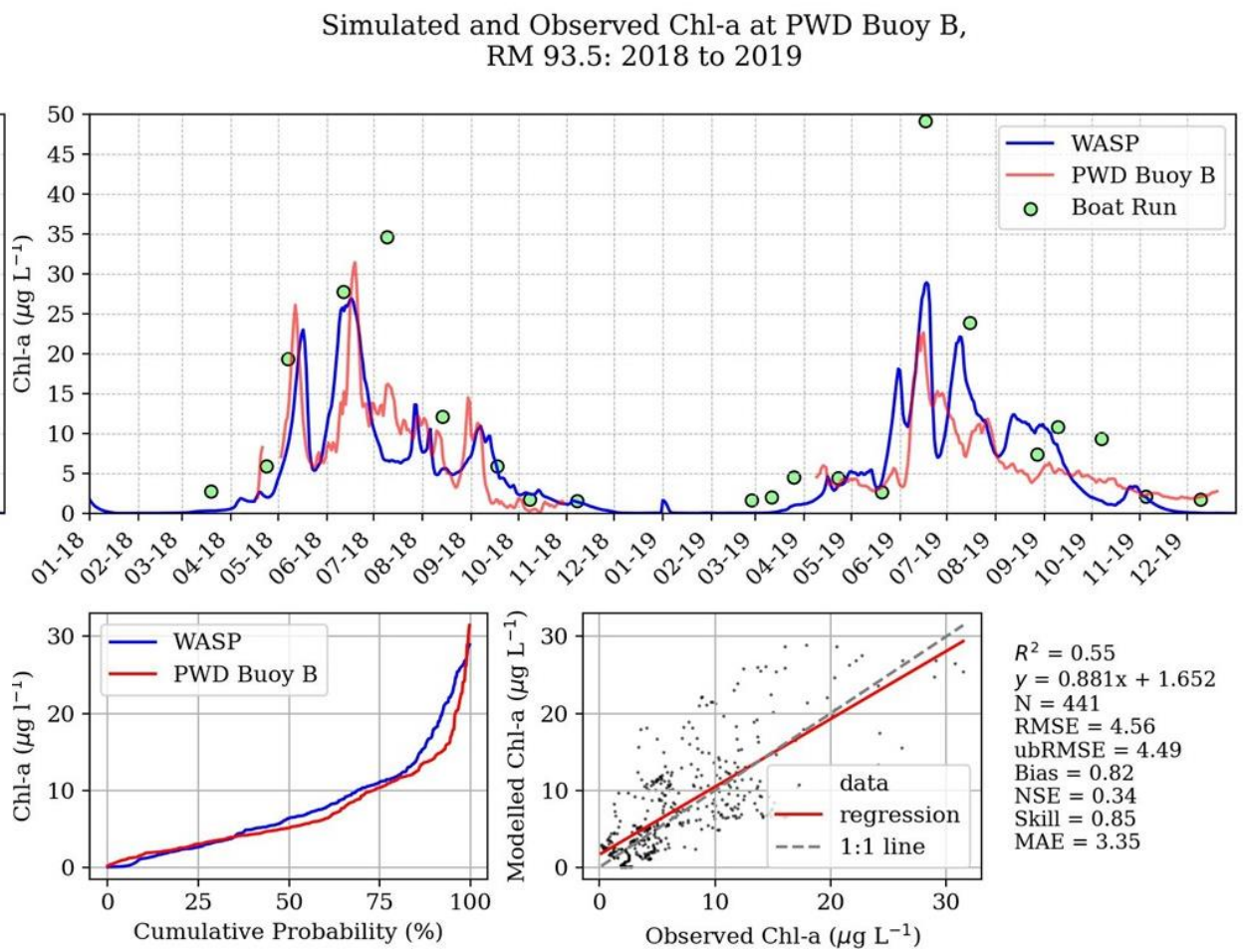
Phytoplankton predictions are vastly improved





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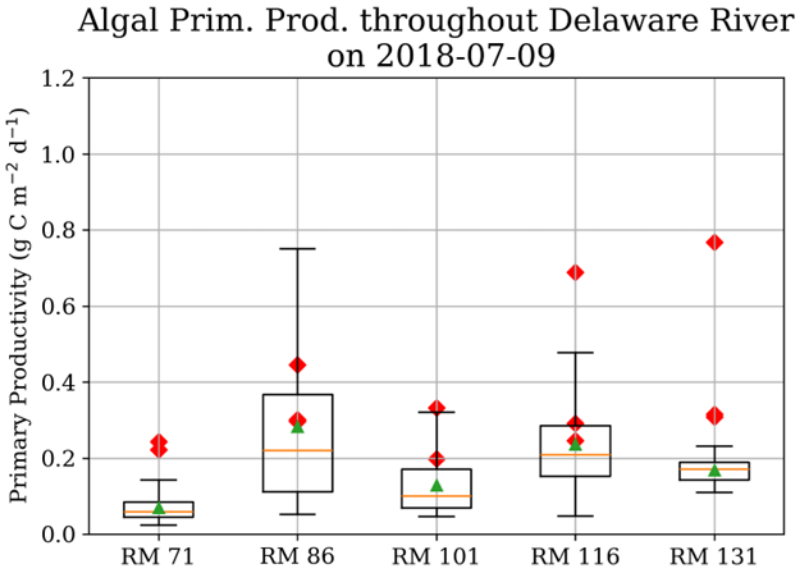
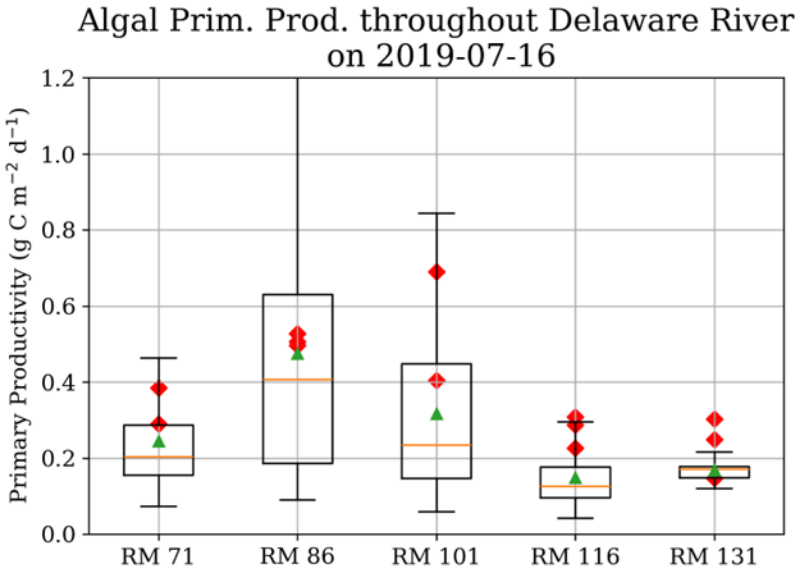
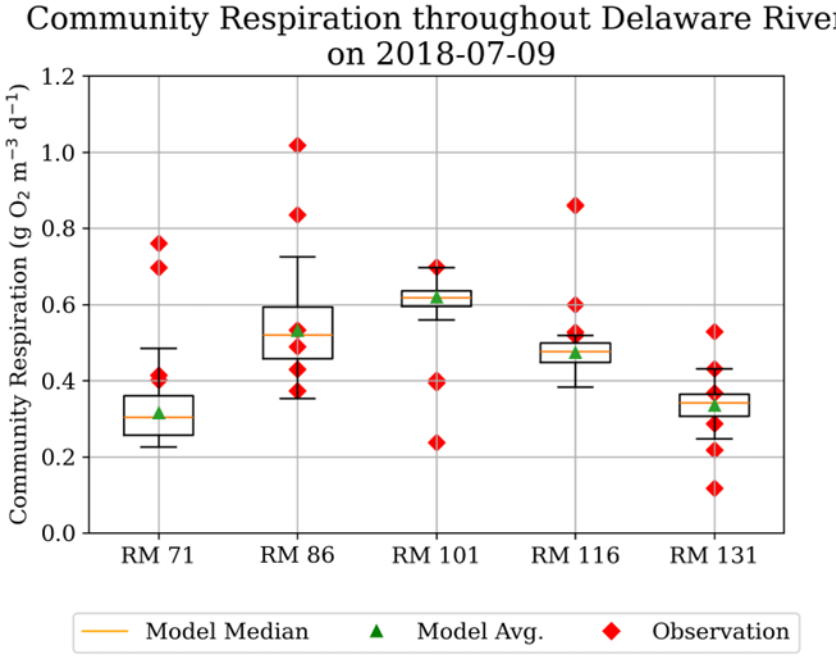
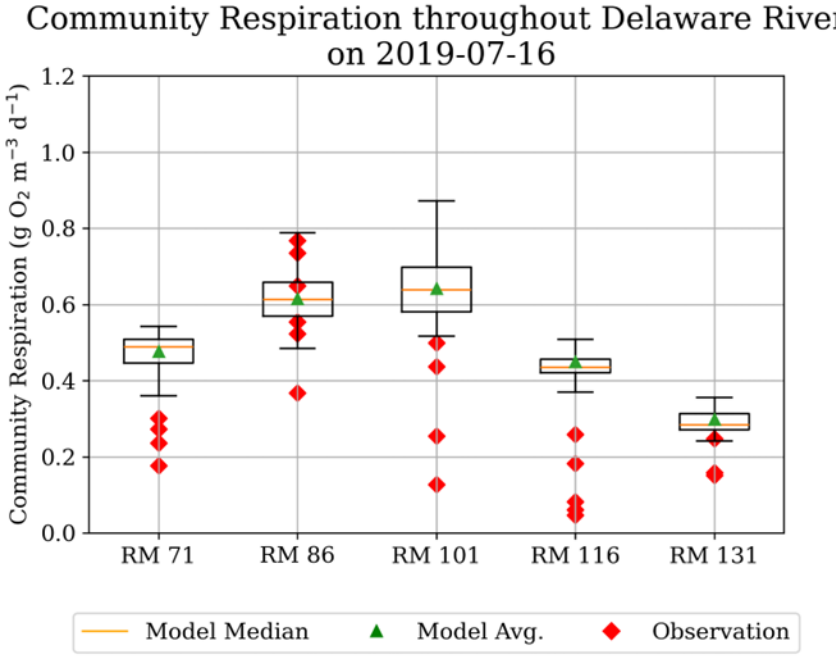
Algae-mediated DO fluxes are the correct magnitude

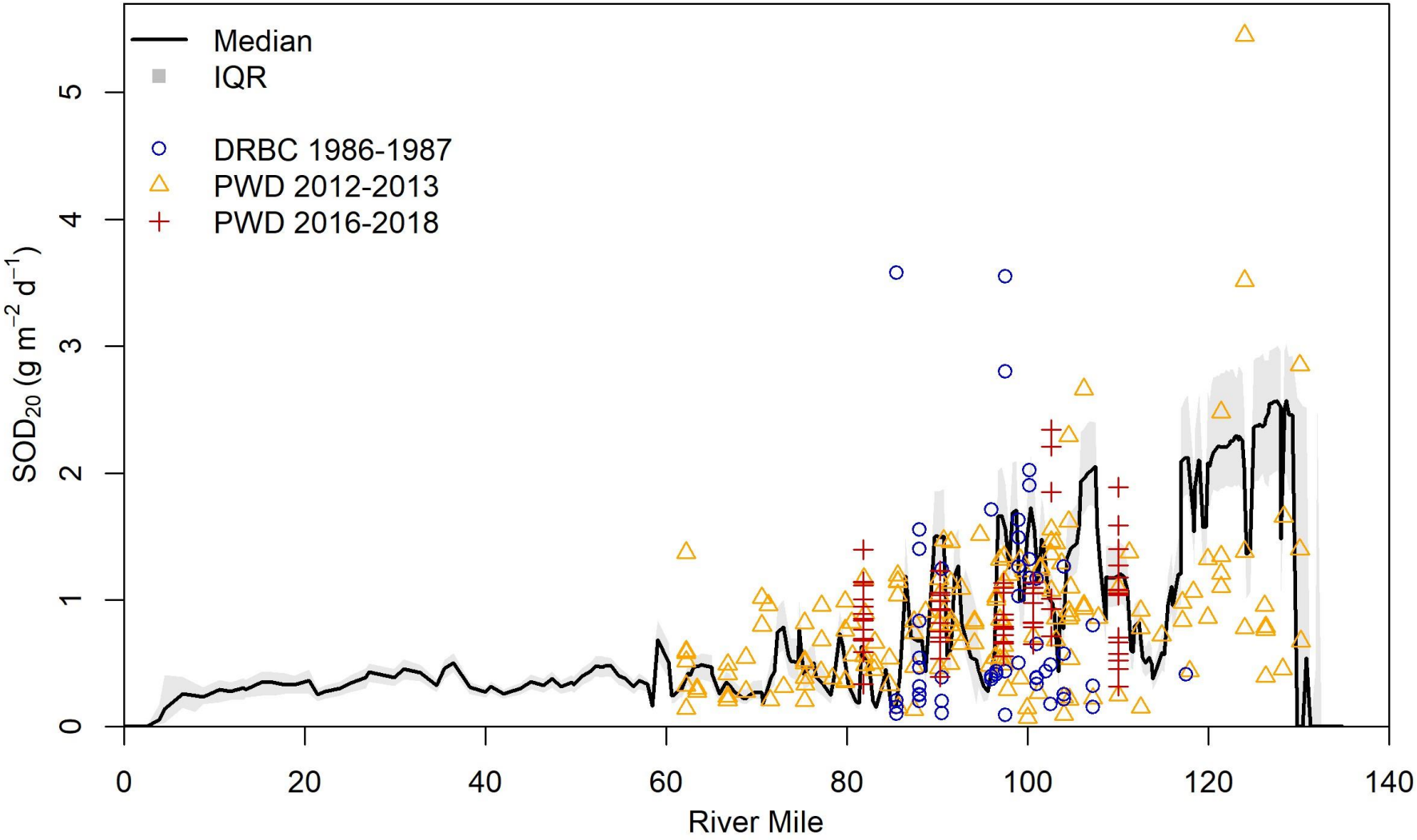








Spatial prediction of sediment oxygen demand is corroborated by previous surveys



Median Apr – Oct
(match PWD)

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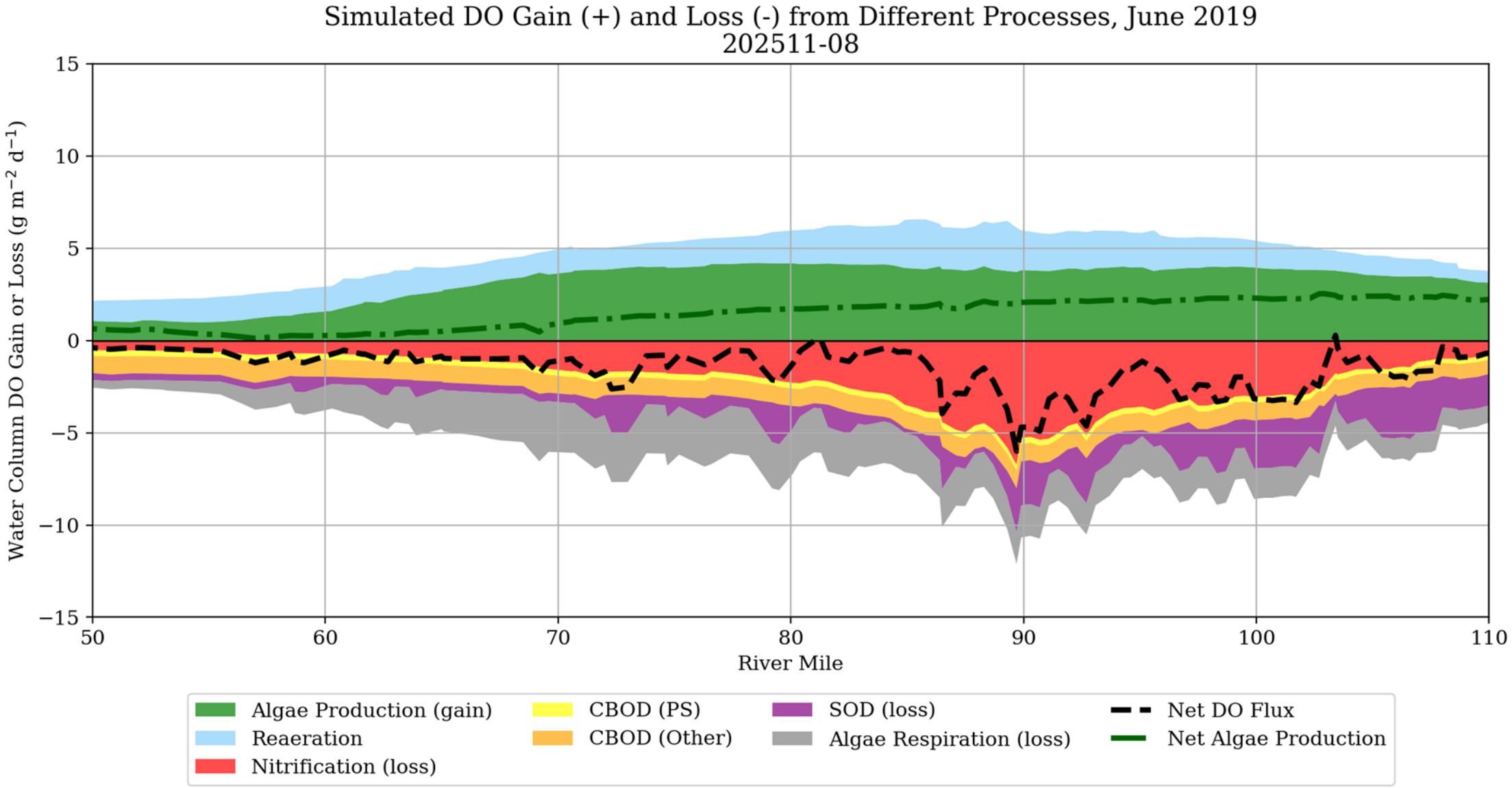
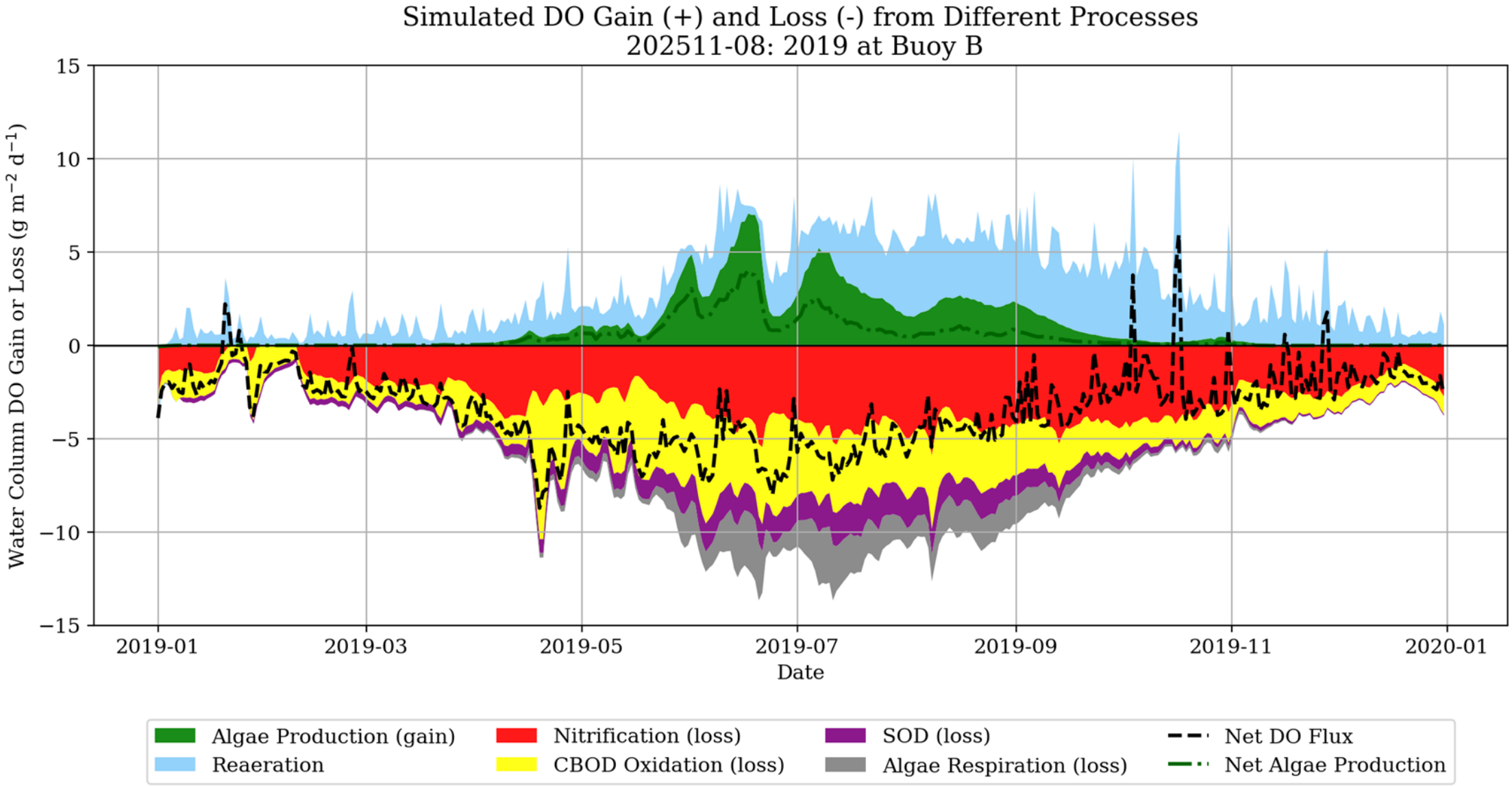
Nitrification is the key to mitigate the DO sag



DO fluxes vary seasonally as well as spatially



What have we learned about sediment impacts on dissolved oxygen?

- Observed levels of SOD and benthic fluxes can be explained by better characterization of POC loads
- POC loads driven by
  - Tributaries (including DR @Trenton)
  - Phytoplankton
  - Marshes
- Future changes to sediment fluxes expected to be driven mostly by changes in DO and ammonia gradients
  - SOD changes only expected to be substantial if POC loads change significantly

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Remaining Steps

1. Finalize calibration of freshwater phyto
   A. Controlling overprediction of Chl and DO in Zone 2 (above RM 108)
2. Coarse calibration of phyto in the bay

2025

3. MEP approval of model at next WQAC
4. Document updated model calibration
5. Apply model to wasteload allocation study

2026

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Questions?

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