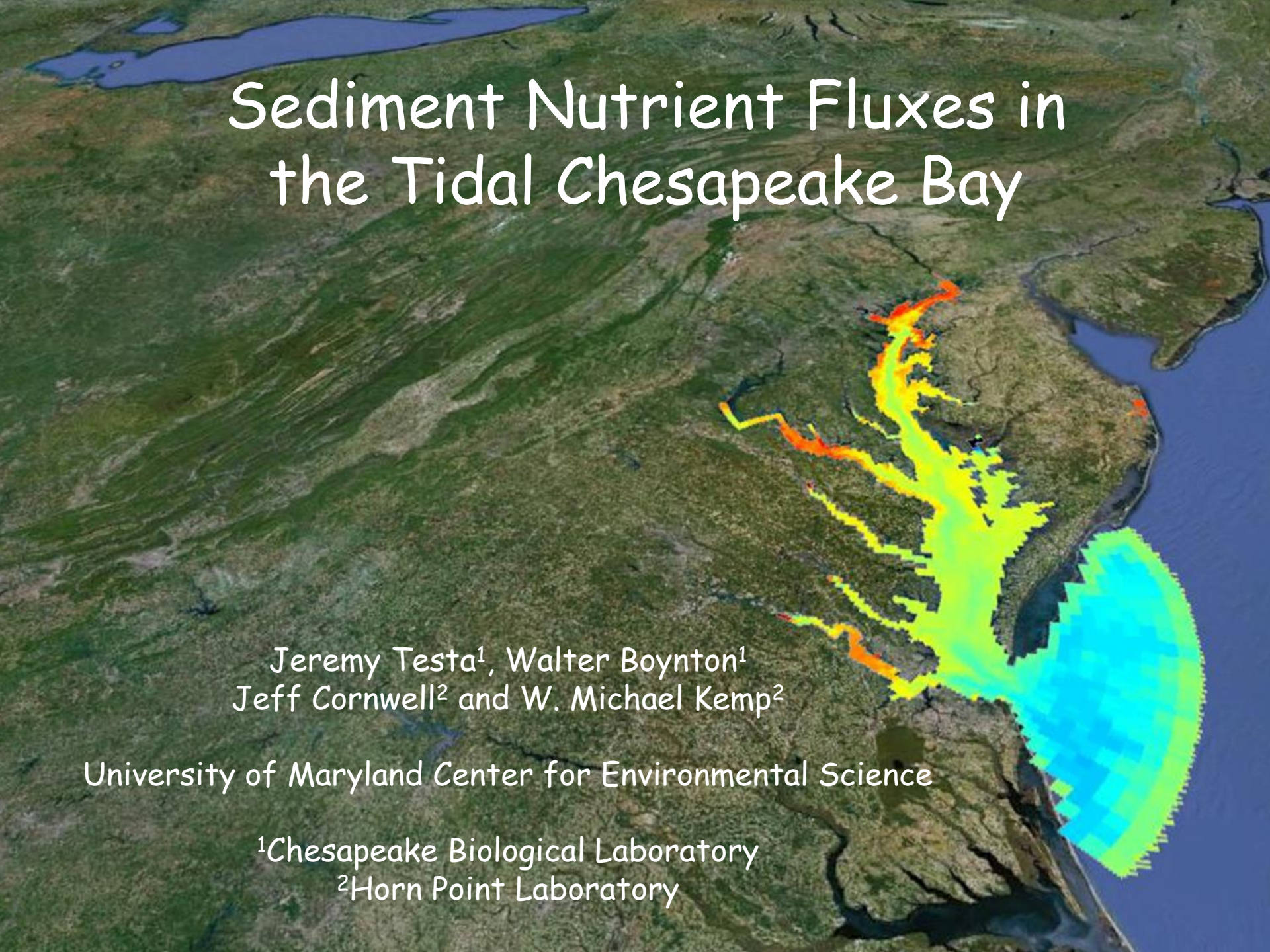
# Sediment Nutrient Fluxes in the Tidal Chesapeake Bay



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[1]Chesapeake Biological Laboratory
[2]Horn Point Laboratory

# Motivating Questions

(1) What are the spatial patterns and controls on sediment-water nutrient and oxygen fluxes in Chesapeake Bay?

(2) What are the implications of these controls for the potential water-column impacts of reservoir-derived particulate material flux to Chesapeake Bay?

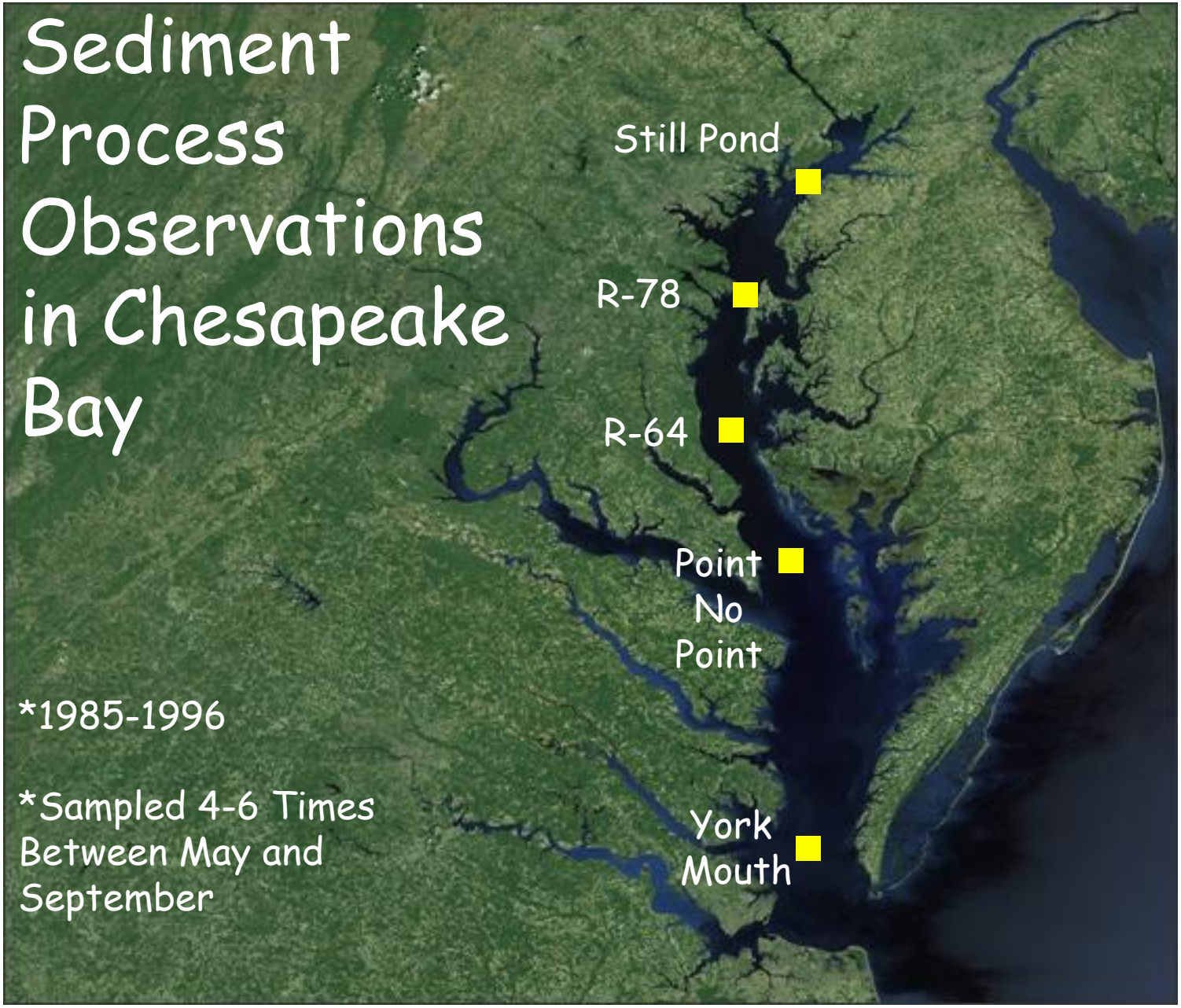
# Some Controlling Mechanisms

(1) Deposition of labile organic material to sediment (Carbon, Nitrogen and Phosphorus)

(2) Oxygen availability in the overlying-water (Nitrogen and Phosphorus)

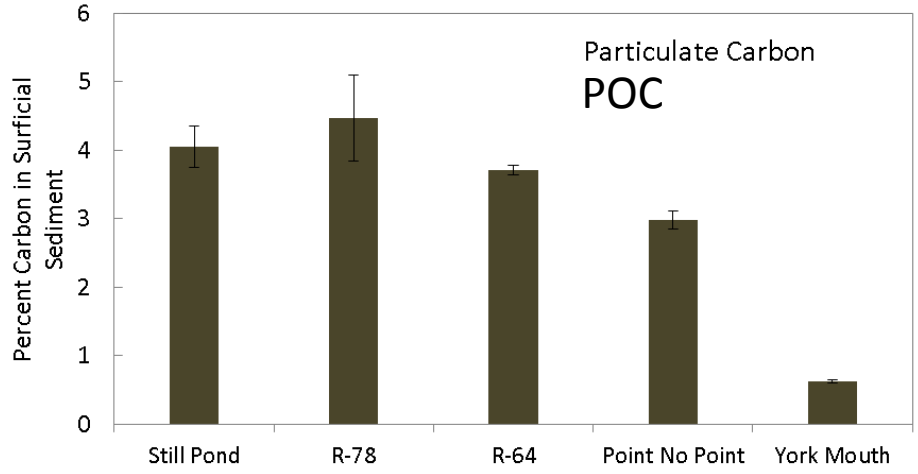
(3) Iron-Sulfur Interactions along a salinity gradient (Phosphorus)

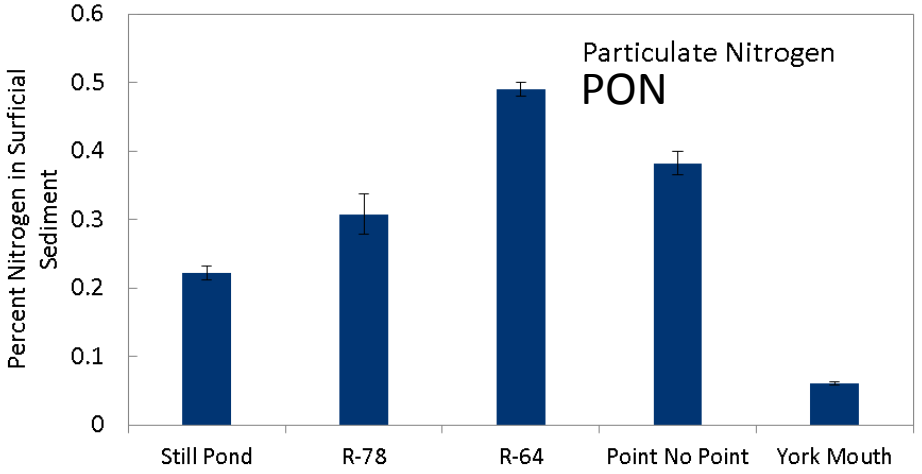
(4) Iron-Phosphorus Interactions along a salinity gradient (Phosphorus)

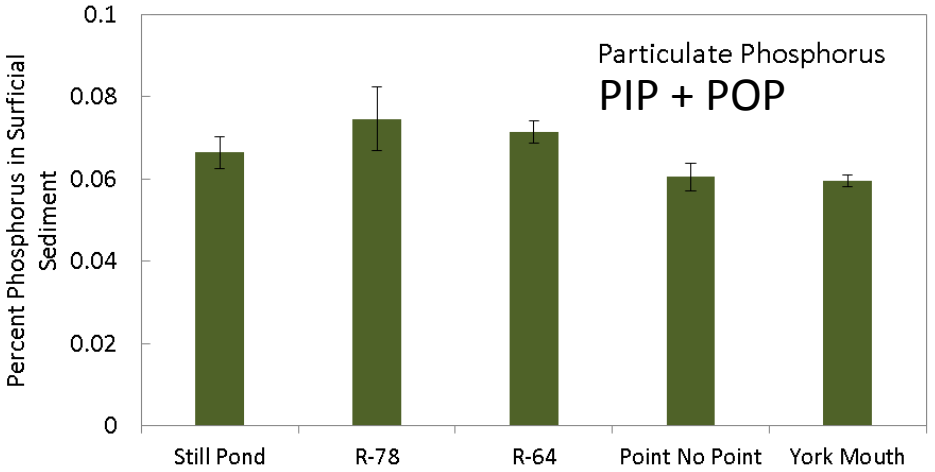

Sediment Process Observations in Chesapeake Bay
Still Pond
R-78
R-64
Point No Point
York Mouth
*1985-1996
*Sampled 4-6 Times Between May and September

# Spatial Variation in Sediment Nutrient Content

- Particulate Carbon peaks in upper-bay
- Particulate nitrogen peaks in mid-Bay
- Particulate P has less spatial variation



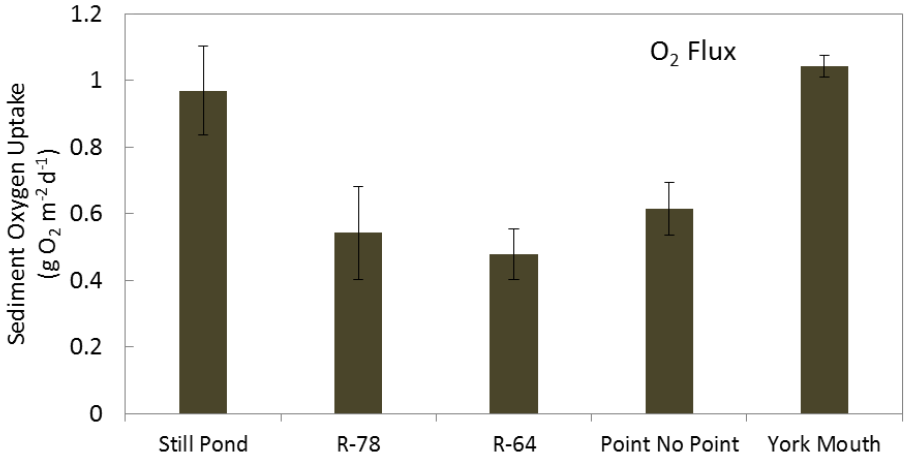



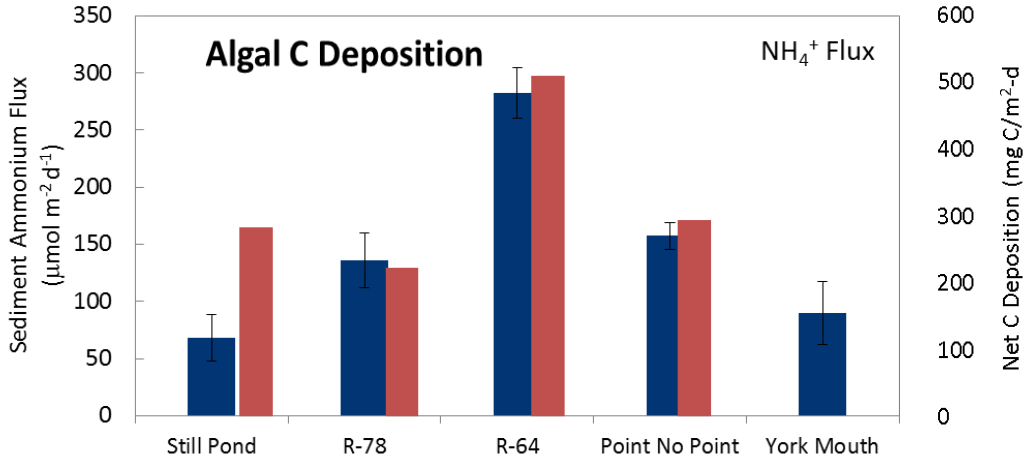

Cowan and Boynton 1996

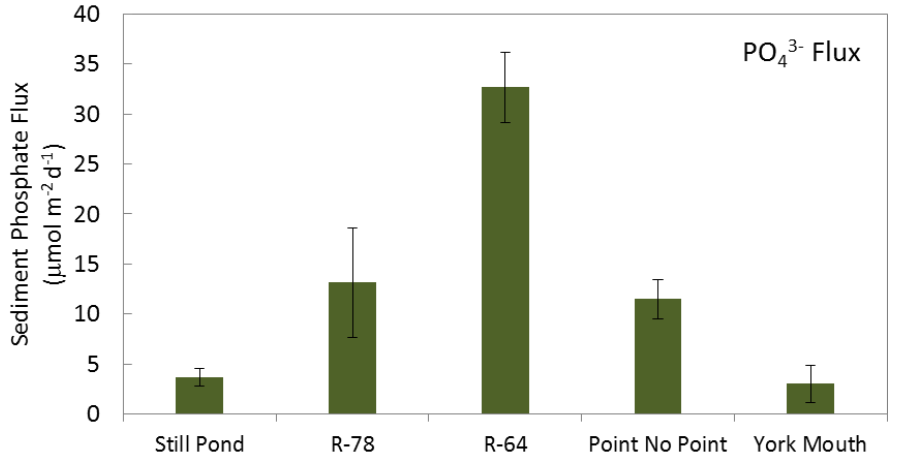
Data from Walter Boynton, published in Cowan and Boynton 1996 (and elsewhere)

# Spatial Variation in Sediment-Water Fluxes

- Sediment $O_2$ Uptake lowest in region between Bay Bridge and Patuxent
- $NH_4^+$ and $PO_4^{3-}$ fluxes peak in mid-Bay

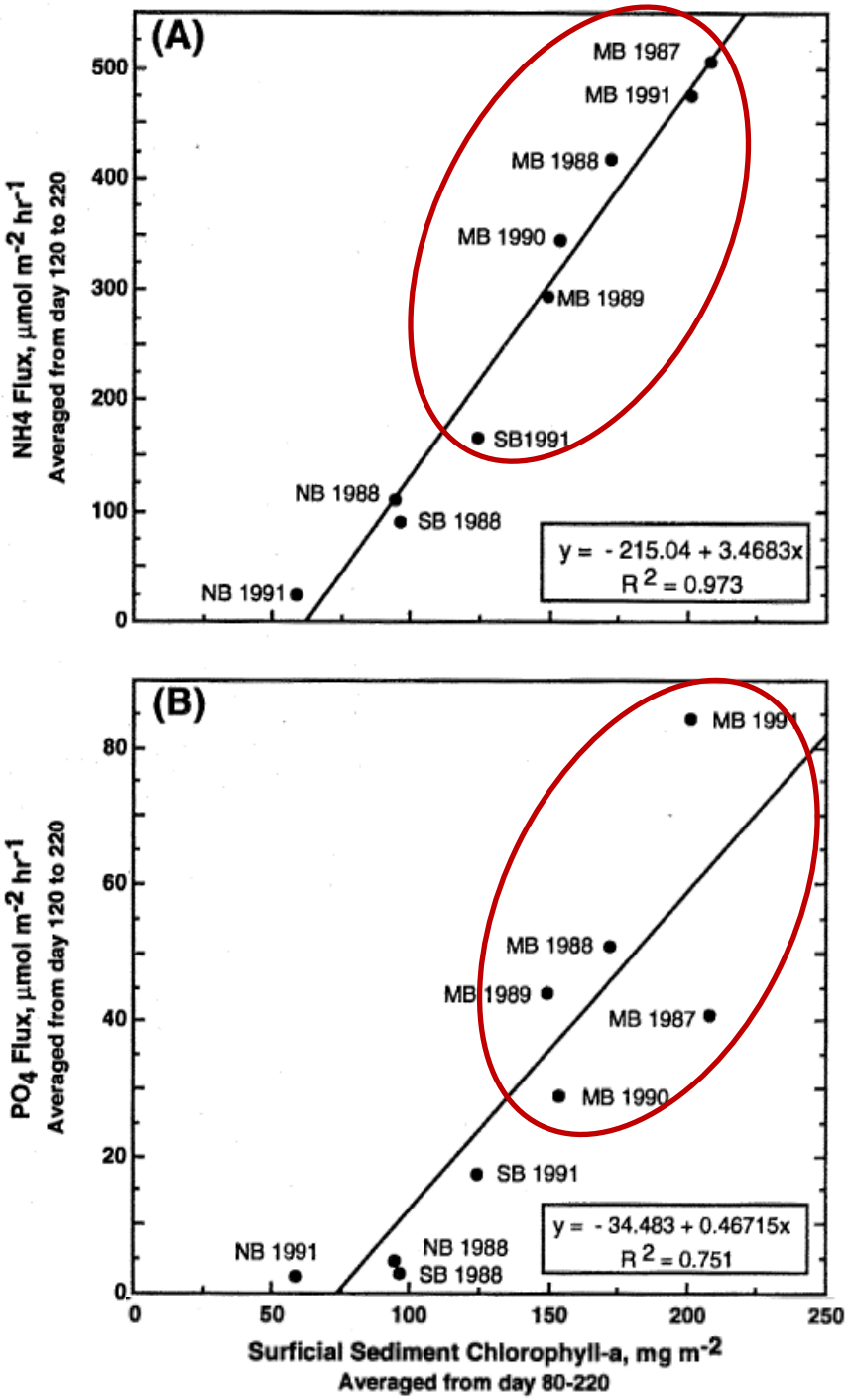



Data from Testa et al. (2013) and Walter Boynton, published in Cowan and Boynton 1996 (and elsewhere)

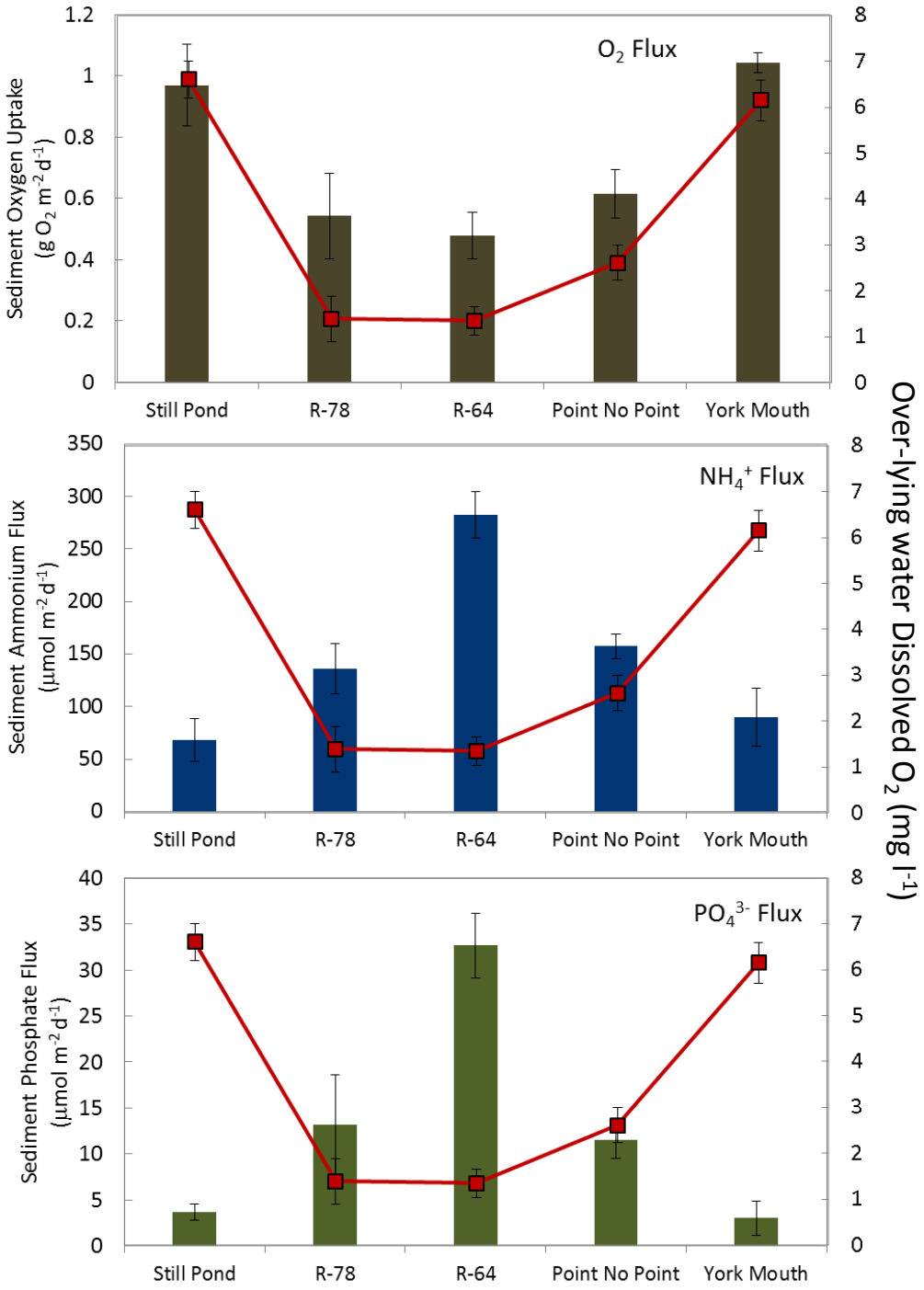
# Sediment-Water Fluxes Respond to Labile Organic Matter



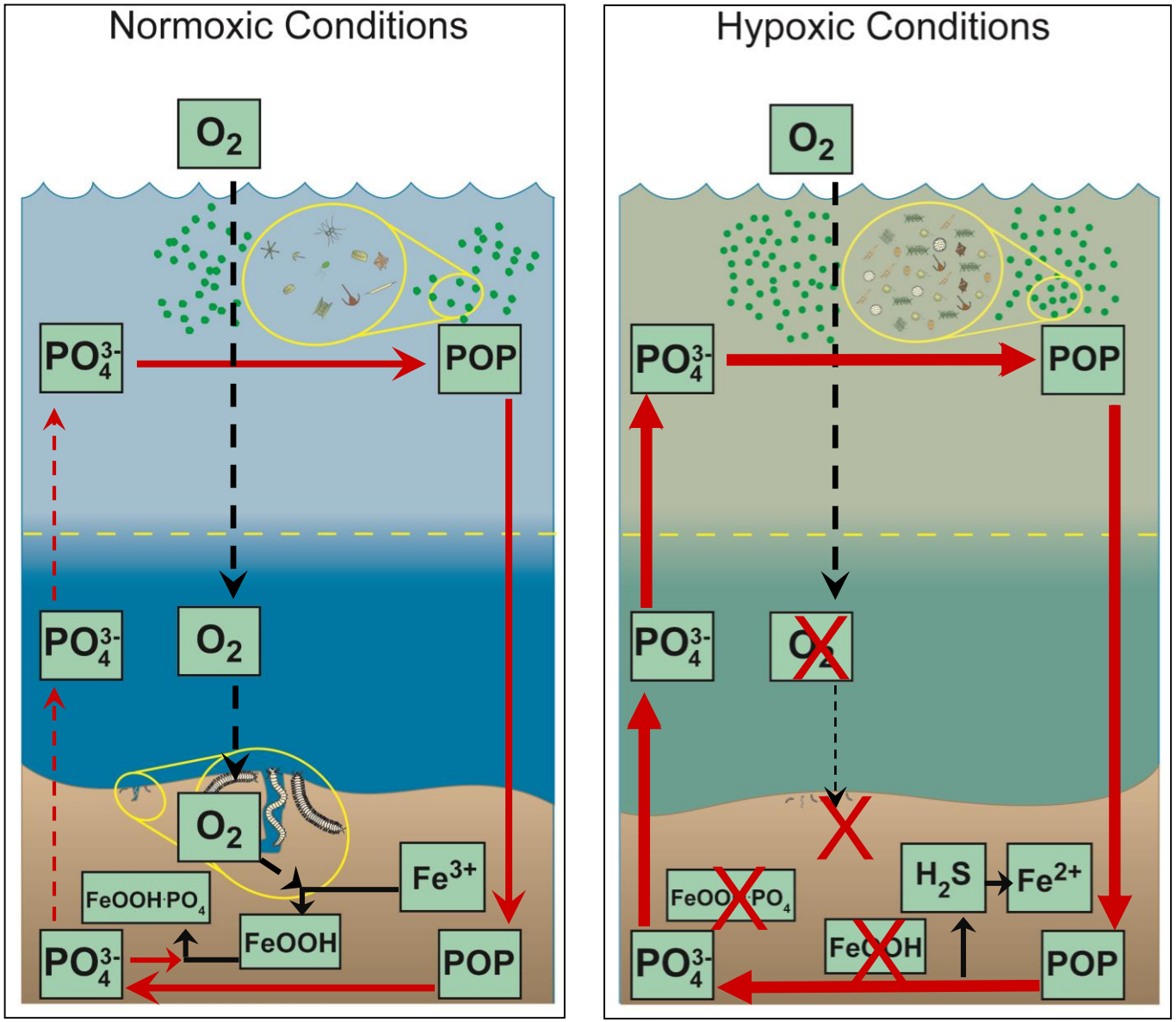

Cowan and Boynton 1996

# Spatial Variation in Sediment-Water Fluxes

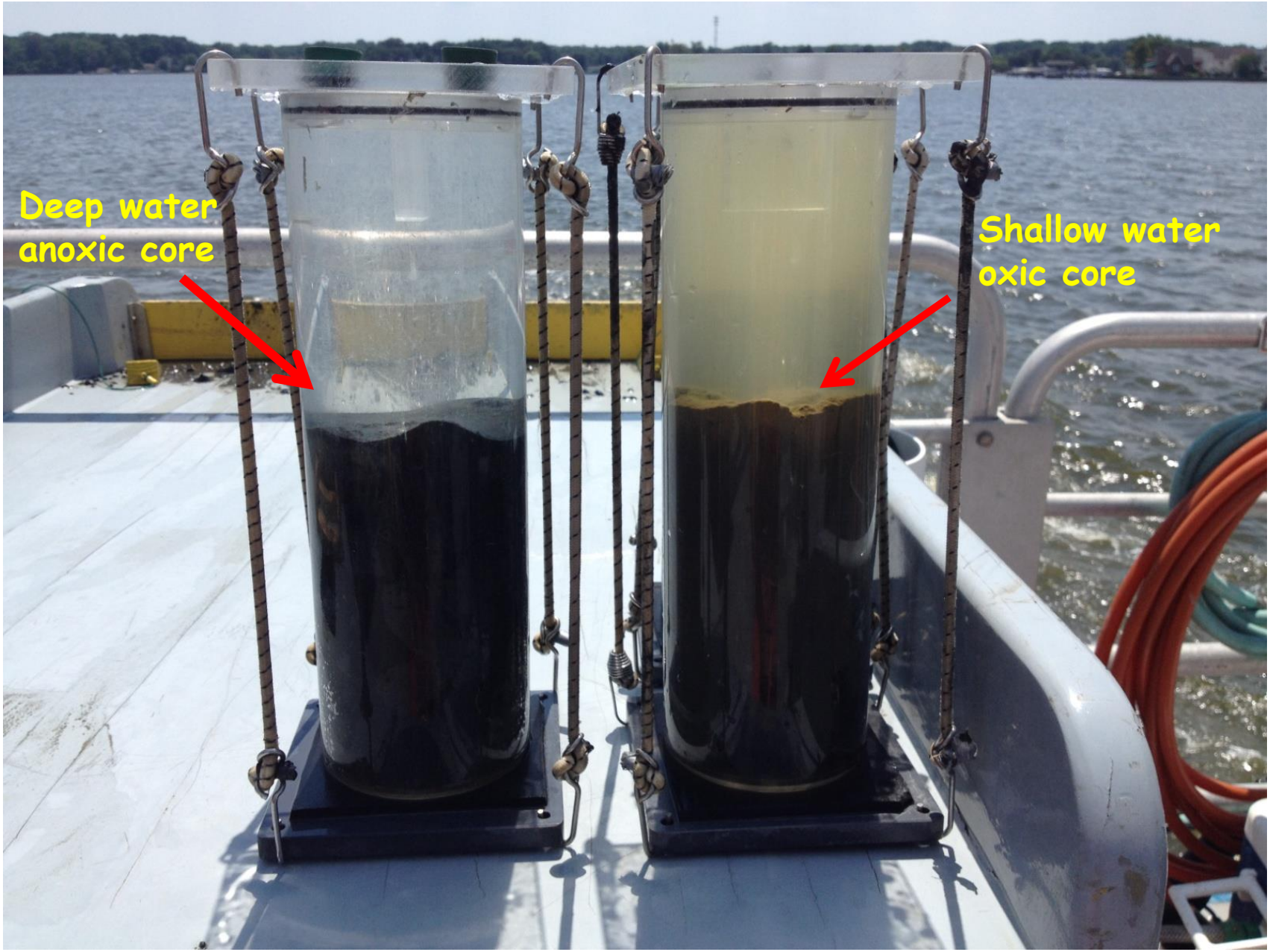
- Sediment $O_2$ Uptake lowest in region between Bay Bridge and Patuxent
- $NH_4^+$ and $PO_4^{3-}$ fluxes peak in mid-Bay
- Bottom-water $O_2$ low where N and P fluxes peak

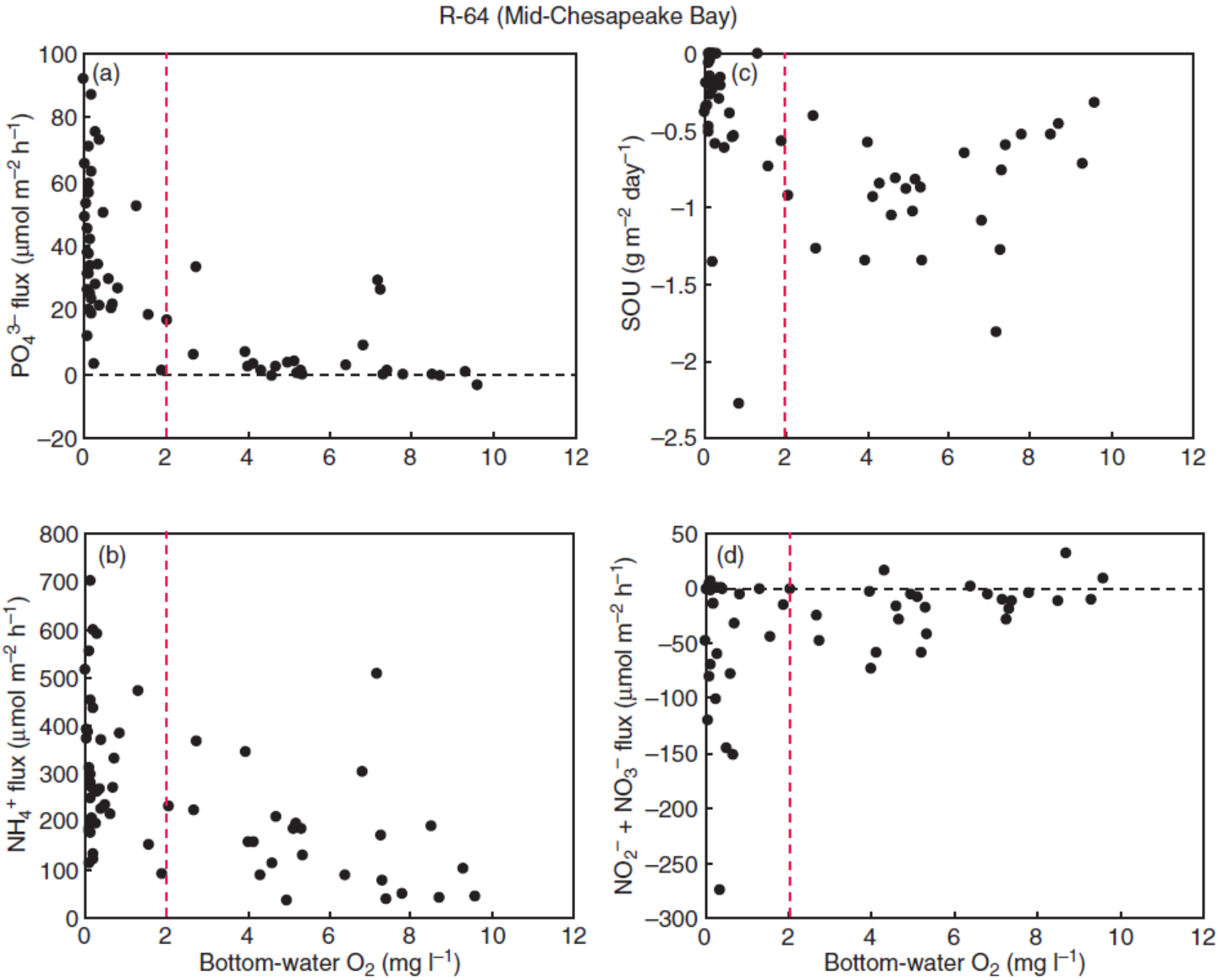


# Conceptual Model of $O_2$ Interactions with P-Cycle



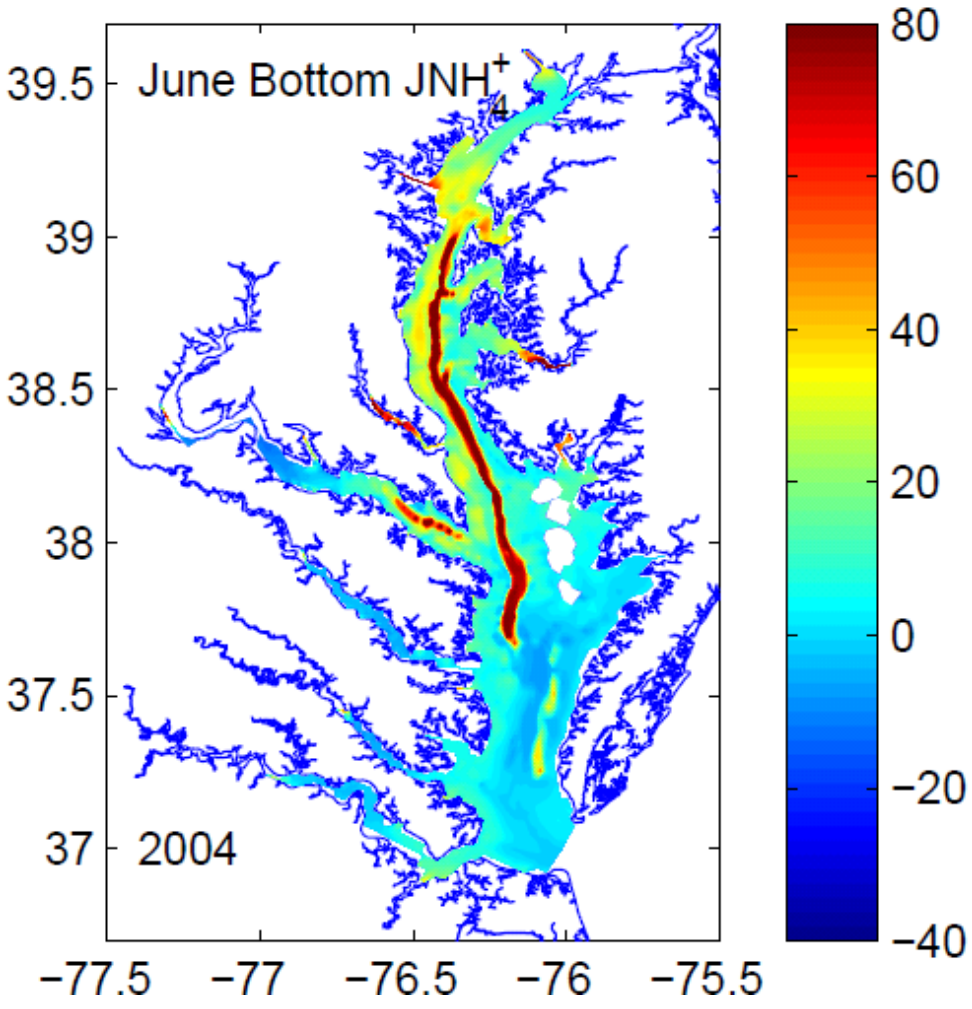
# Water-Column Oxygen Drives Fluxes

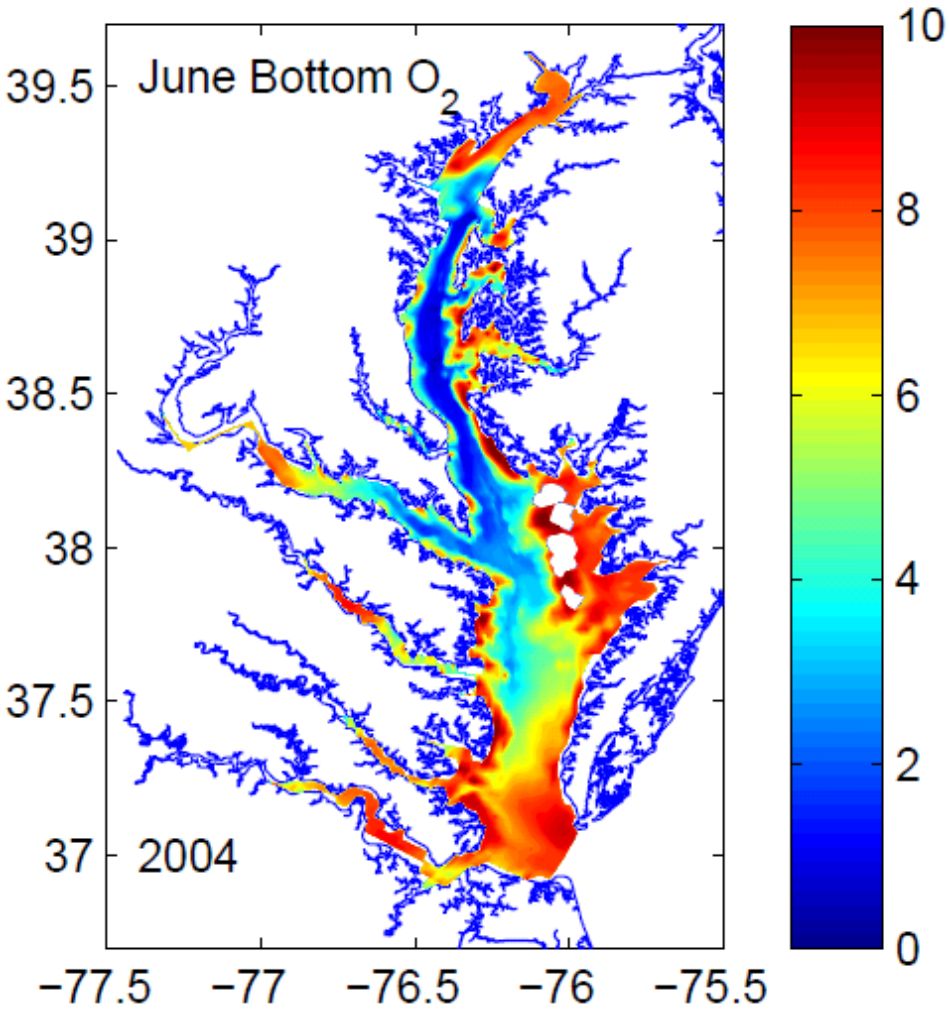





Data from Walter Boynton, published in Testa and Kemp 2011, 2012

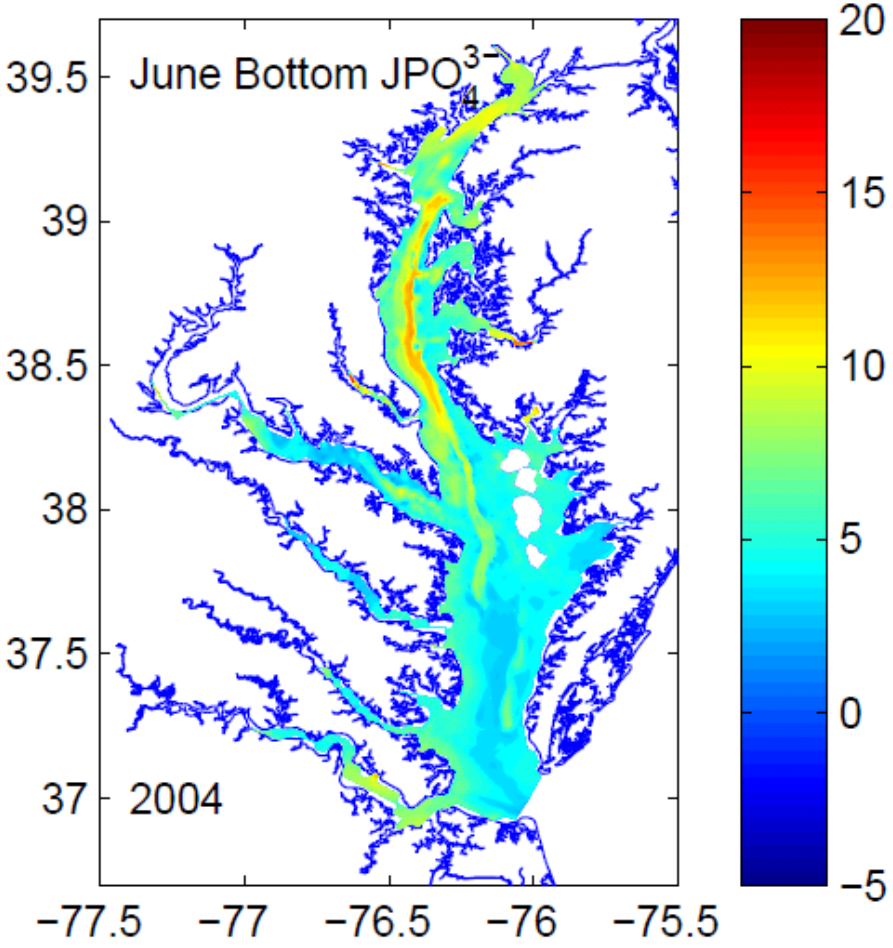
# Numerical Model Distributions of N Flux

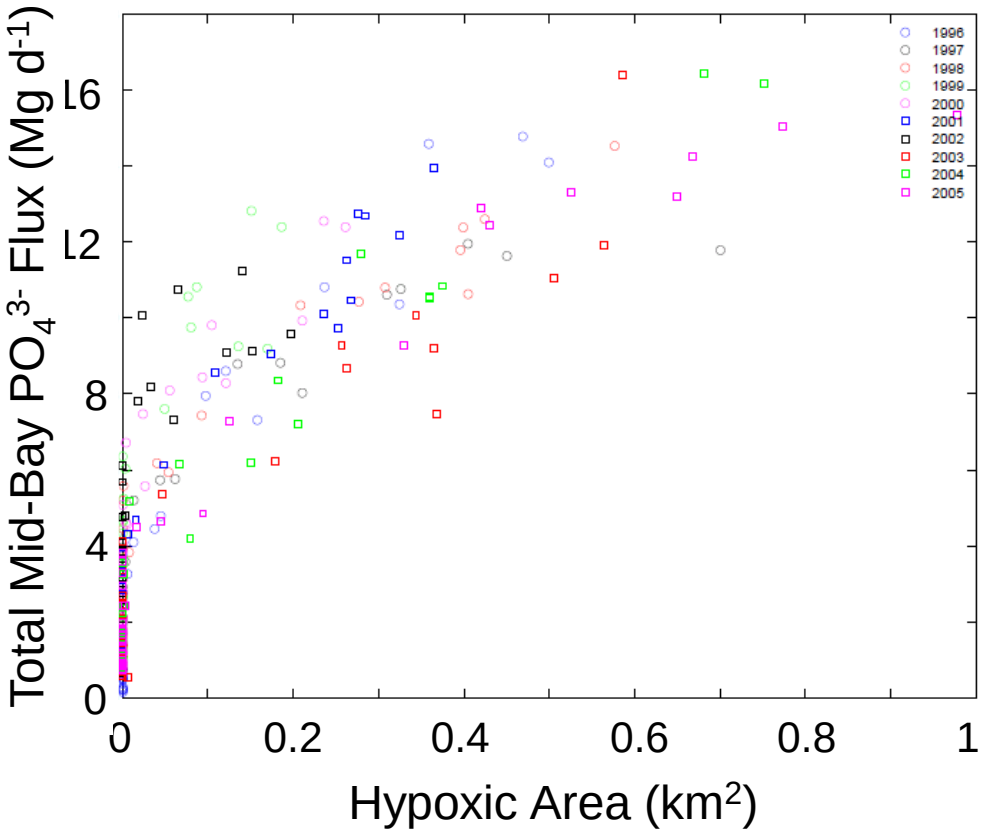



Model Simulations reported in Testa et al. 2014

# Numerical Model Distributions of P Flux

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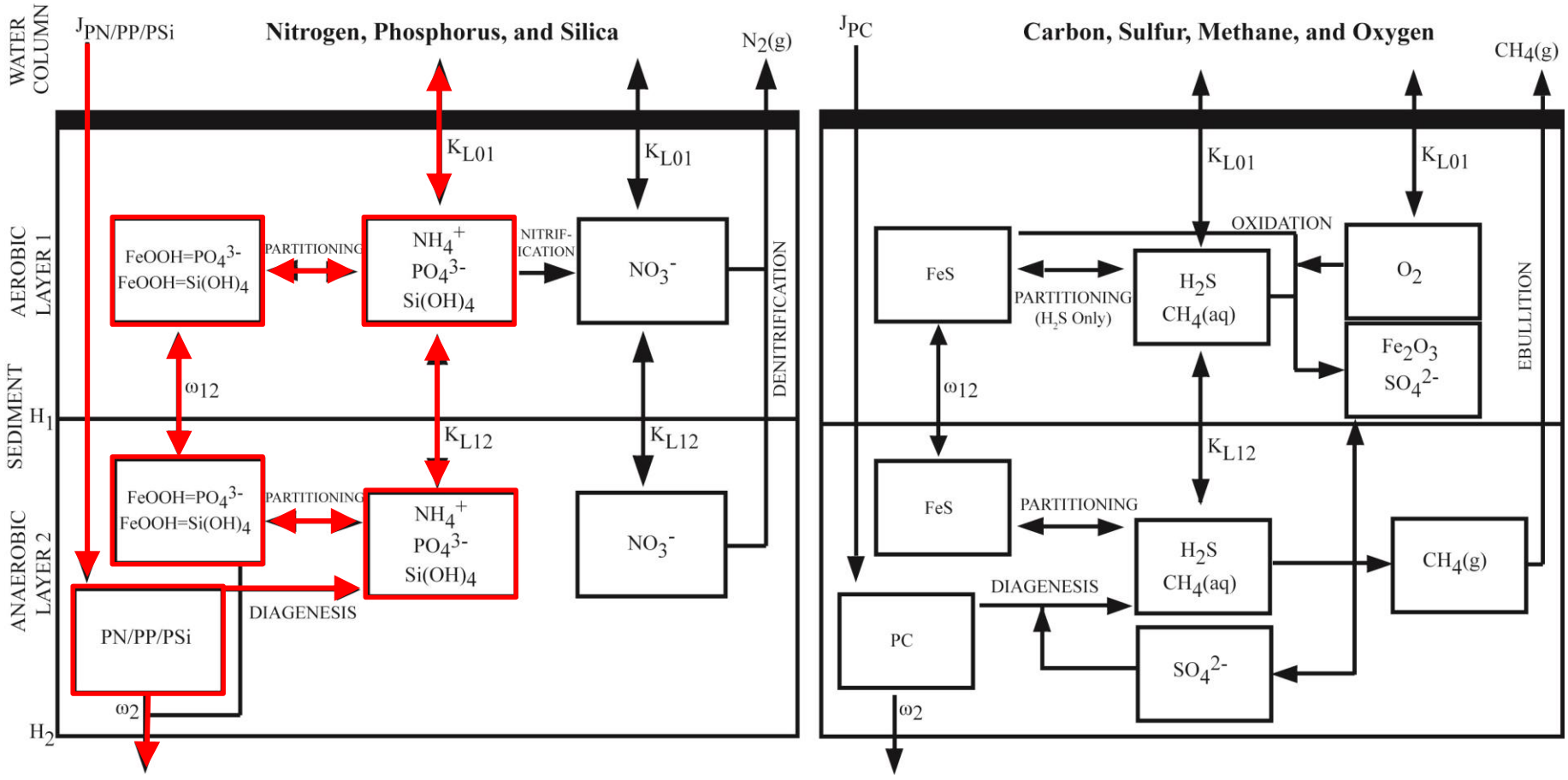
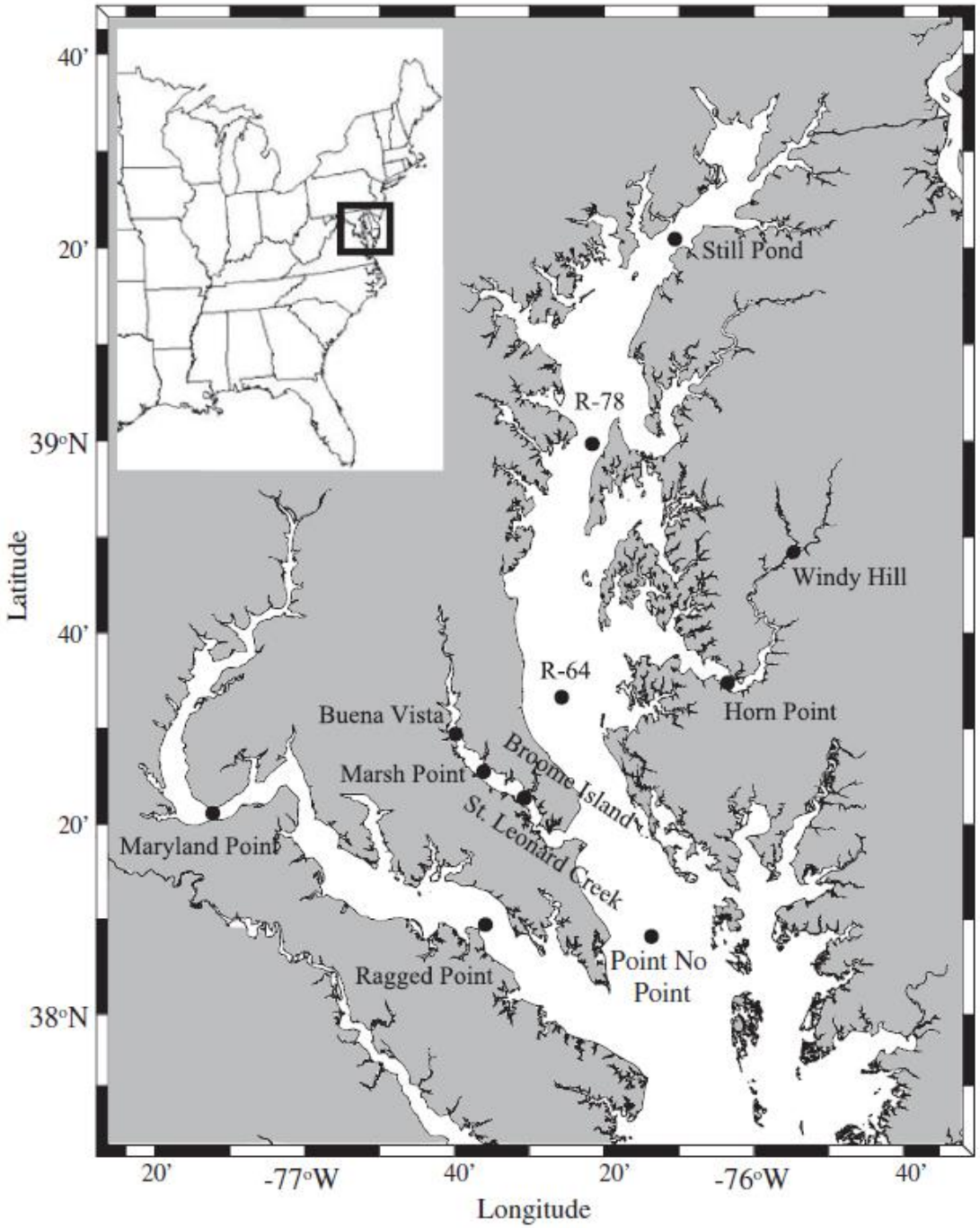
# Sediment Flux Model Schematic



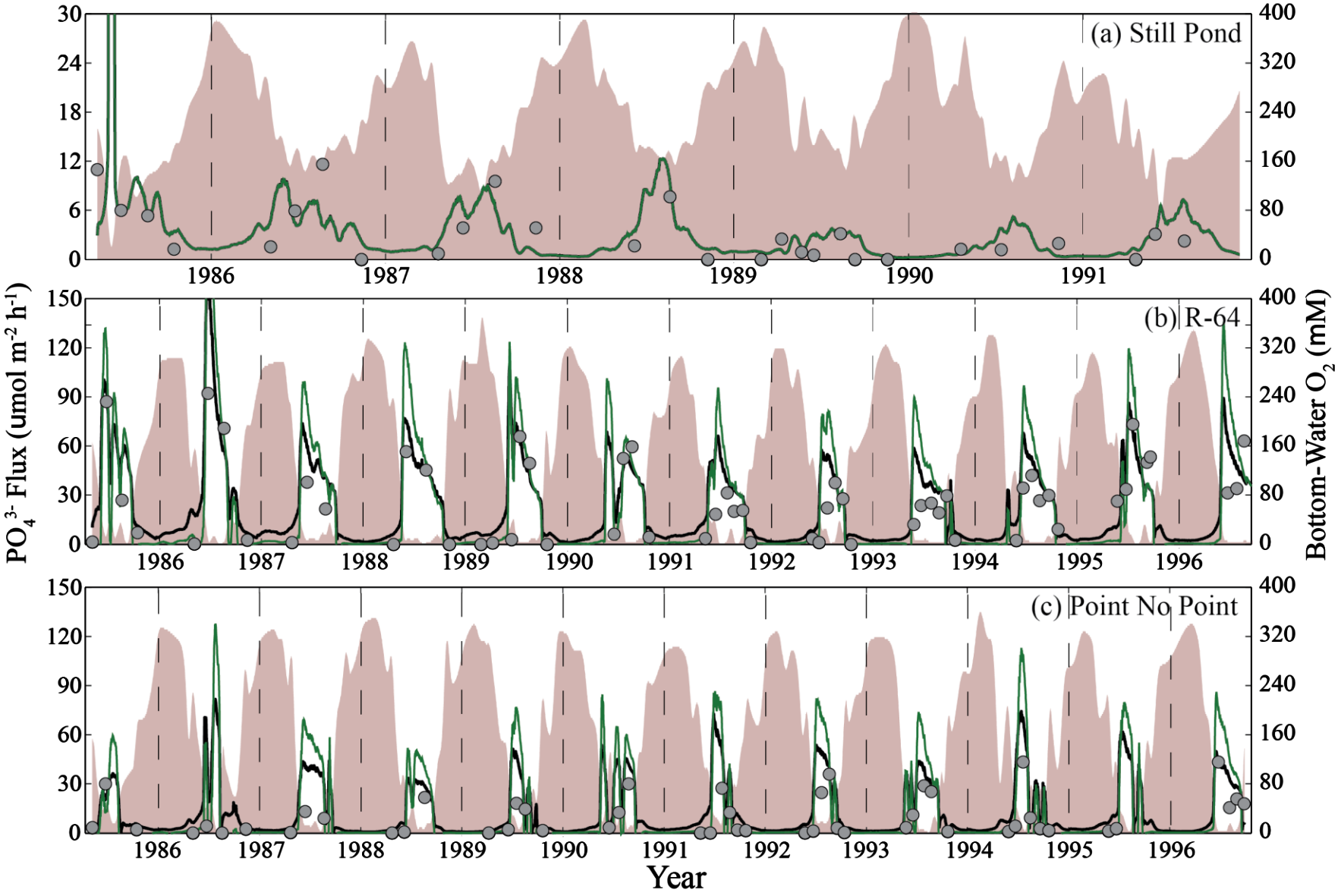

*Deposited organic matter partitioned into 3 reactivity classes, representative of algal material or non-algal material




# Sediment Flux Model Run in "Stand-Alone" For Chesapeake Bay

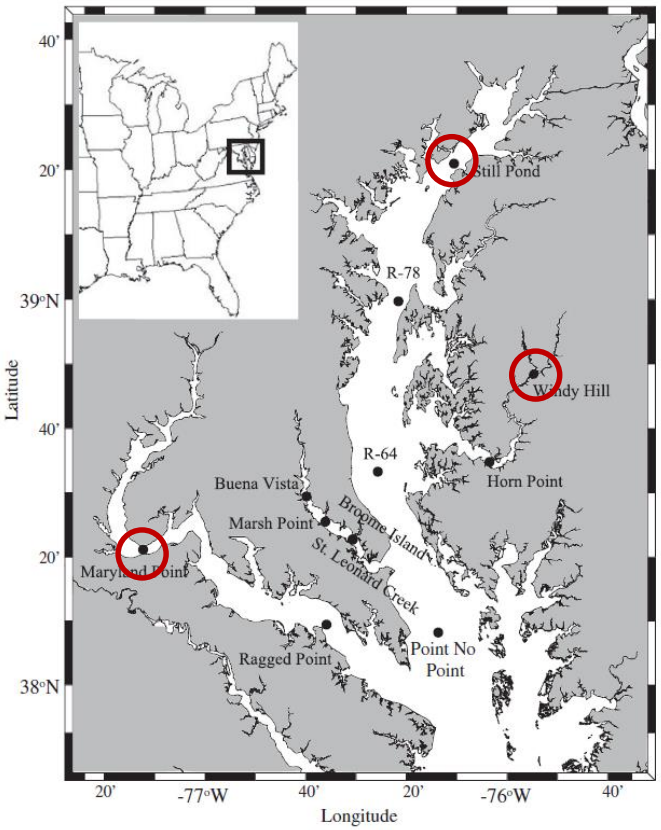
- Model forced by overlying-water nutrient and oxygen concentrations
- POM deposition estimated by fitting model $NH_4^+$ flux to observations
- Rapid runs allow for sensitivity runs, scenarios

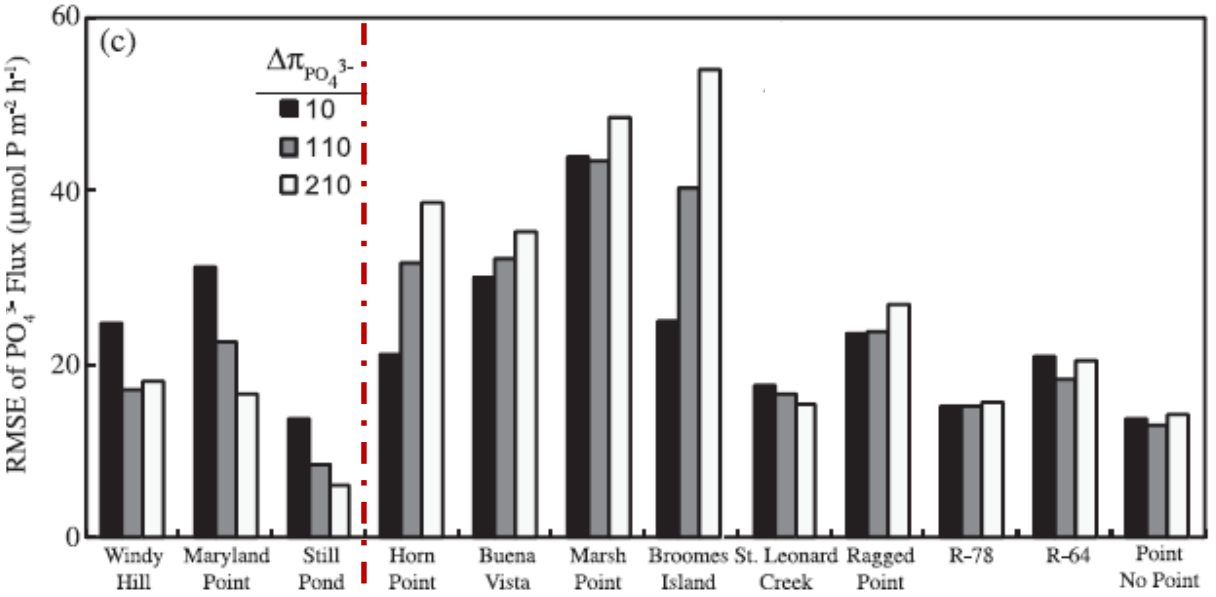
# Model Time-Series of $PO_4^{3-}$ Flux and $O_2$

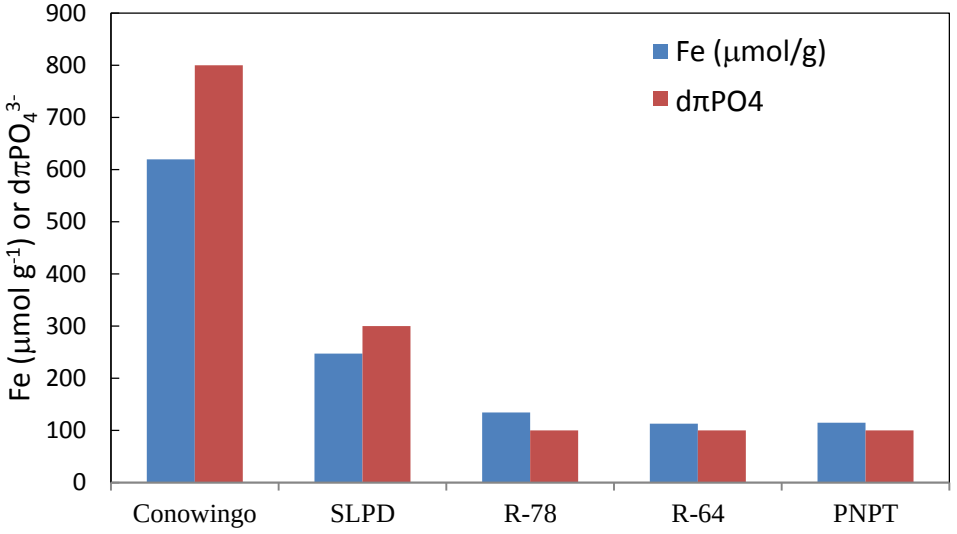



Model Simulations reported in Testa et al. 2013

# Spatially-Dependent Model Optimization



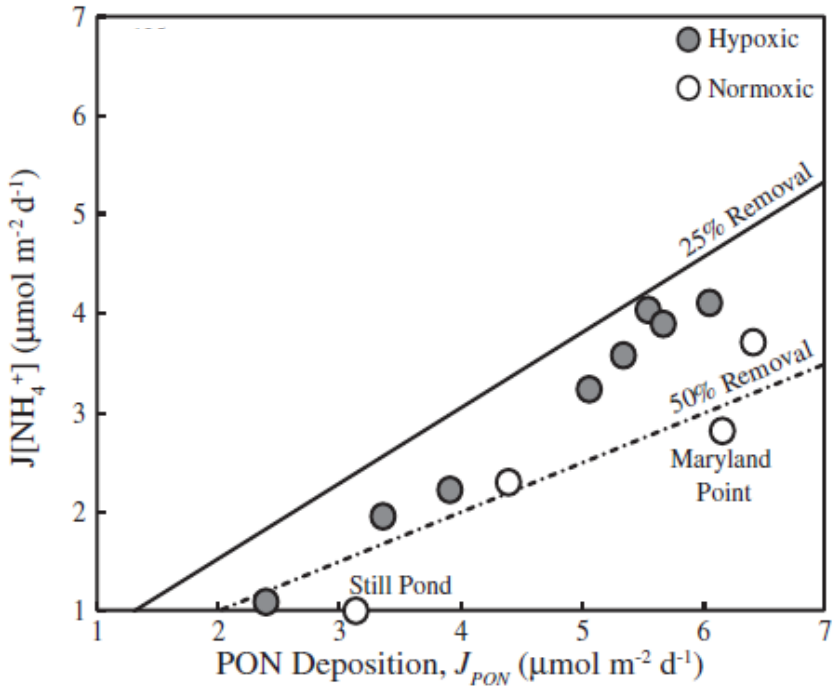



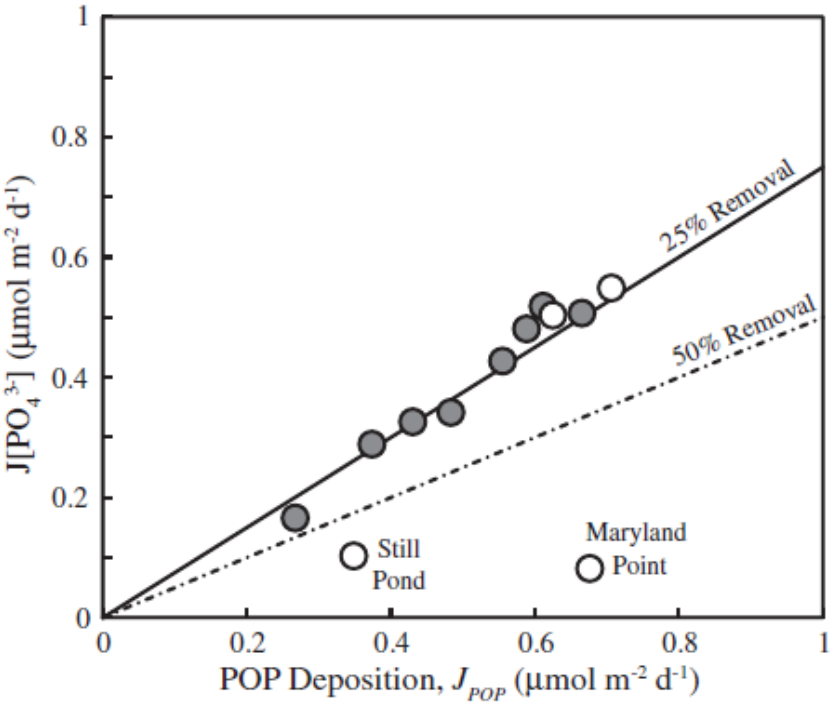

Model Simulations reported in Testa et al. 2013

# Fraction of Recycled N and P Varies by Location

- Roughly 35% of N removed, but ~50% at oxygenated stations

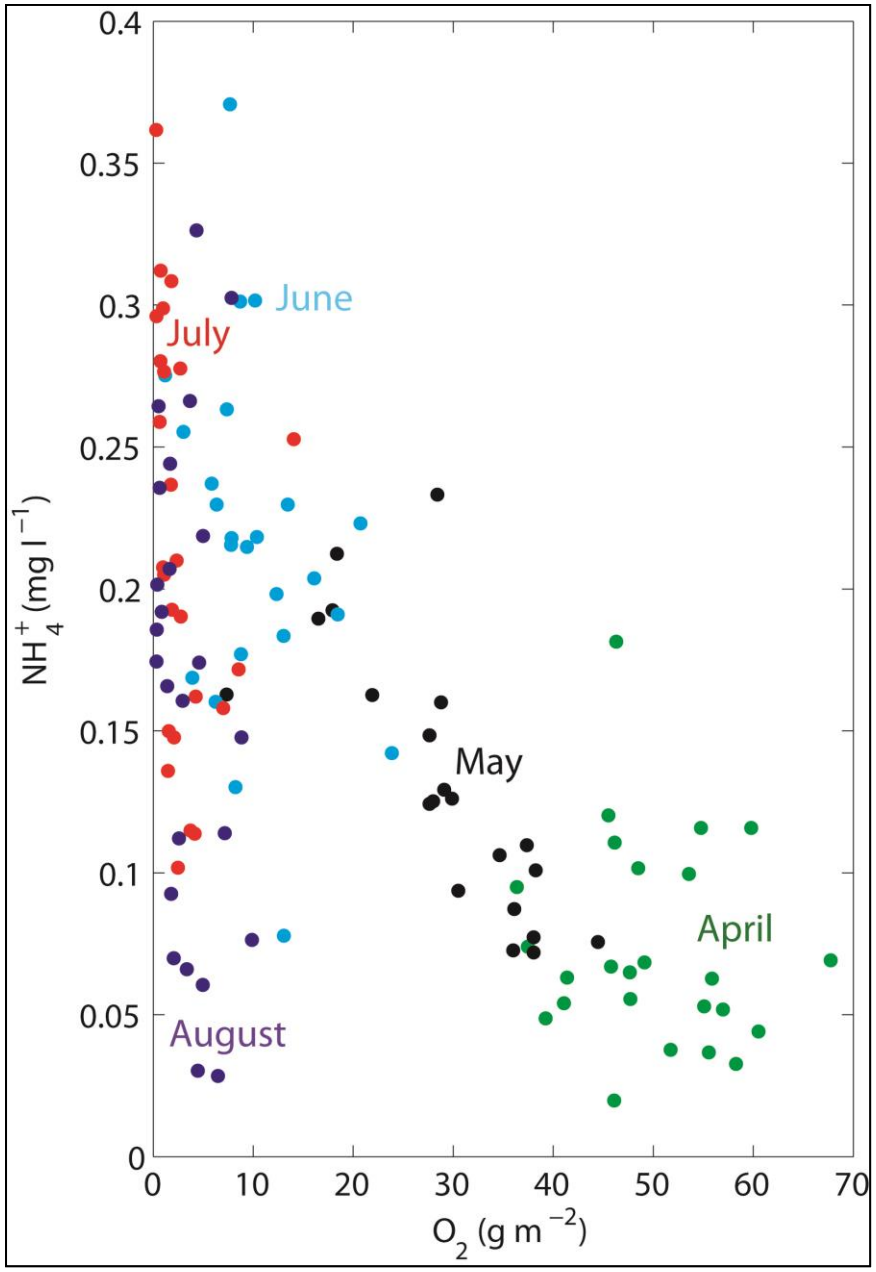
- Roughly 25% of P removed, except at oxic, high-Fe locations

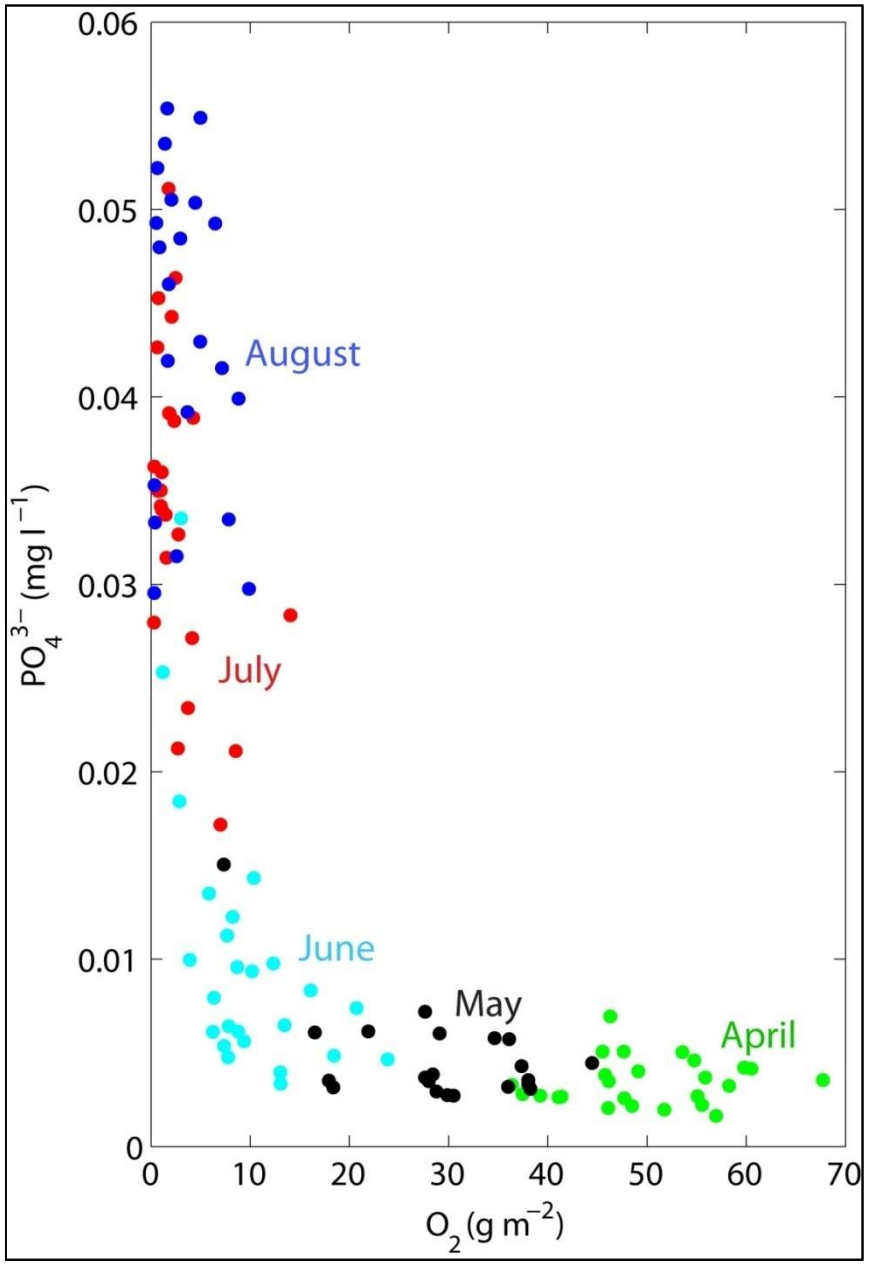



Model Simulations reported in Testa et al. 2013

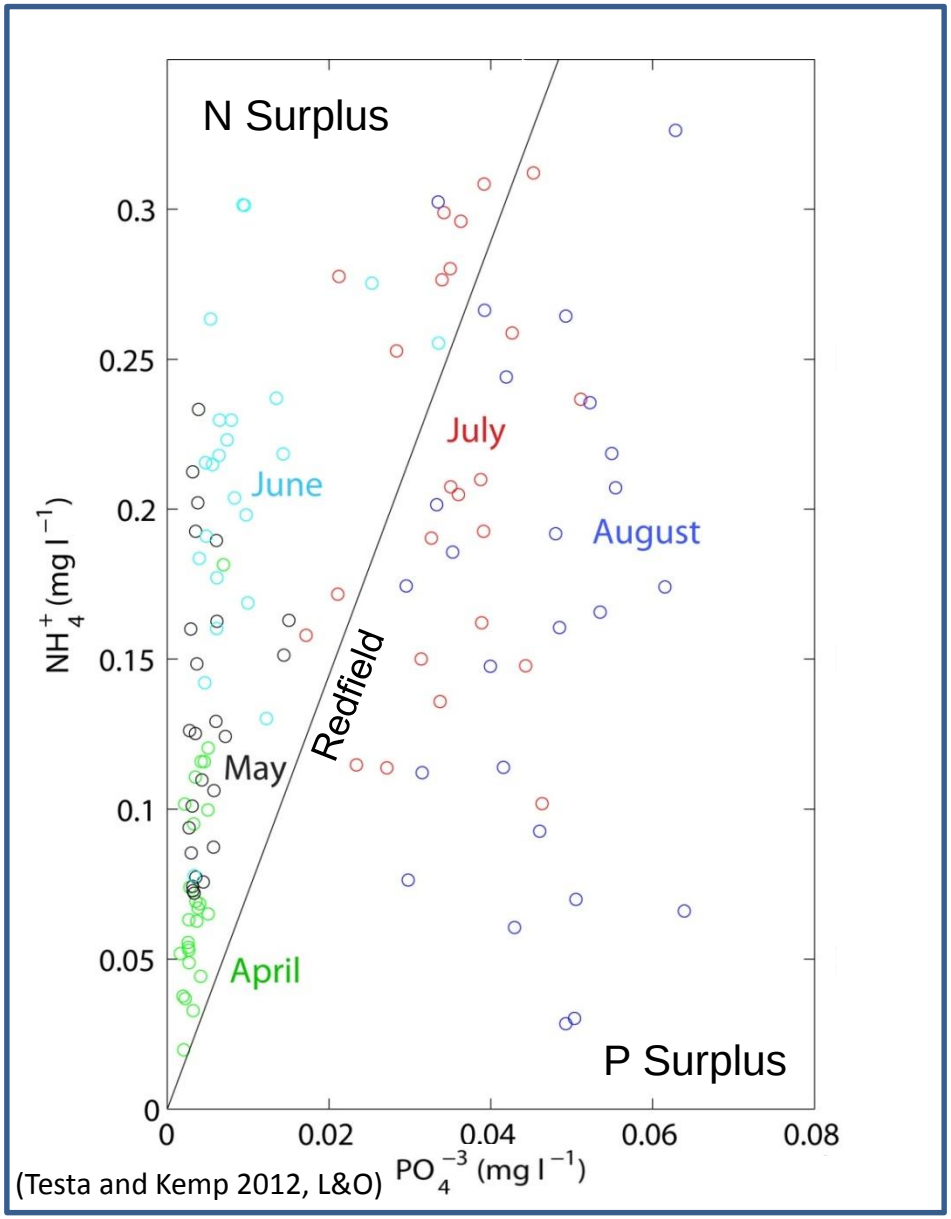
# Seasonal Trends in Bottom $NH_4^+$ & $PO_4^{3-}$ vs. $O_2$




(Testa and Kemp 2012, L&O)

# Temporal Mismatch in Fluxes Drives N:P Ratios

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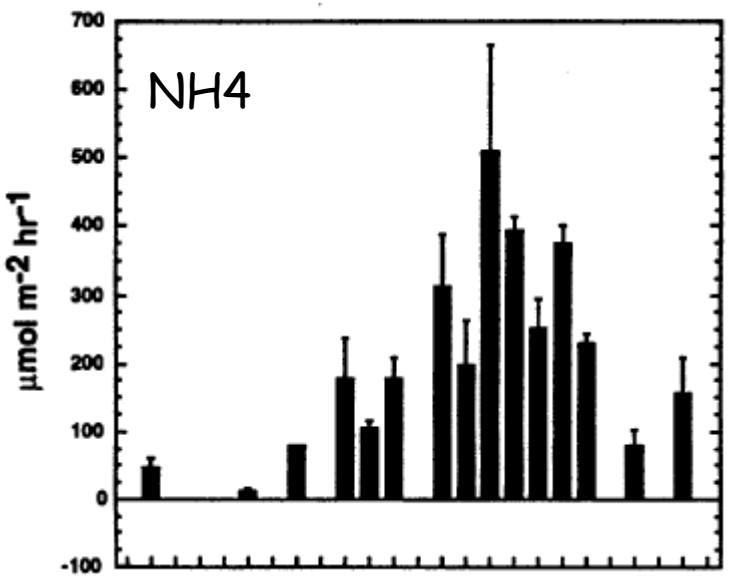


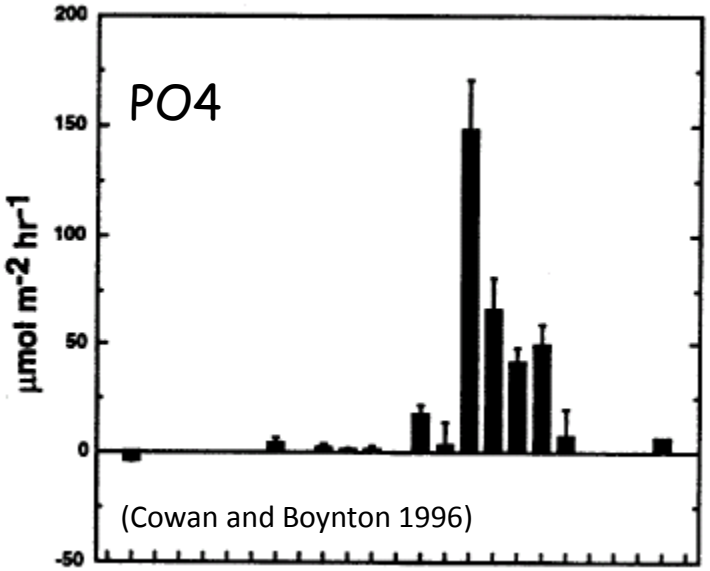


(Cowan and Boynton 1996)

# Summary

(1) Upper Bay sediment N and P fluxes generally lower than mid-Bay region, despite higher POM deposition

(2)Fate of N and P deposited to sediment in Chesapeake Bay dependent on sediment properties and overlying-water dissolved oxygen

(3) Differential behavior of N and P in sediments drives timing of water-column $NH_4^+$ and $PO_4^{3-}$

# Acknowledgements

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Exelon.

MARYLAND DEPARTMENT OF NATURAL RESOURCES

NCCOS
Modeling Hypoxia & Ecological Responses to Climate & Nutrients
CHRP

Data:

Chesapeake Bay Program

Chesapeake Bay Program
Science. Restoration. Partnership.

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