Organic matter processing in shallow water tributaries - environmental controls

"Could I please go back to the rack now?"

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Outline

- Organic matter source and fate relative to tributaries and open bay
- Case Study 1: Organic matter and nutrient cycling in the upper Sassafras River
- Case Study 2: Corsica River
- Case Study 3: Harris Creek, a lagoonal system

Emphasis on: organic matter processing in sediments

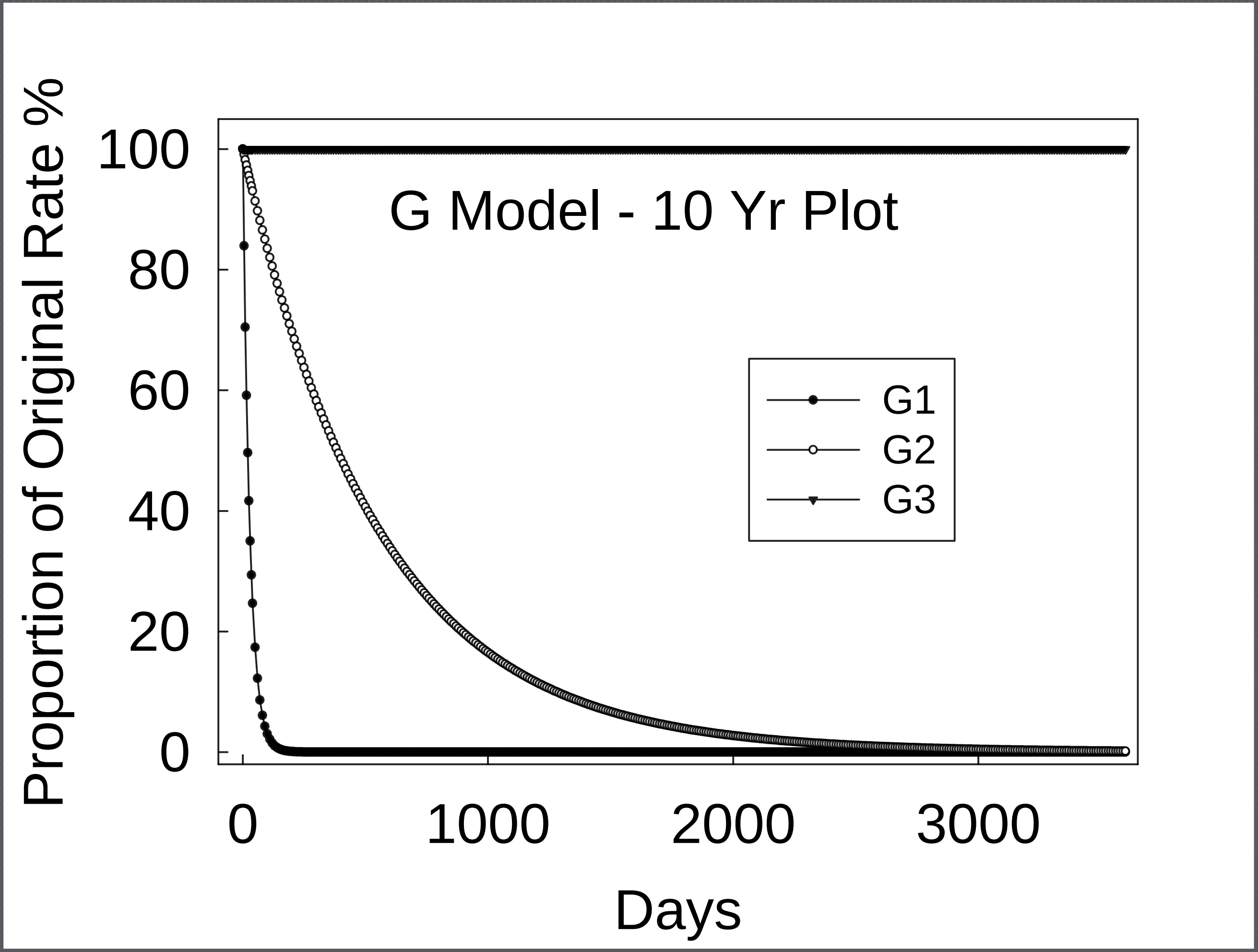
Triblet Biogeochemical Characteristics

- Variable salinity, fresh to mesohaline
- Variable nutrient loading, sometimes very high nitrate
- Benthic photosynthesis – algae and SAV
- Susceptibility to cyanobacterial blooms
- Mixed sources of organic matter – phytoplankton, benthic algae, SAV, wetland macrophytes, terrestrial organic matter
- Potential impact by benthic filter feeders

Whence organic matter and nutrient remineralization – Berner G model

- Very labile sources: phytoplankton, benthic algae – G1 class
- Less labile: terrestrial organic matter, wetland organic matter, SAV organic matter – G2 class
- Recalcitrant: weathered terrestrial organic matter, coal, wood, etc. – G3 class
- In shallow water, increased proportion of benthic vs water column organic matter processing

$$\frac{dN}{dt} = K * C_N$$



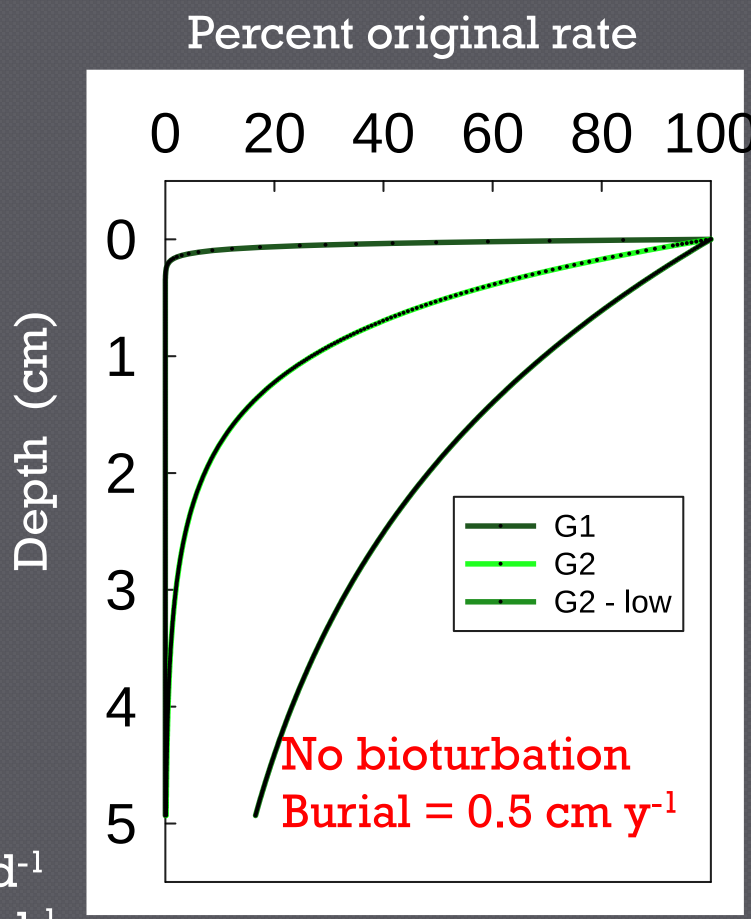
$K_{G1} = 0.035\ d^{-1}$

$K_{G2} = 0.0018\ d^{-1}$

DiToro 2001 Sediment Flux Modeling

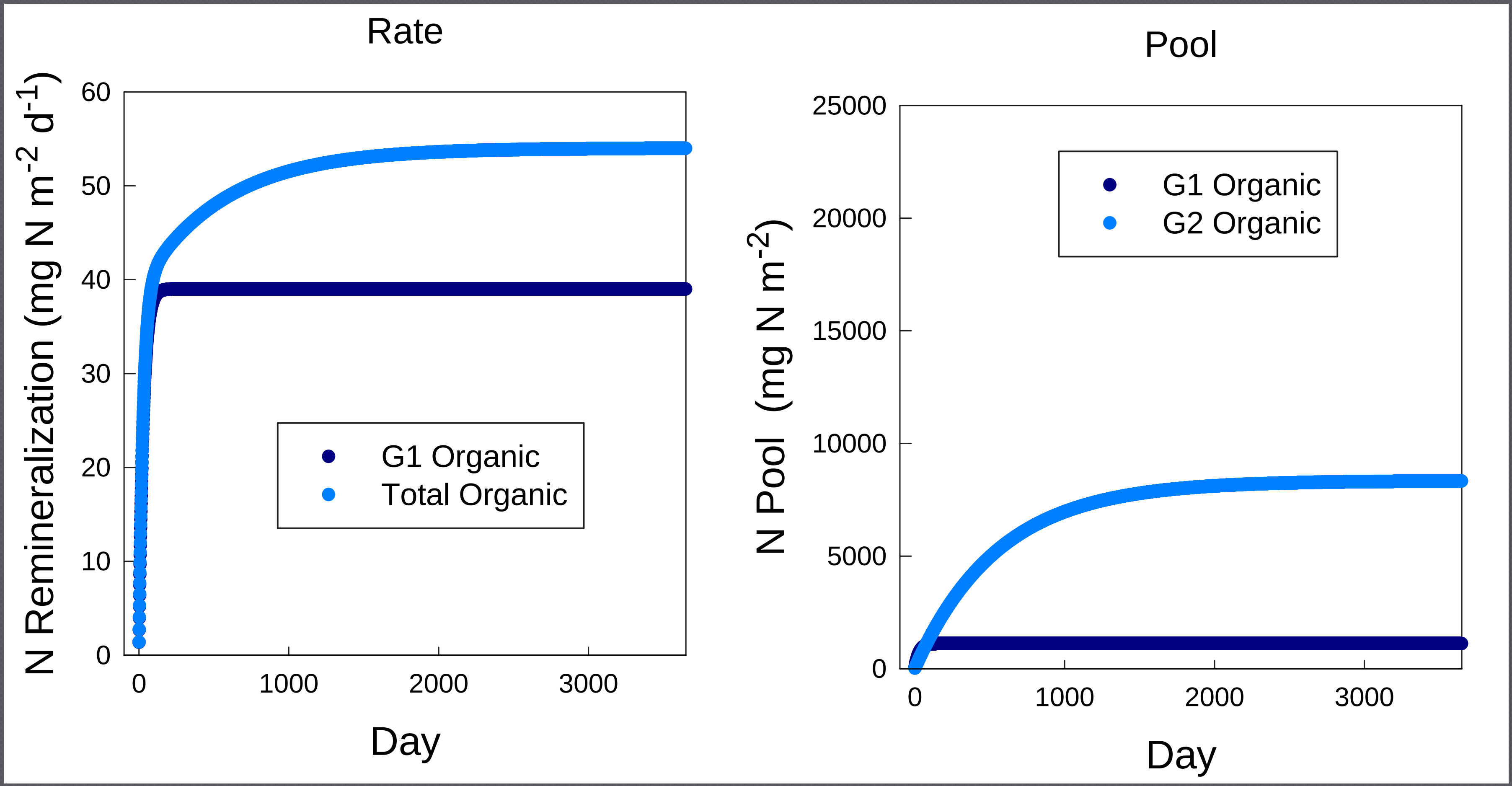
Changing Redox Pathways

- With more G2 (terrestrial) organic matter, more of the activity is moved to deeper, more reducing horizons
- Algal organic matter efficiently fuels respiration in the top few mm under aerobic and anaerobic conditions. Poorer quality organic matter fuels processes like methanogenesis at depth. Low levels of sulfate also enhance this.



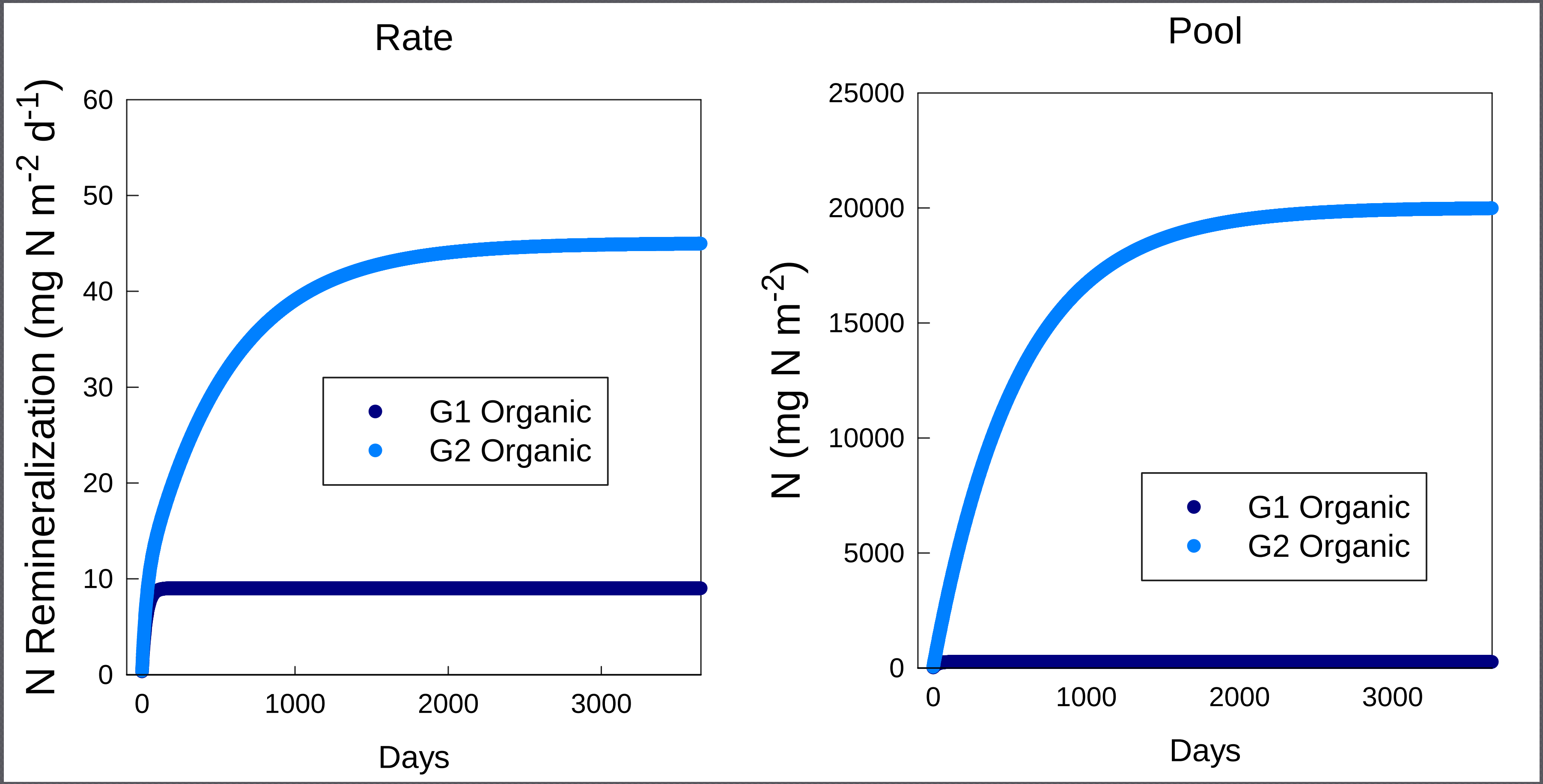
$K_{G1} = 0.035\ d^{-1}$
$K_{G2} = 0.0018\ d^{-1}$
$K_{G2\ -\ low} = 0.0005\ d^{-1}$

Input = 60 mg N m^{-2} d^{-1}; 65% G1, 25% G2, 10% G3



Using DiToro's algal proportions and K's, G1 pool is ephemeral but dominant for rates

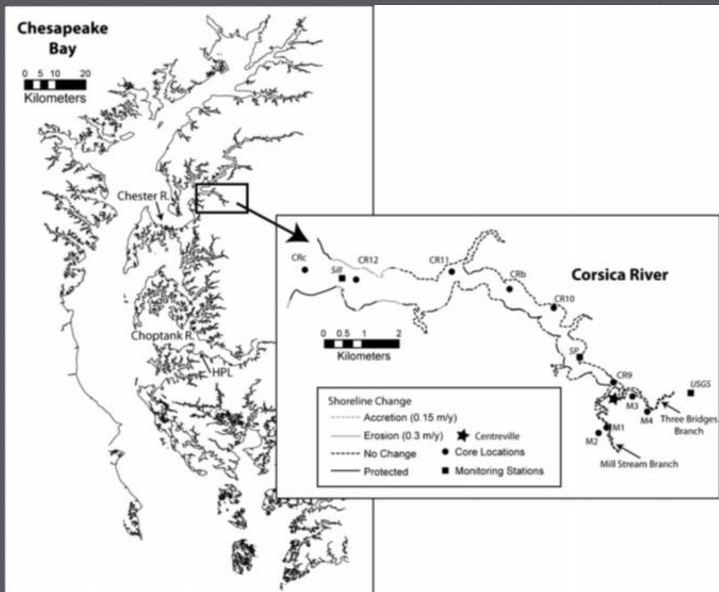
Input = 60 mg N m^{-2} d^{-1}; 15% G1, 60% G2, 25% G3



Lowering DiToro's algal proportions, G1 pool is ephemeral and terrestrial materials persist

What Does This Mean For Triblets?

- With increasing proportions of non-algal organic material, the system is less "flashy".
- Nitrogen remineralization, potentially a major sources of N for plant growth, is buffered against quick changes.
- Changing nutrient inputs via management action will have a slower sediment response.

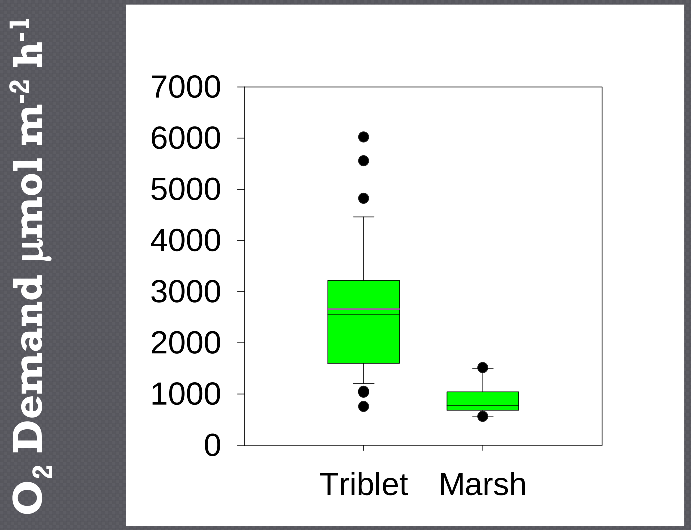


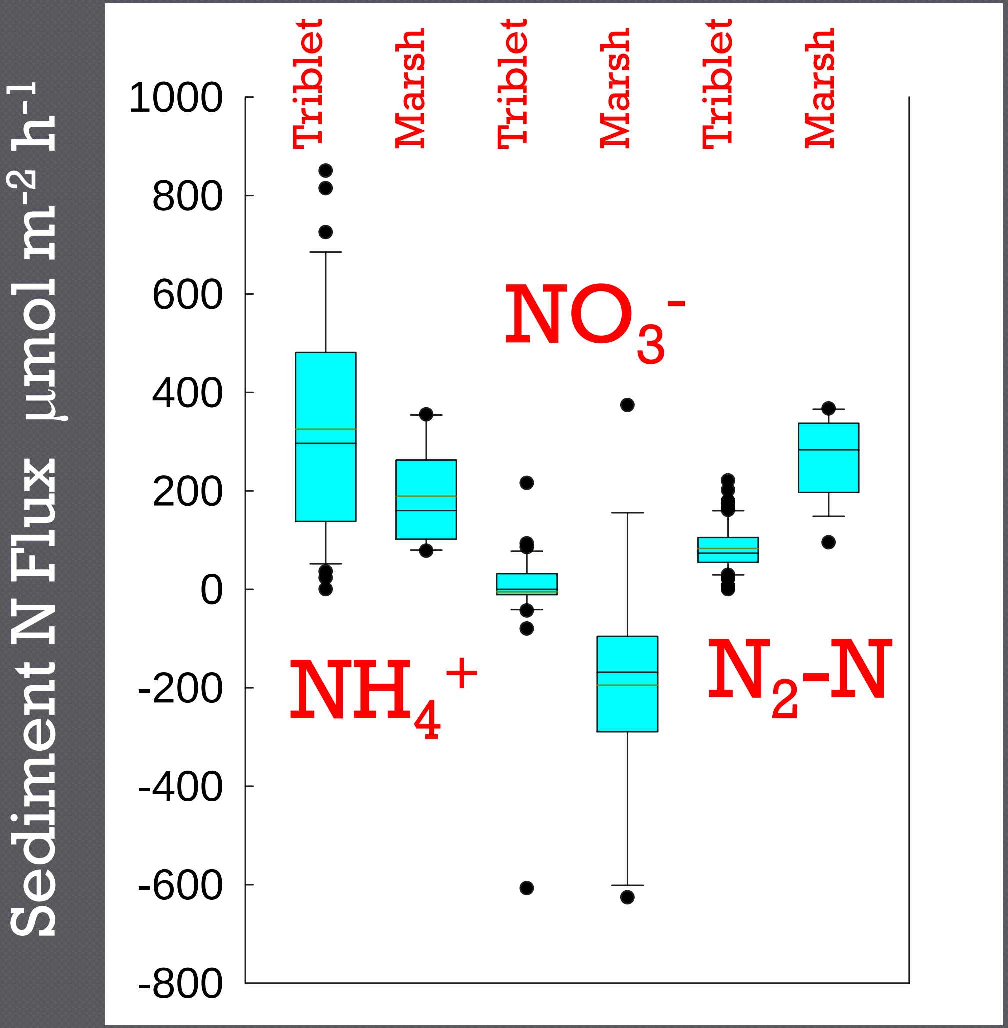
Triblet Examples

- Corsica River – priority management action and wetland rate assessment
- Sassafras River – sediment interactions may support nuisance cyanobacterial blooms
- Harris Creek – perhaps more lagoon than triblet? Effects of management actions – oyster restoration

Scaling: Rates and Areas

Marsh area < 10% of total triblet ares

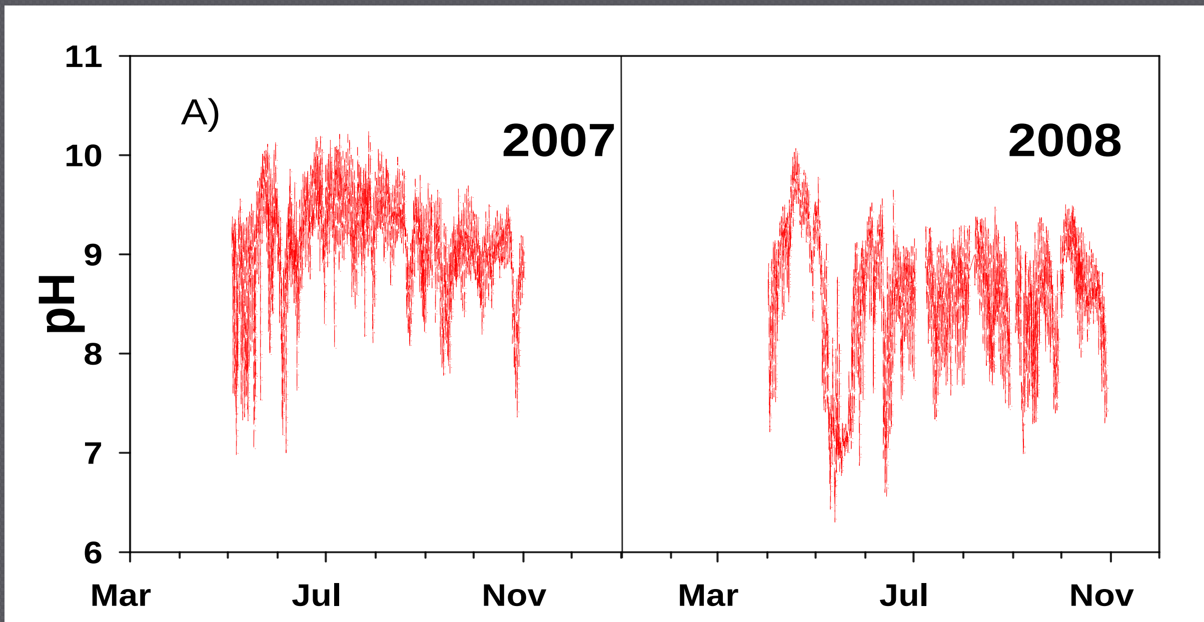




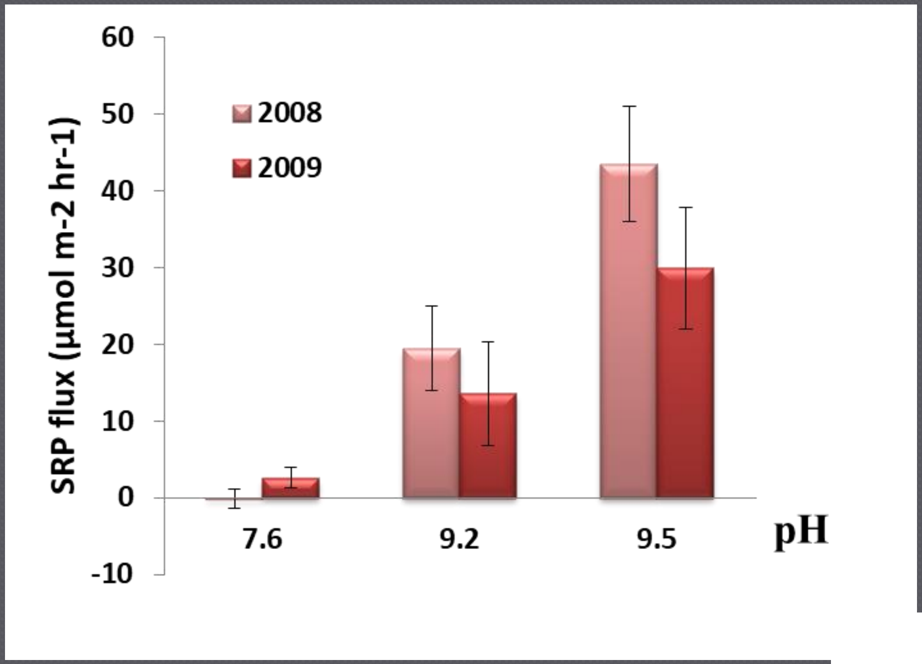
Corsica River – Cornwell, Palinkas, Boynton

Sassafras River – Thesis Work of Yonghui Gao

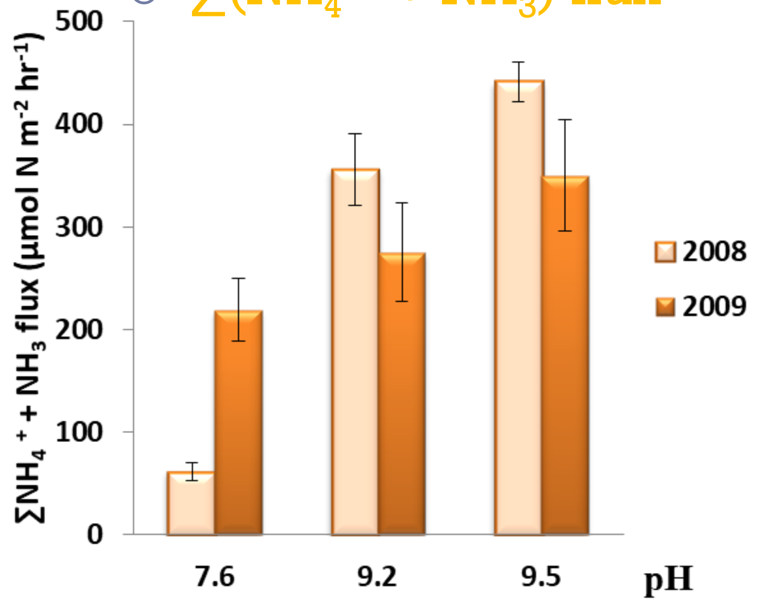
Biogeosciences 2012; L&O 2014; Aquatic Microbial Ecology 2014

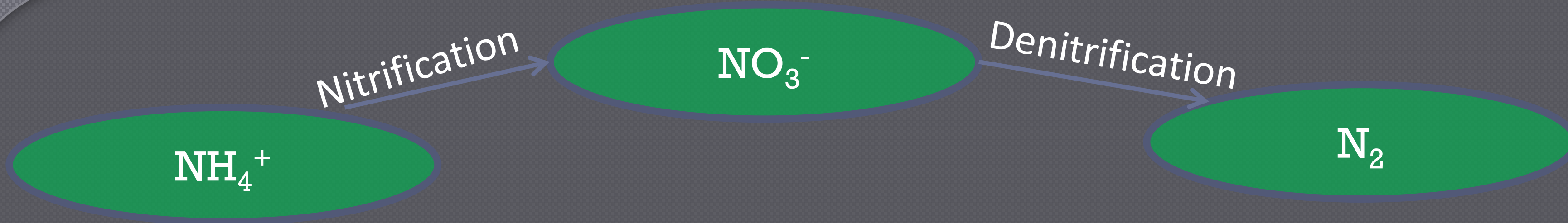


- Shallow (< 2 m)
- Tidal fresh water (low pH buffering capacity)
- Cyanobacterial blooms result in high pH



$\sum(NH_4^{+} + NH_3)$ flux





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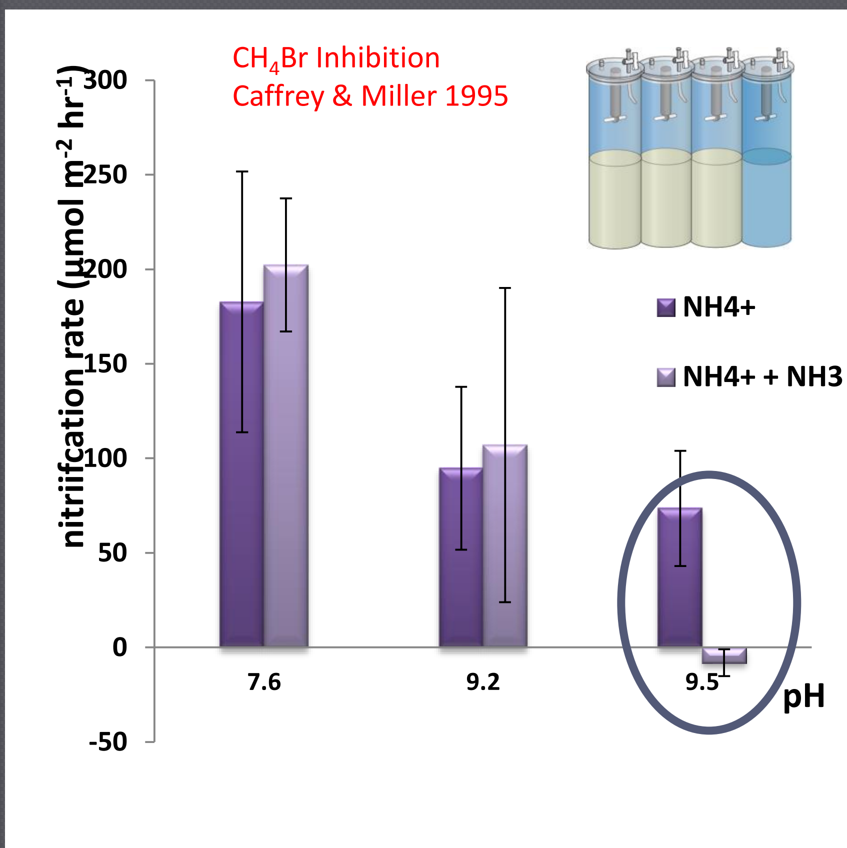

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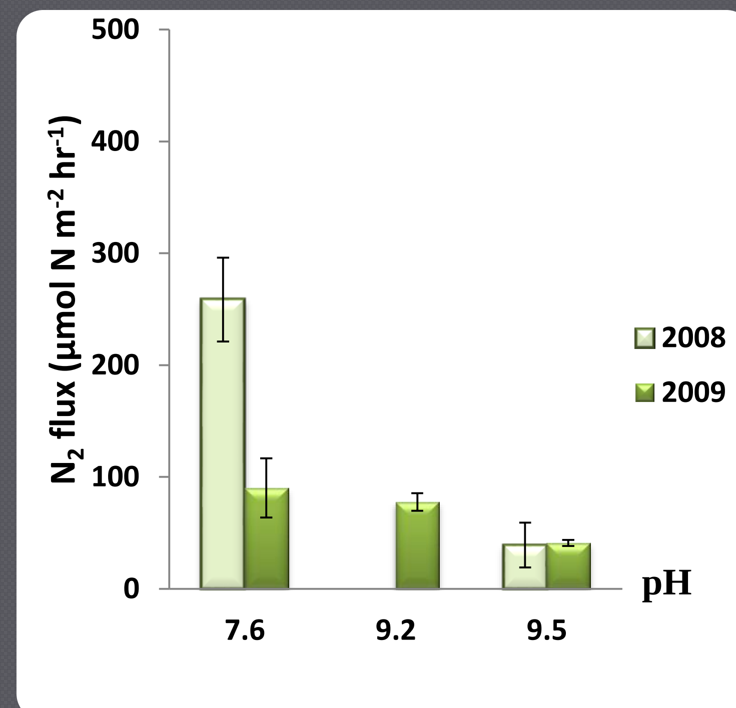
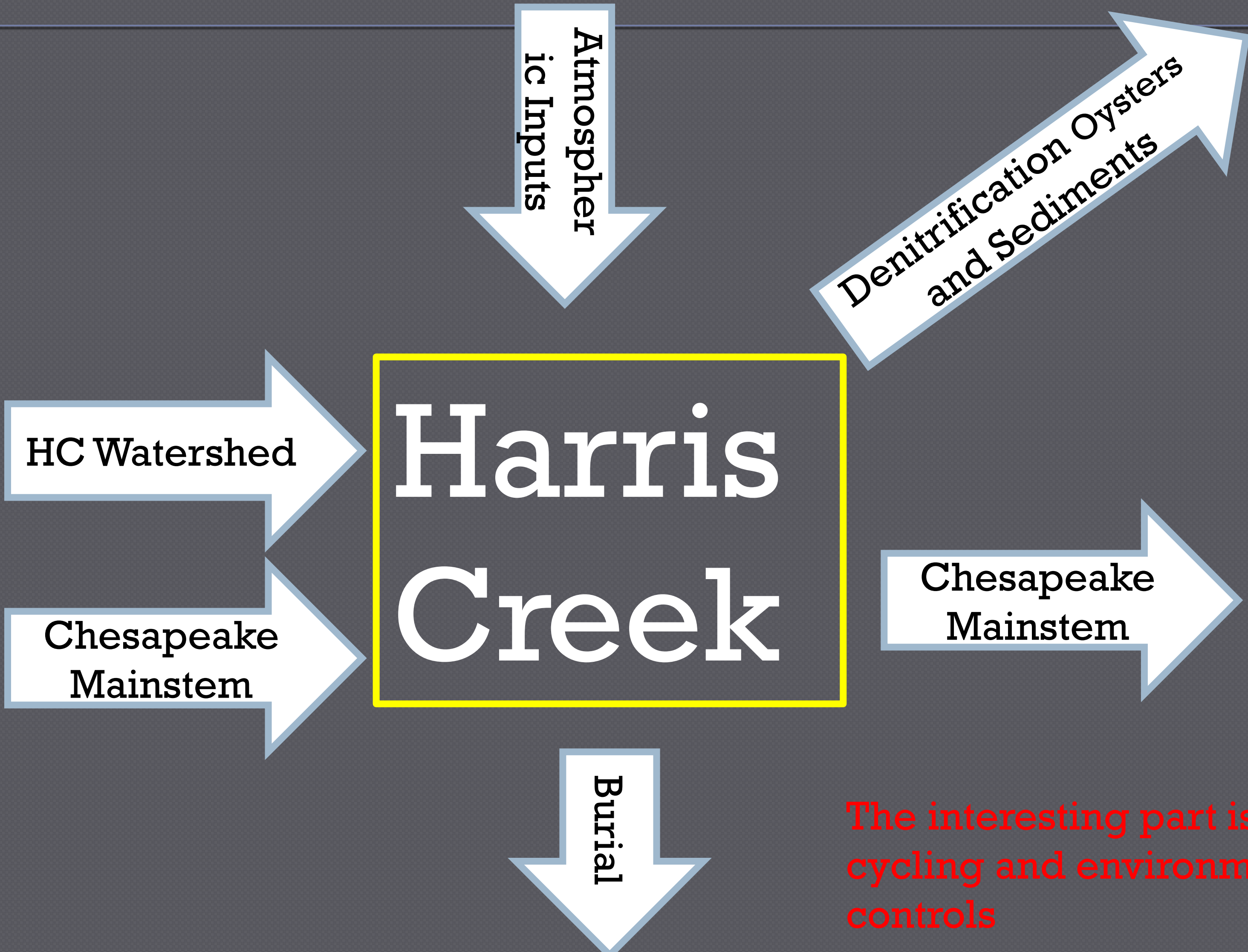


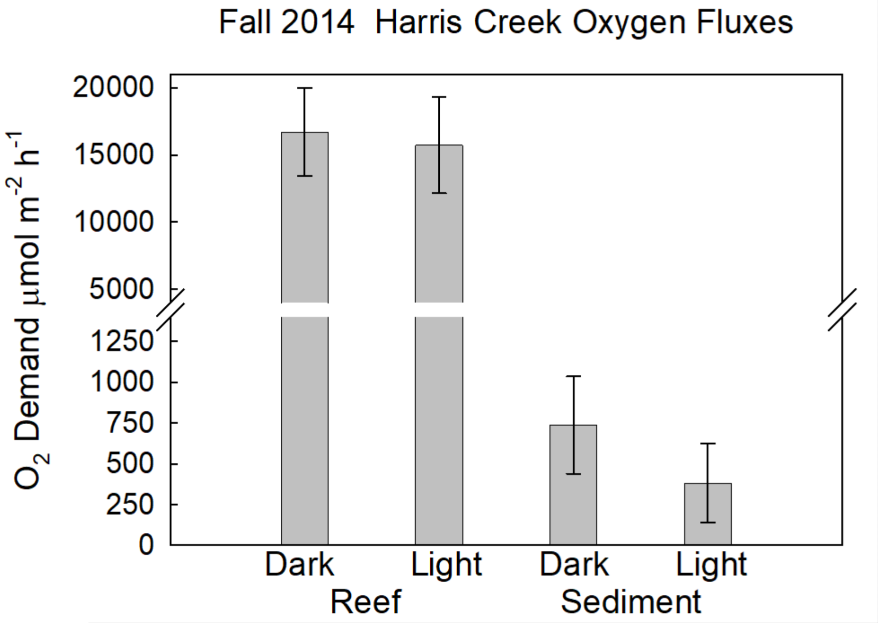
Nitrogen Mass Balance

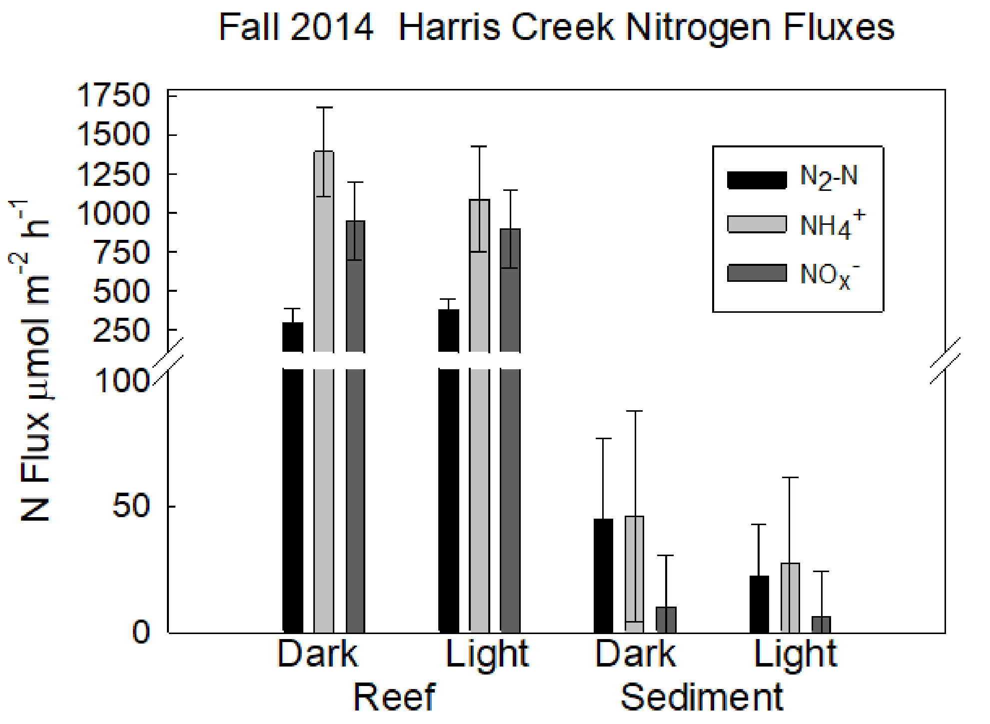


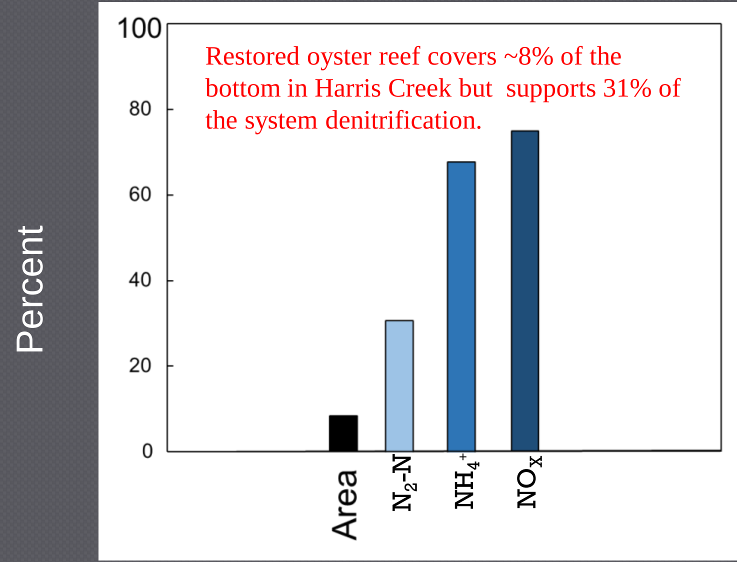
The interesting part is internal cycling and environmental controls

Harris Creek, MD

~350 acres of oyster restoration







Conclusions

- Each triblet likely has characteristics related to nutrient and sediment inputs, morphology, biotic make up
- The nature of organic matter inputs to sediments may have a strong influence on the amount and timing of carbon and nutrient remineralization
- The connection between sunlight, overlying water and sediment is strong – sediment nutrient sources and cycling may be more important than larger systems.
- Photosynthesis is a key process, whether to limit nutrient exchange in sediments, baffle physical energy (SAV), or in the case of HAB's completely change the whole ecosystem.