Oxygen Effects on Nutrient Biogeochemistry: Feedback Effects on Coastal Eutrophication

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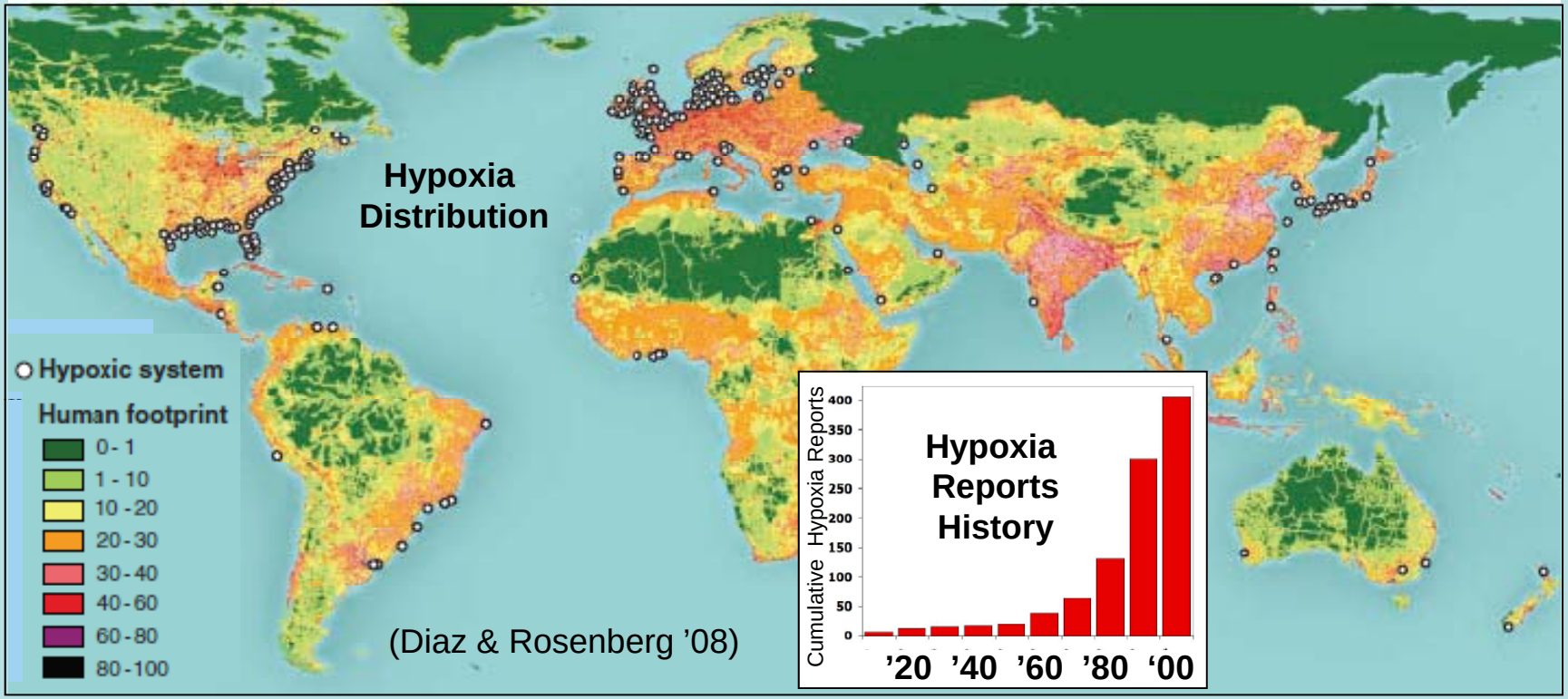
Modeling Hypoxia & Ecological Responses to Climate & Nutrients
CHRP NCCOS

CBEO
Chesapeake Bay Environmental Observatory
NSF

Outline of Talk

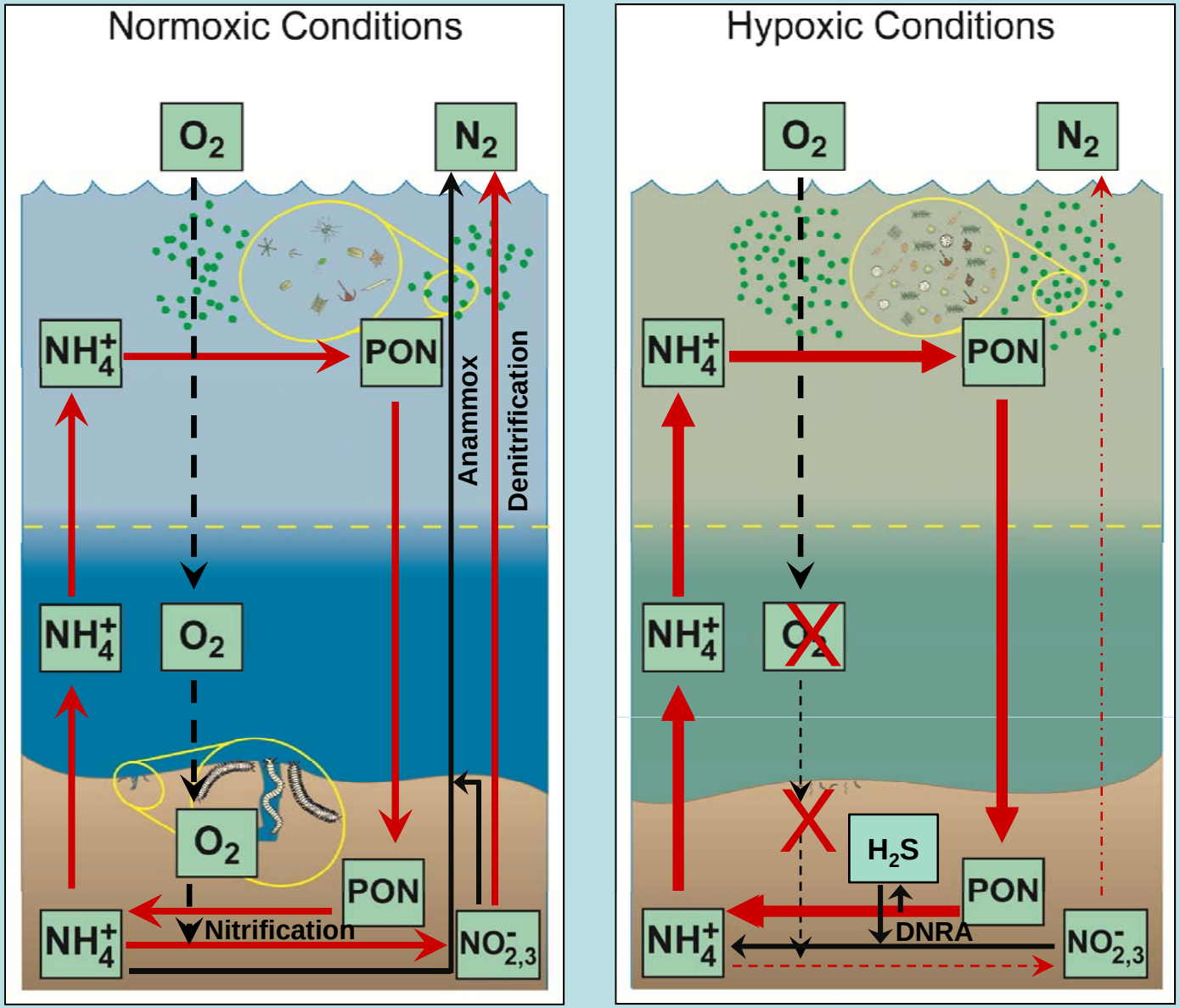
- Introduction: Linking Nutrient Inputs to Hypoxia and Nutrient cycling
- Chesapeake Bay as a data-rich system to study Hypoxia-Nutrient links
- Bay hypoxia relationships to benthic recycling of NH_4^+ and PO_4^{3-}
- Feedback effects of low O2 on N and P recycling influence recovery of Bay

Global-Scale Spread of Coastal Hypoxia

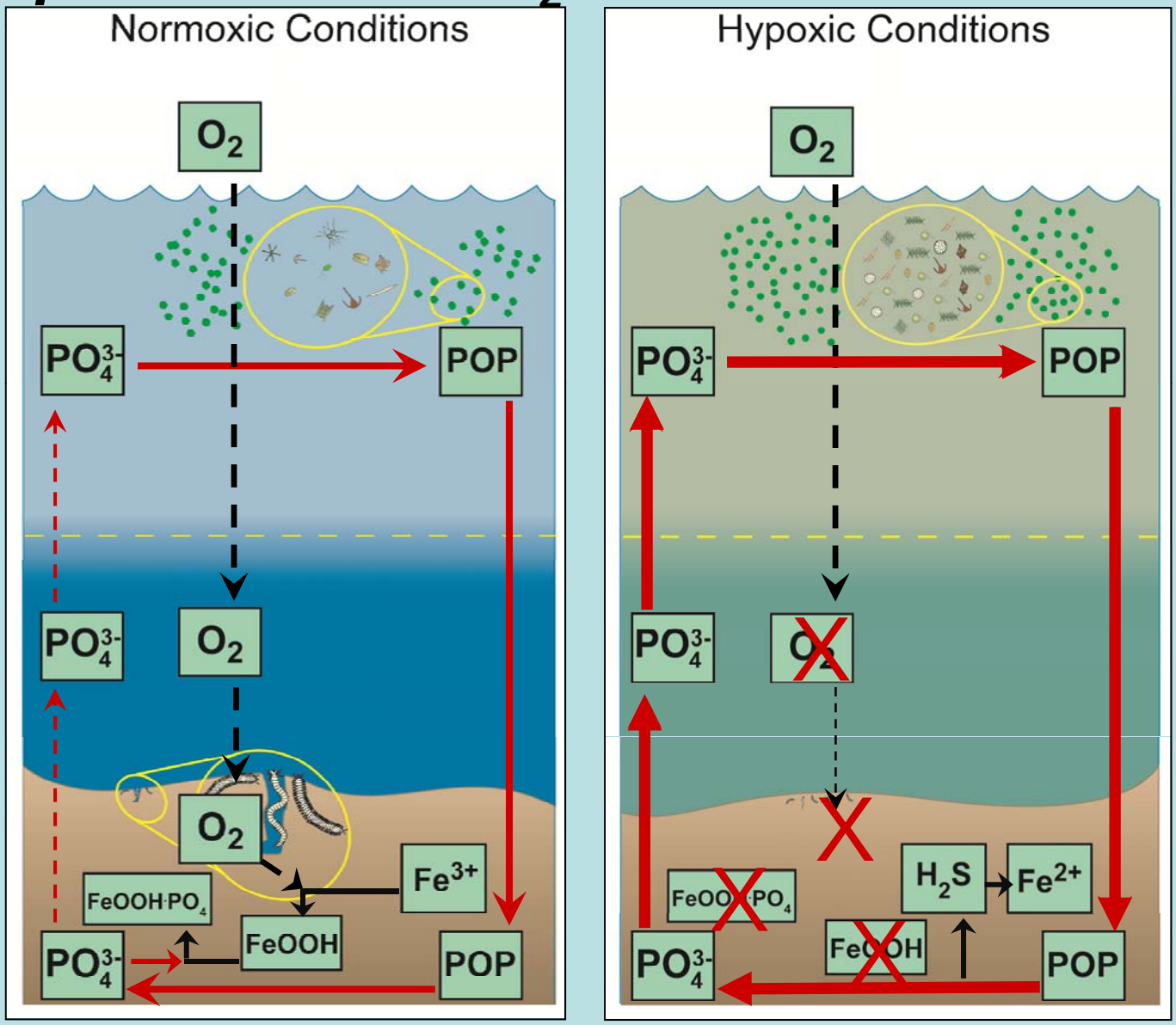


- **Global distribution of coastal hypoxia**
- **Hypoxia concentrated near intense human activities**
- **Global spread of hypoxia related to eutrophication**
- **Other processes (e.g., climate change) also important**

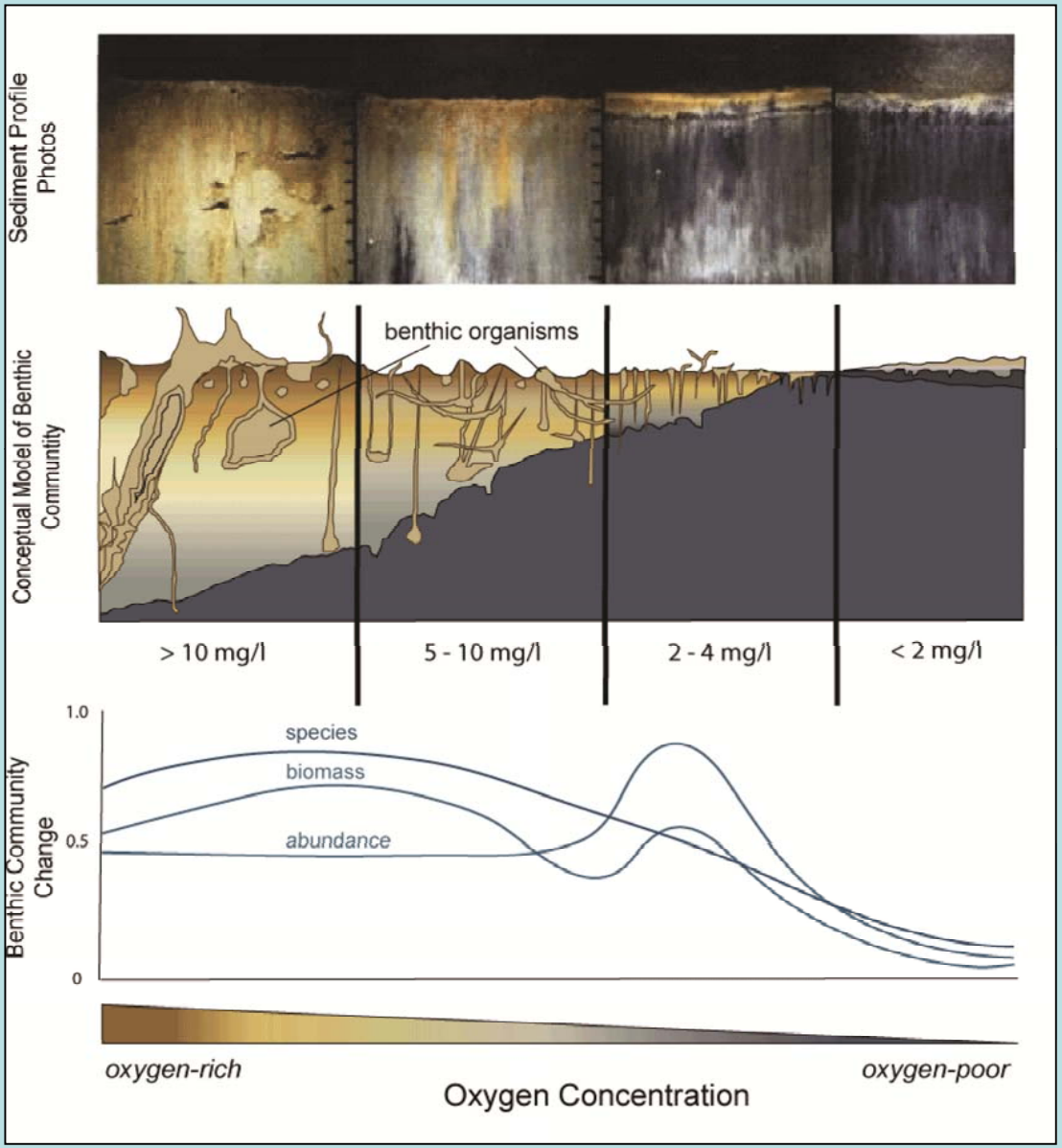
Conceptual Model of O_2 Interactions with N-Cycle



Conceptual Model of O_2 Interactions with P-Cycle

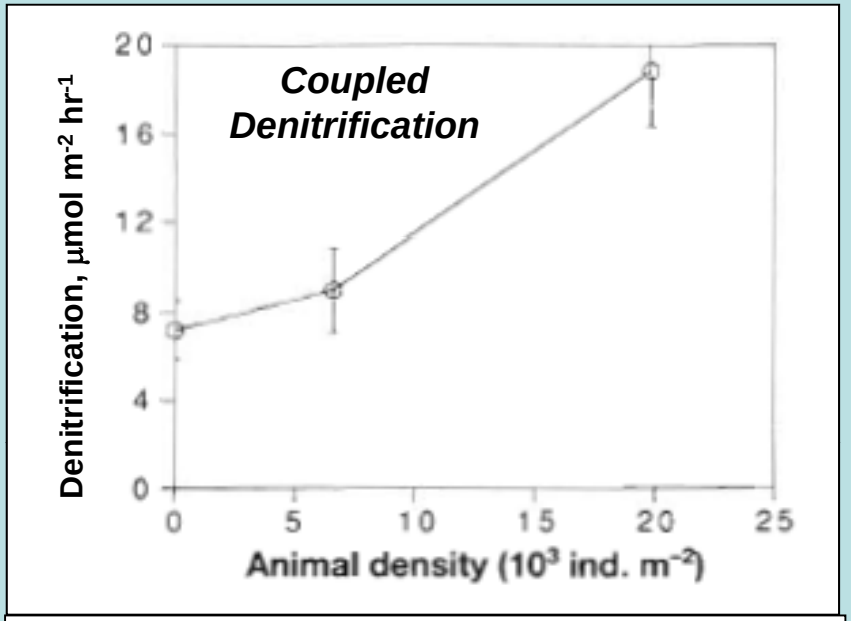


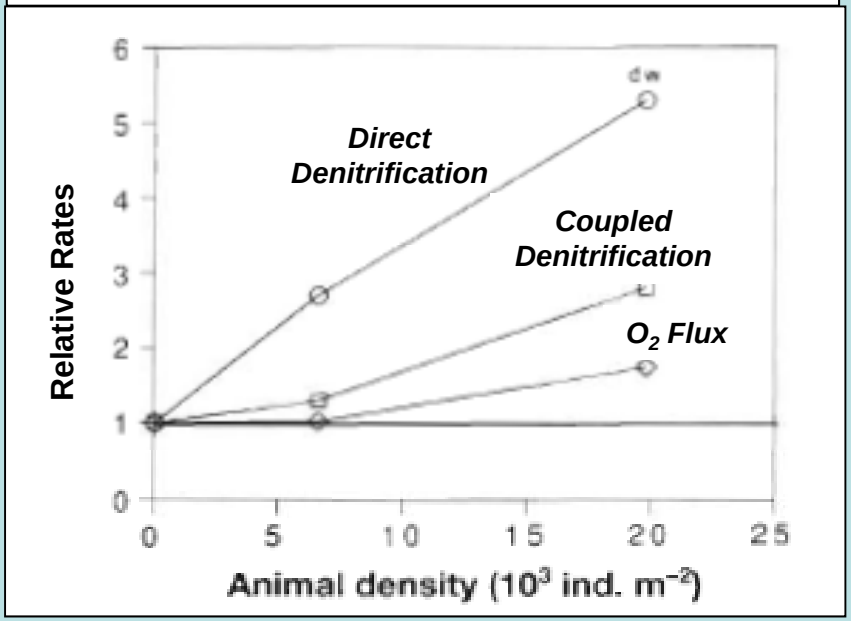
Benthic Macrofauna Bioturbation vs. Bottom O_2



(Nilsson & Rosenberg 2000)

Macrofauna Effects on Benthic N-Cycling

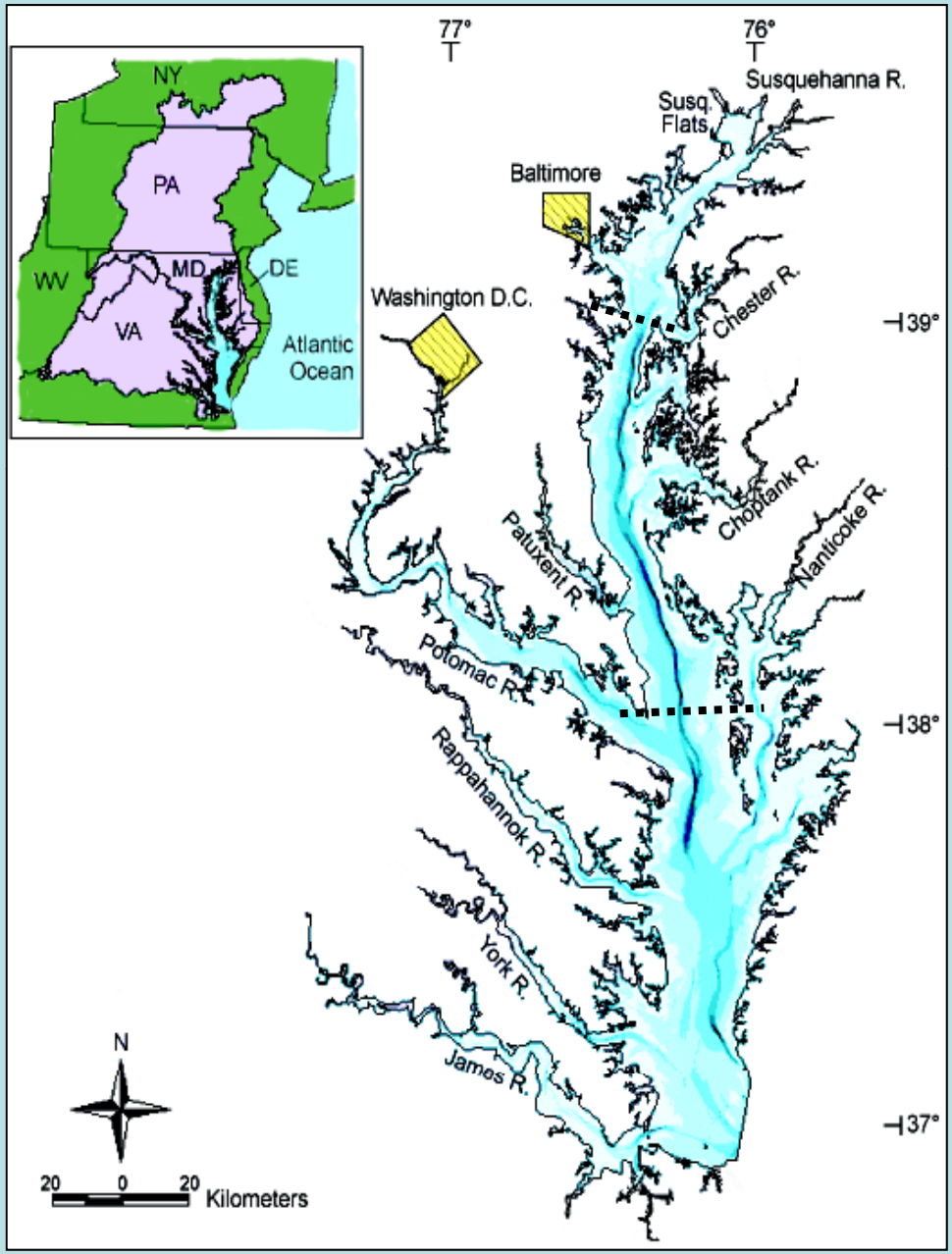




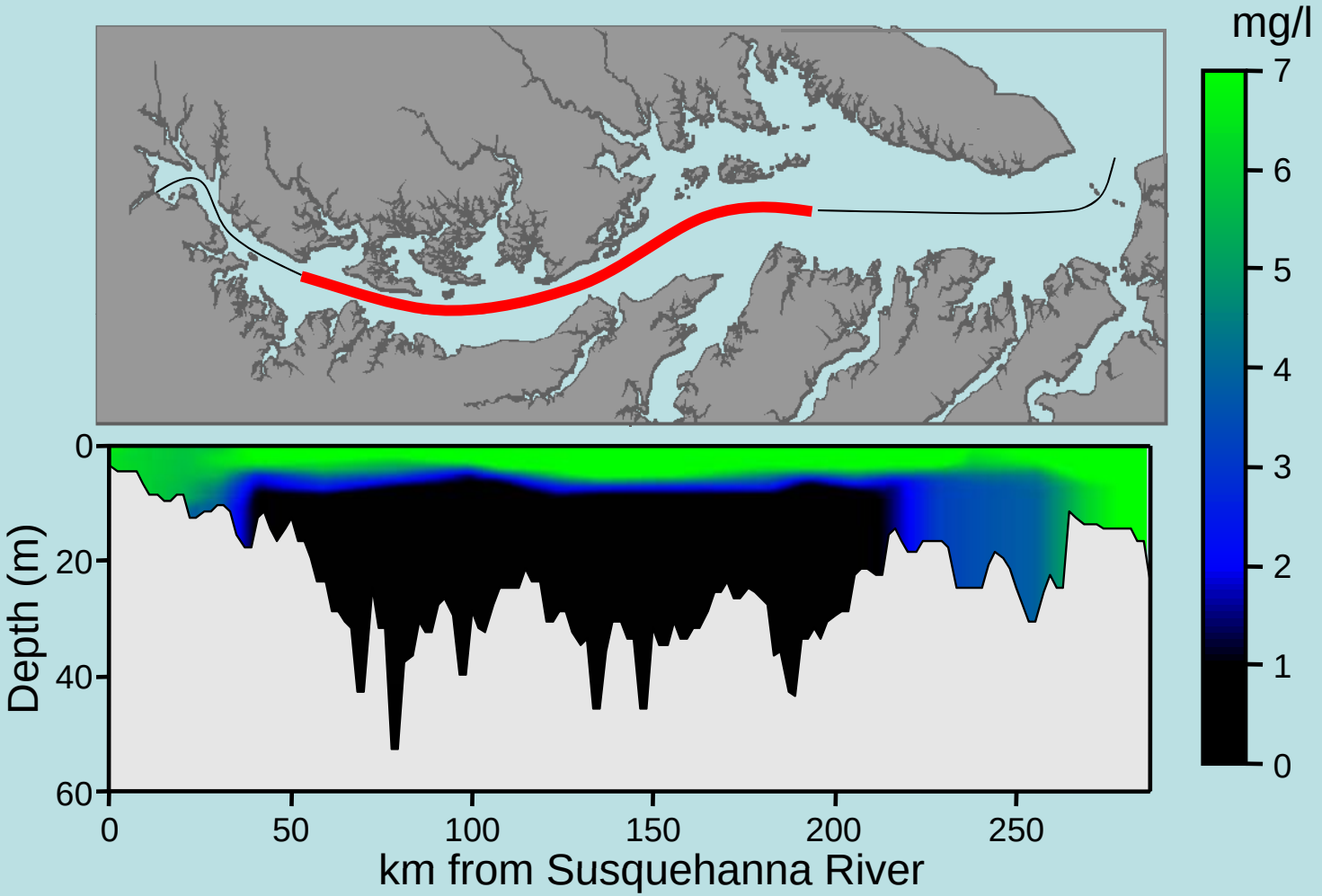
- Amphipods enhance denitrification
- Direct & Coupled nitrification-denitrification
- Enhancement → 8-fold

(Pelegri et al. 1994)

Chesapeake Bay and its Watershed

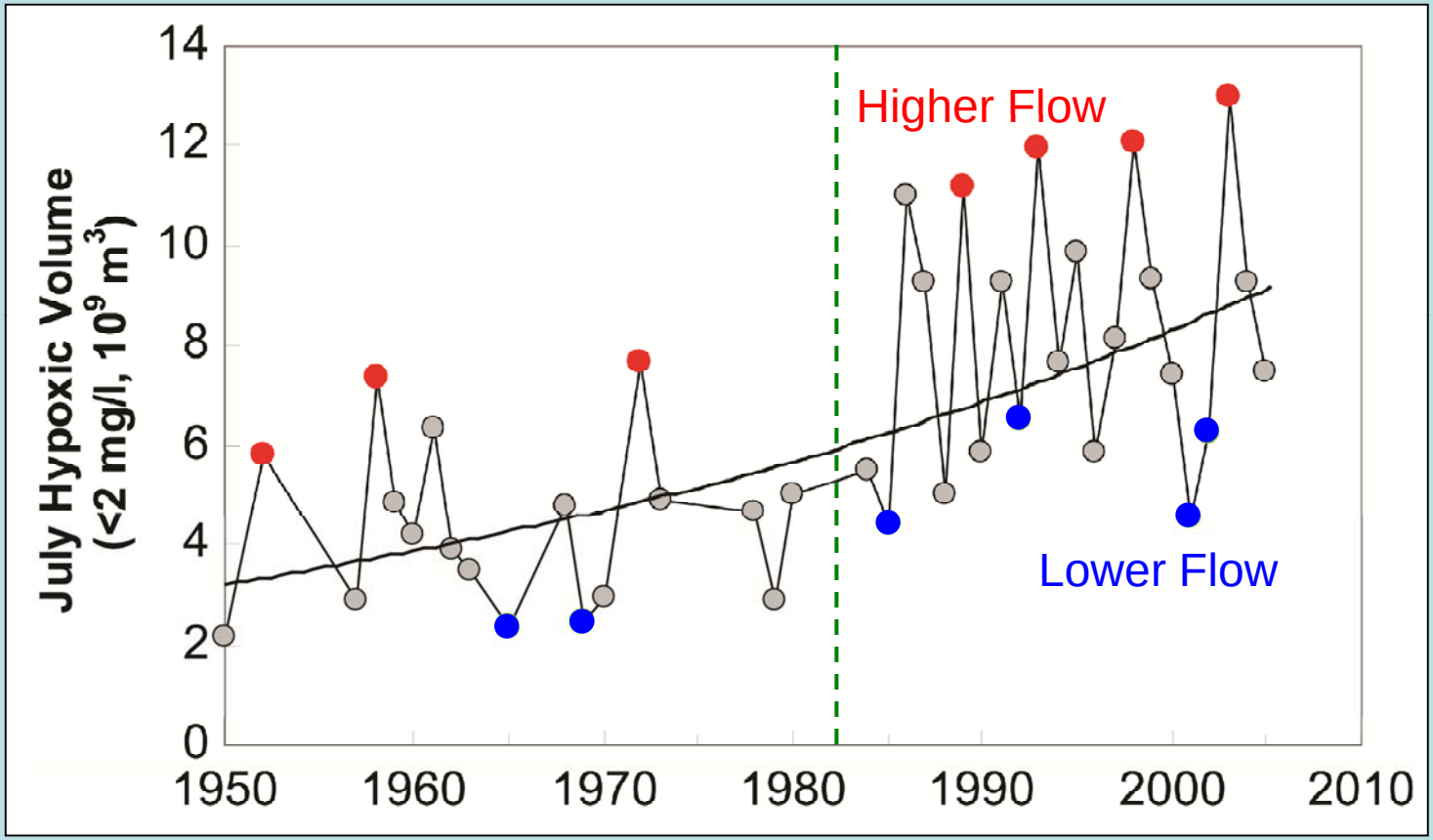


Location of Chesapeake Hypoxic Zone

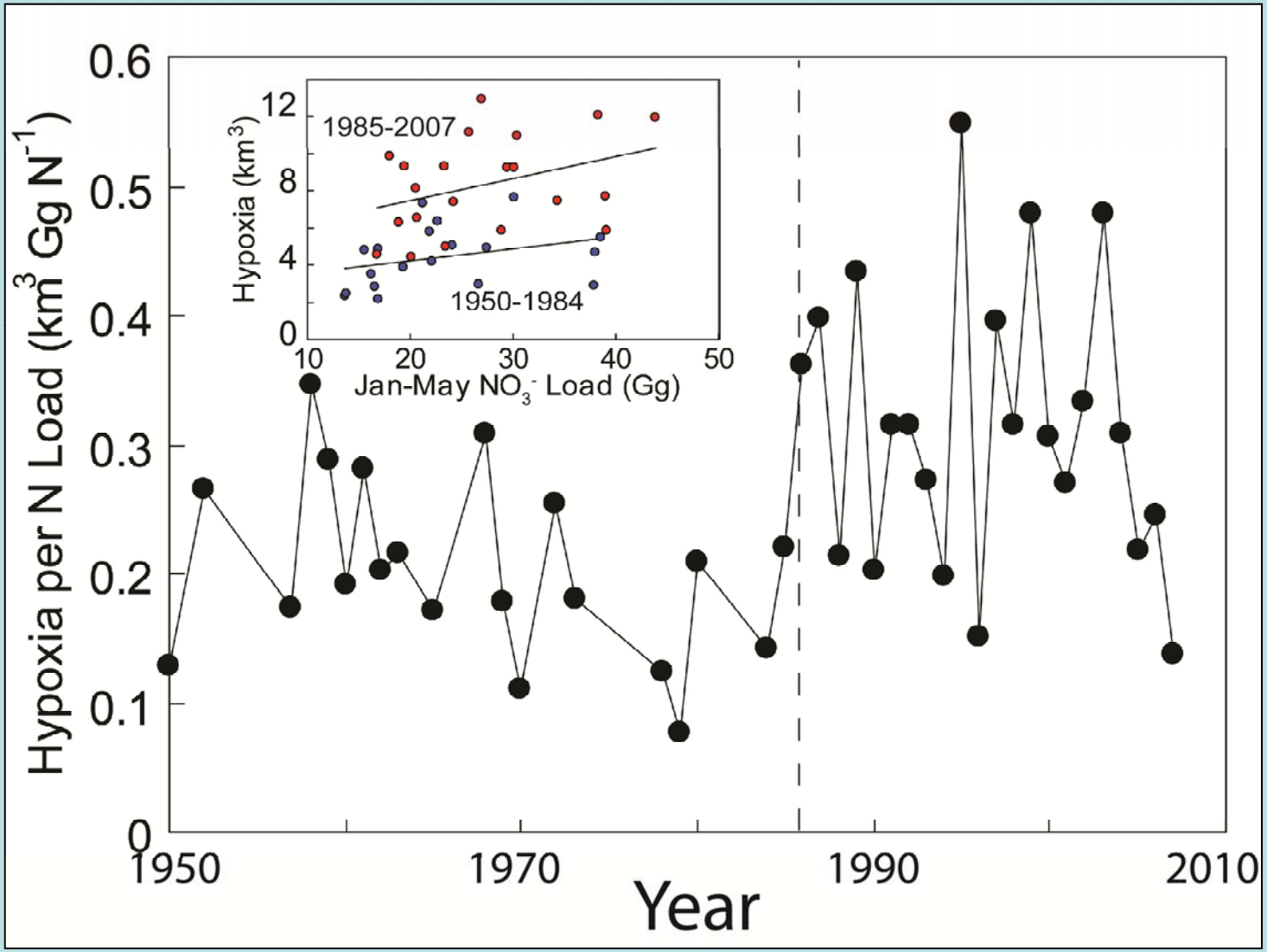


(Hagy 2002)

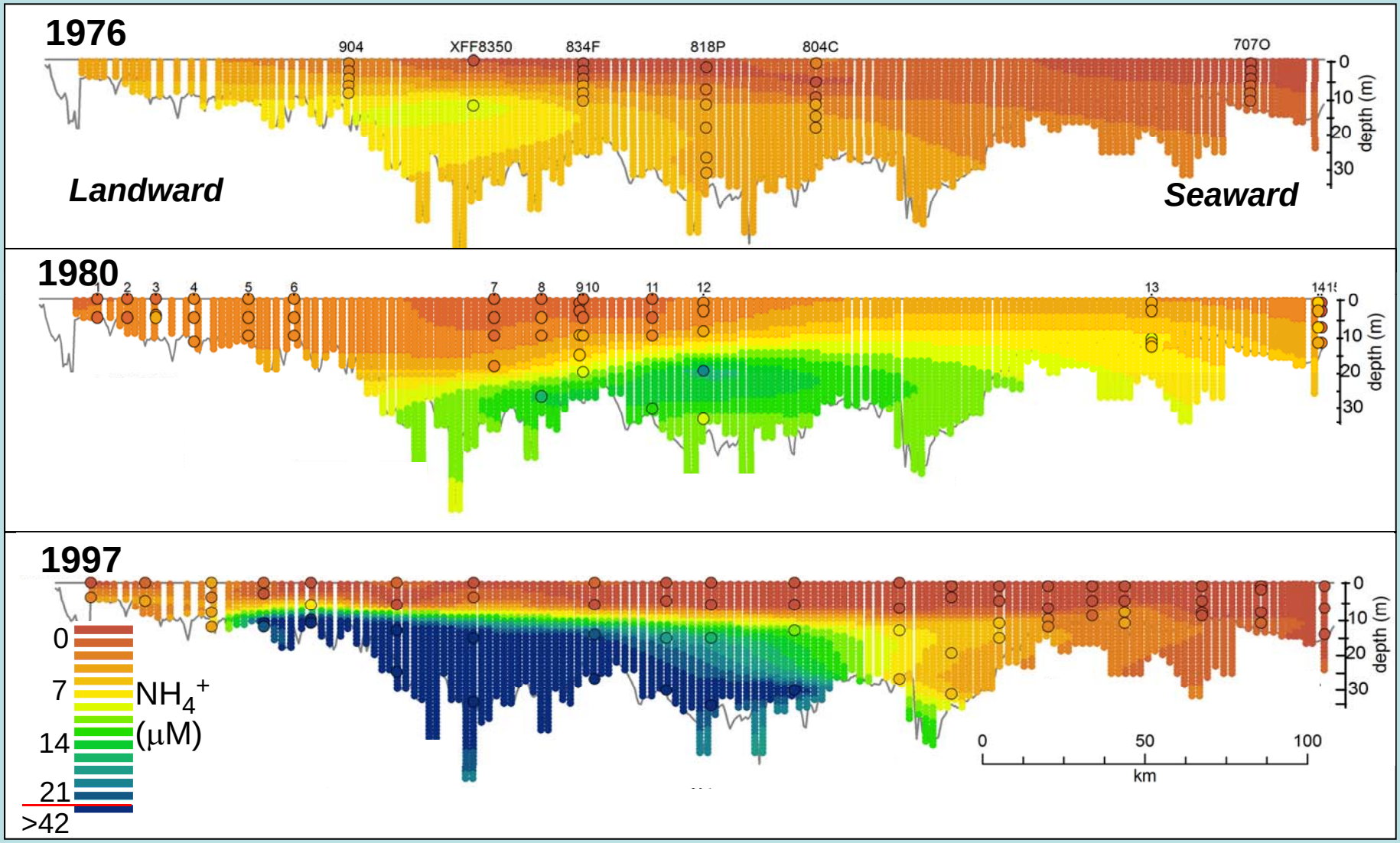
Trend in Bay July Hypoxic Volume



Shift in Hypoxia Volume per TN Loading

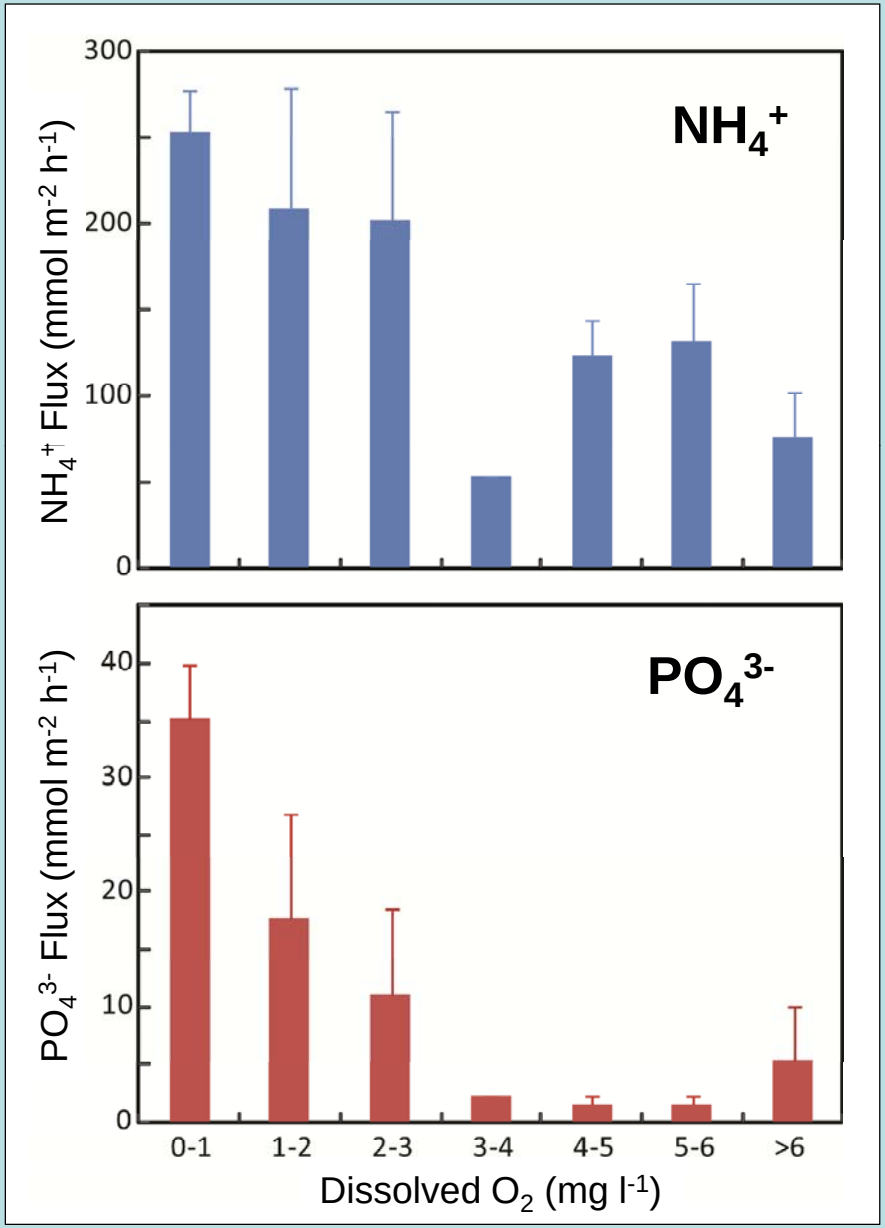


Decadal Change in Bay July [NH_4^+] Distribution



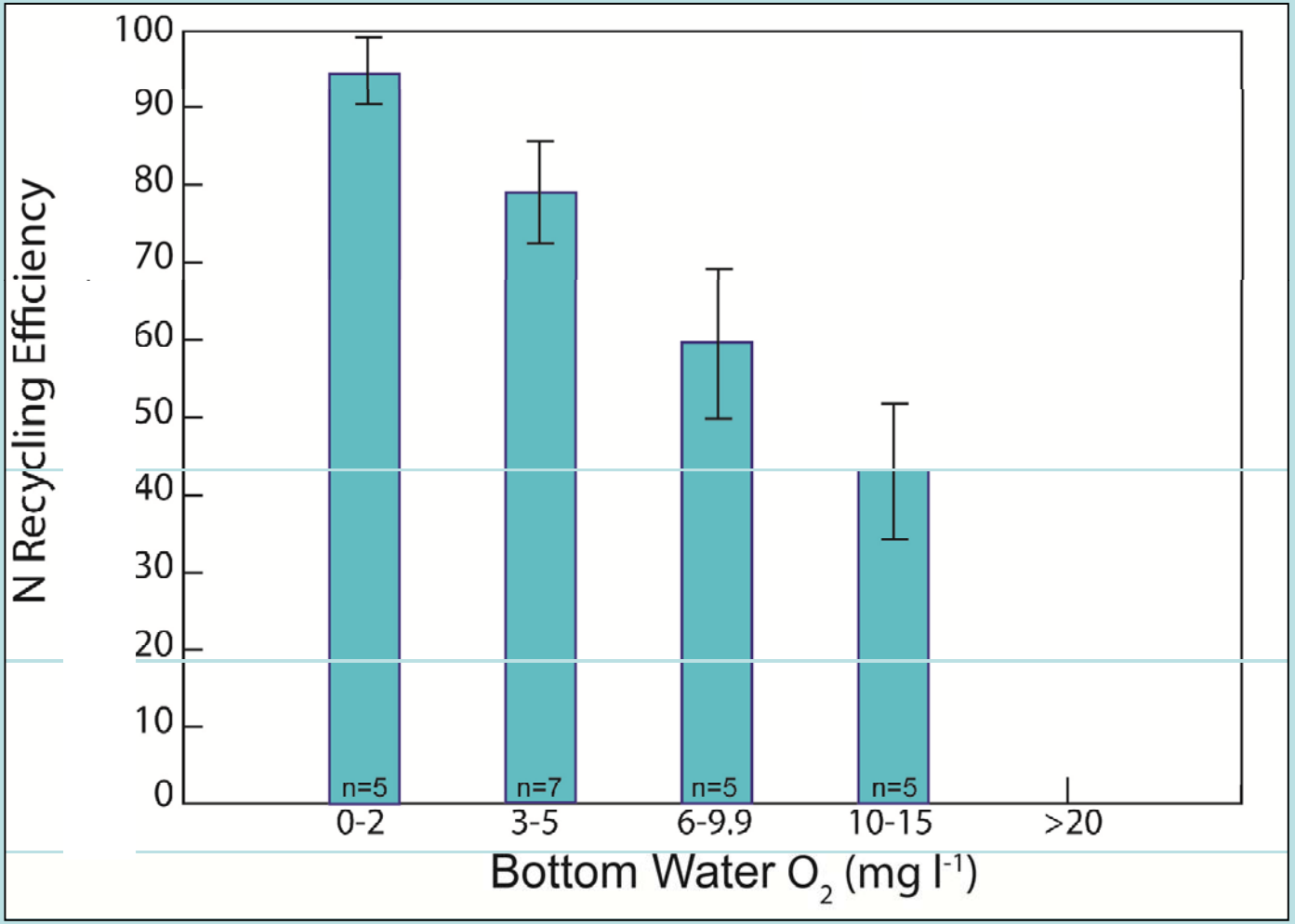
(Rebecca Murphy, JHU. unpublished)

Benthic Fluxes of NH_4^+ & PO_4^{3-} vs. Bottom O_2



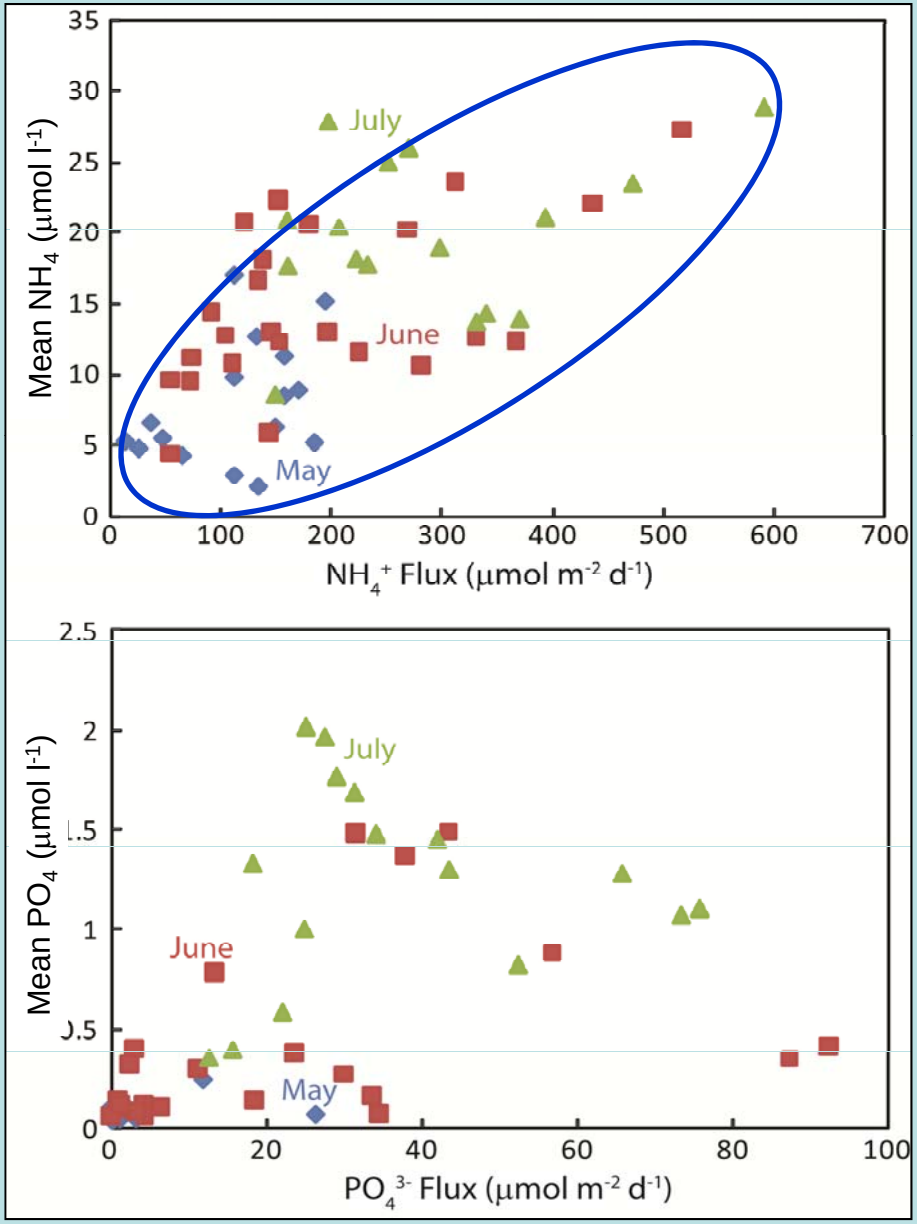
Nitrogen Recycling Efficiency vs. Bottom O_2

Efficiency = [($Flux_{NH4}$) / ($Flux_{N2}$ + $Flux_{DIN}$)]

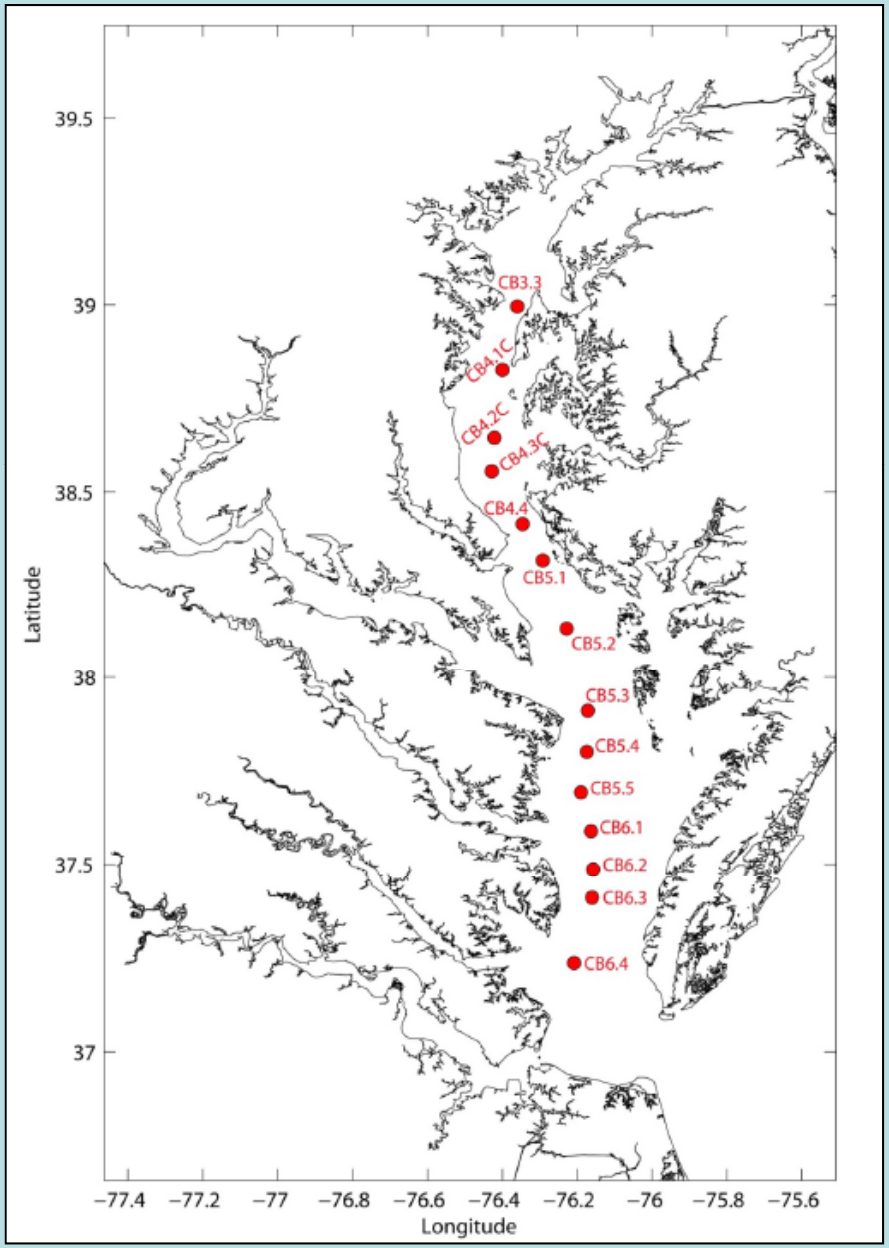


(Boynton and Kemp 2008)

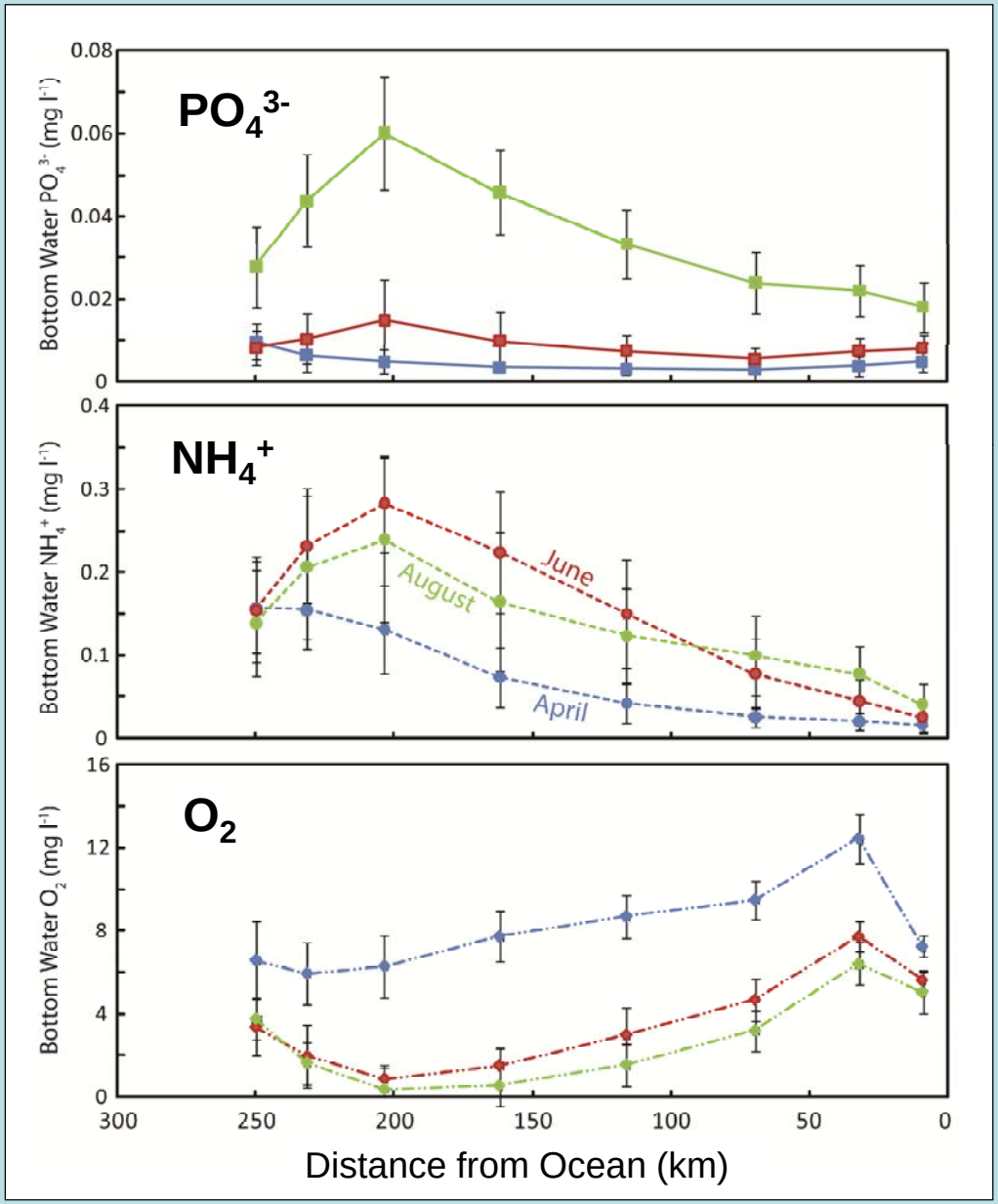
NH_4^+ & PO_4^{3-} Benthic Fluxes vs. Bottom Pools



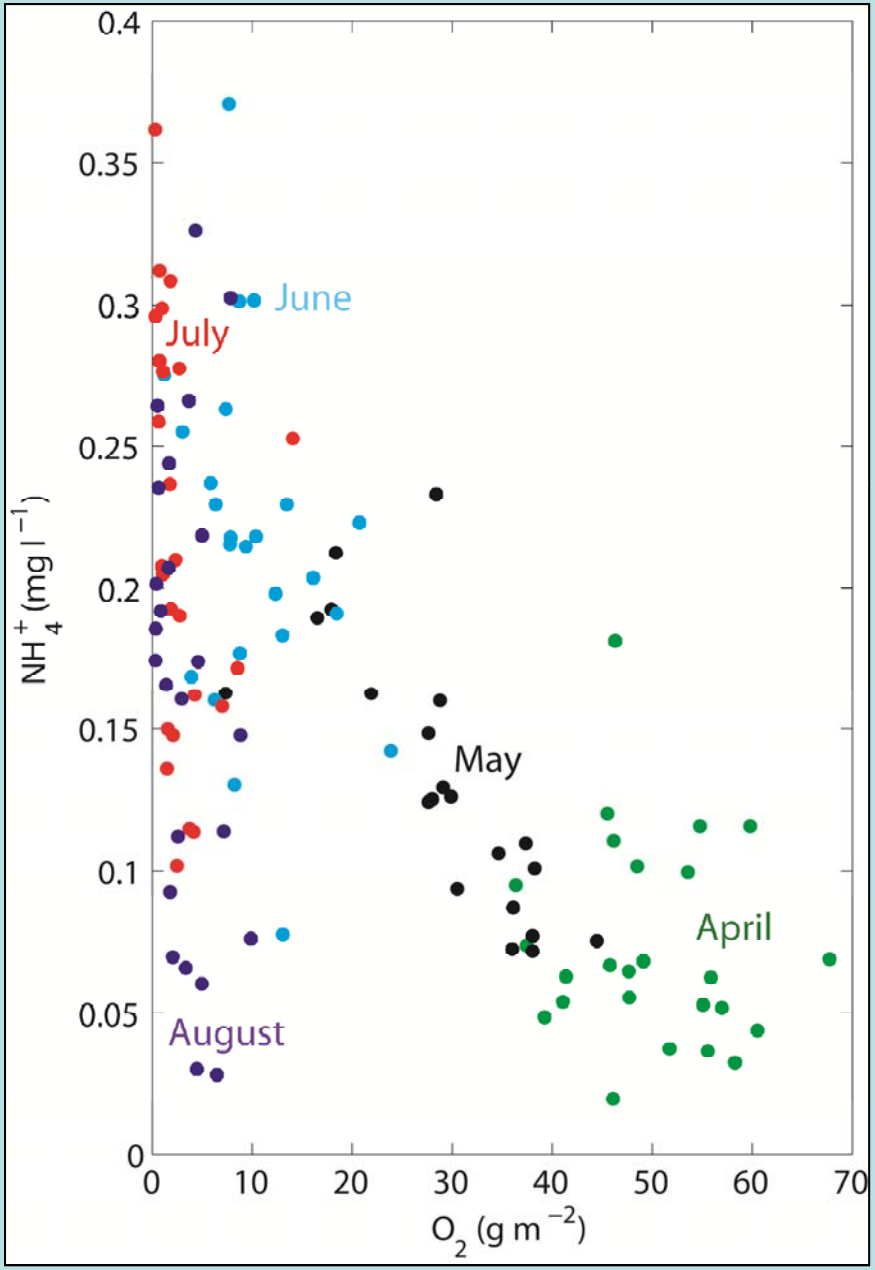
Chesapeake Bay Key Monitoring Stations

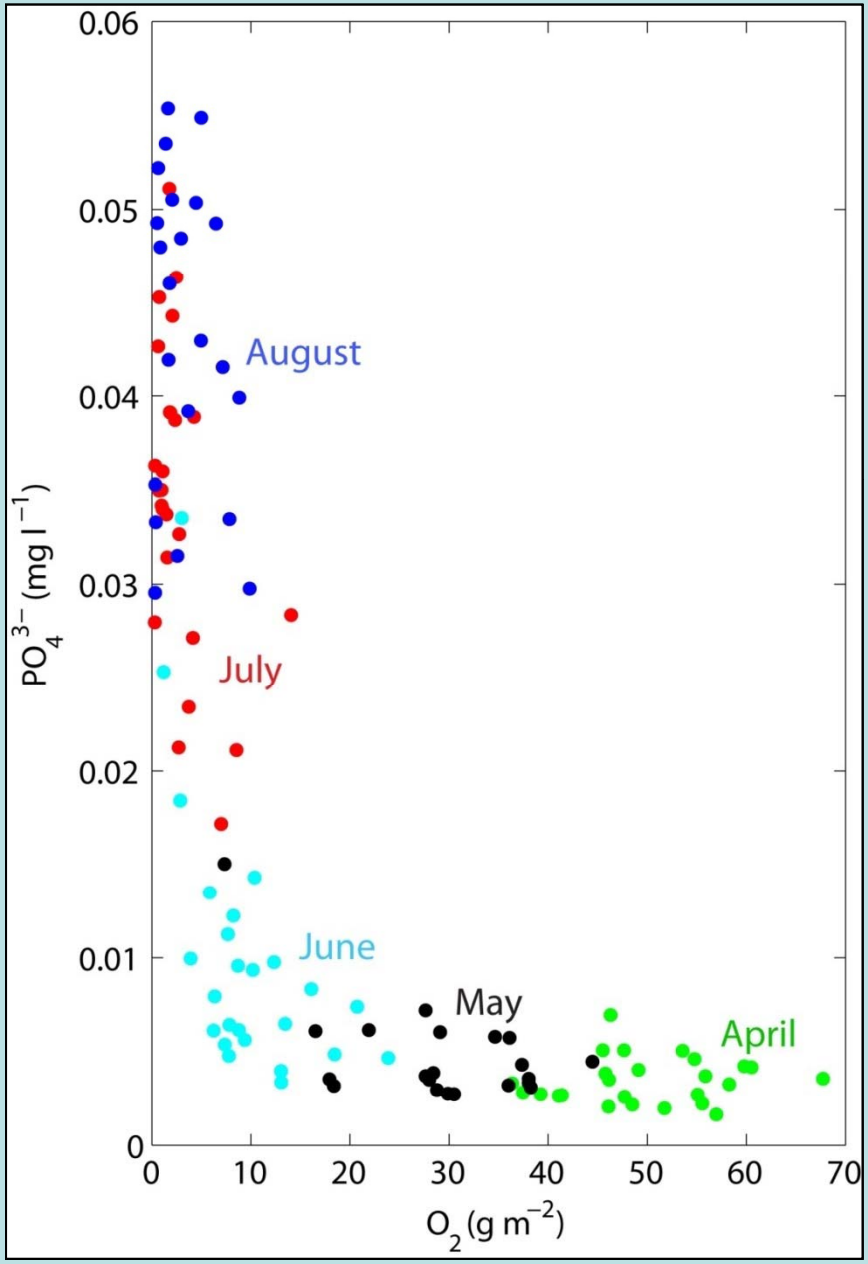


Time-Space Distributions of Bottom O_2, NH_4 & PO_4

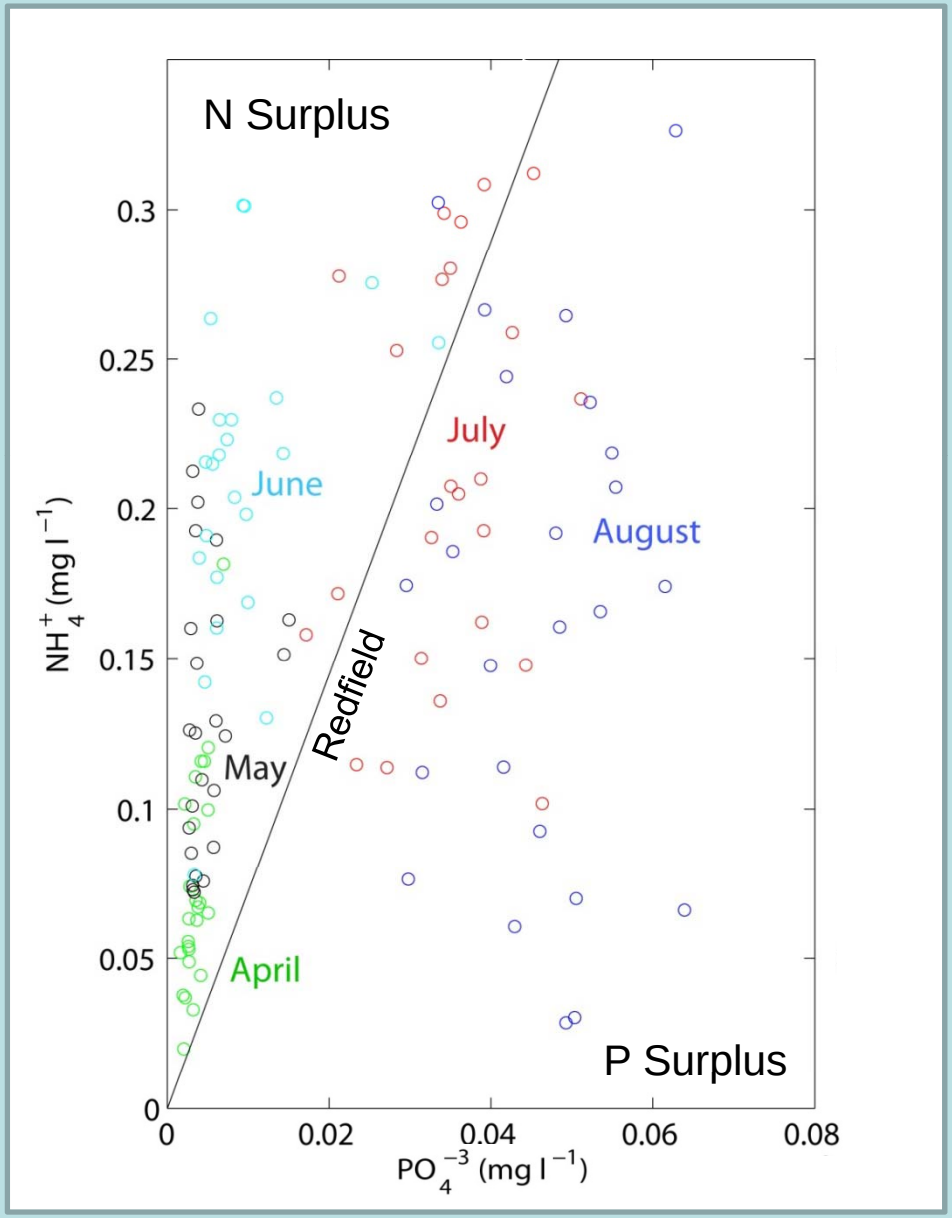


Seasonal Trends in Bottom NH_4^+ & PO_4^{3-} vs. O_2

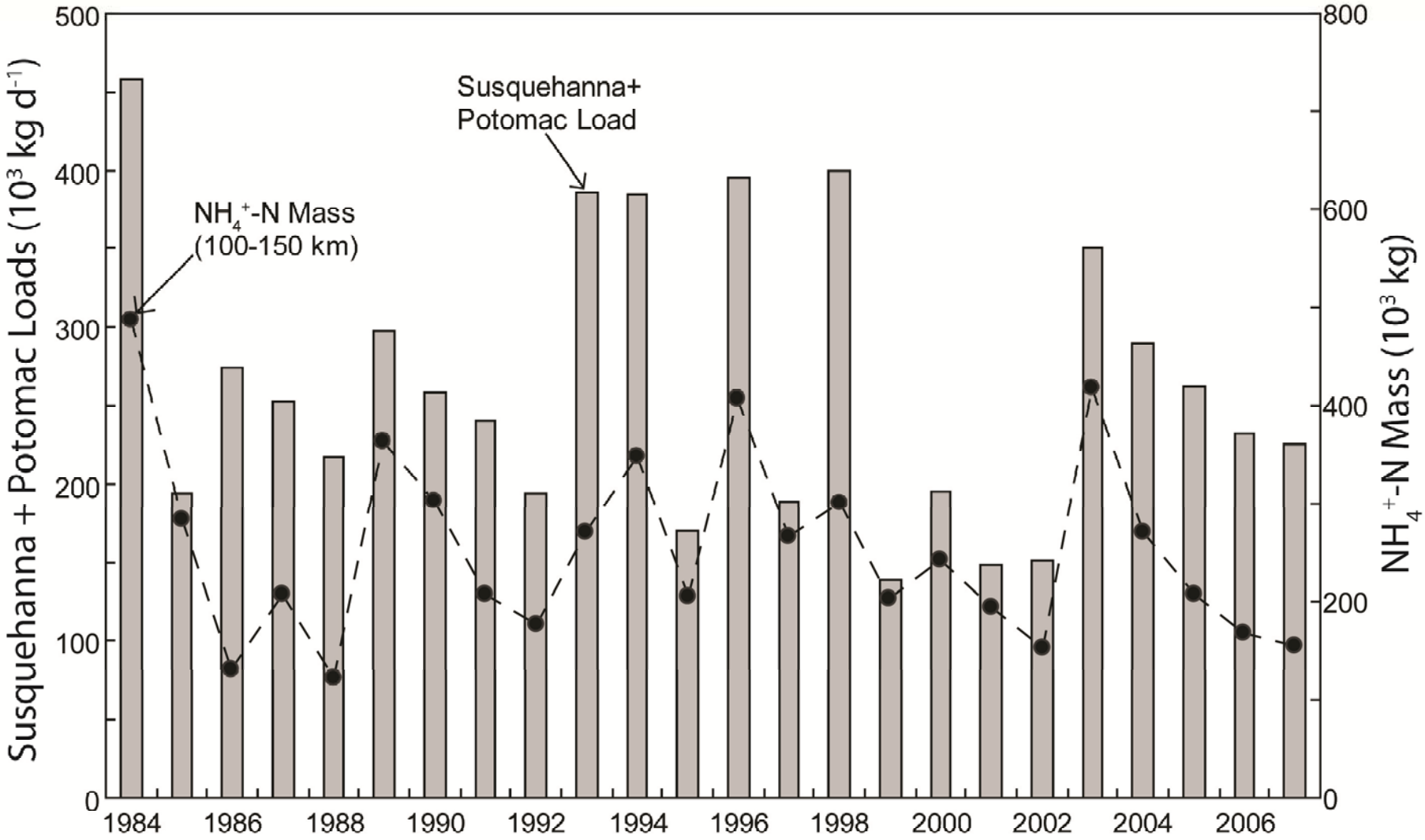




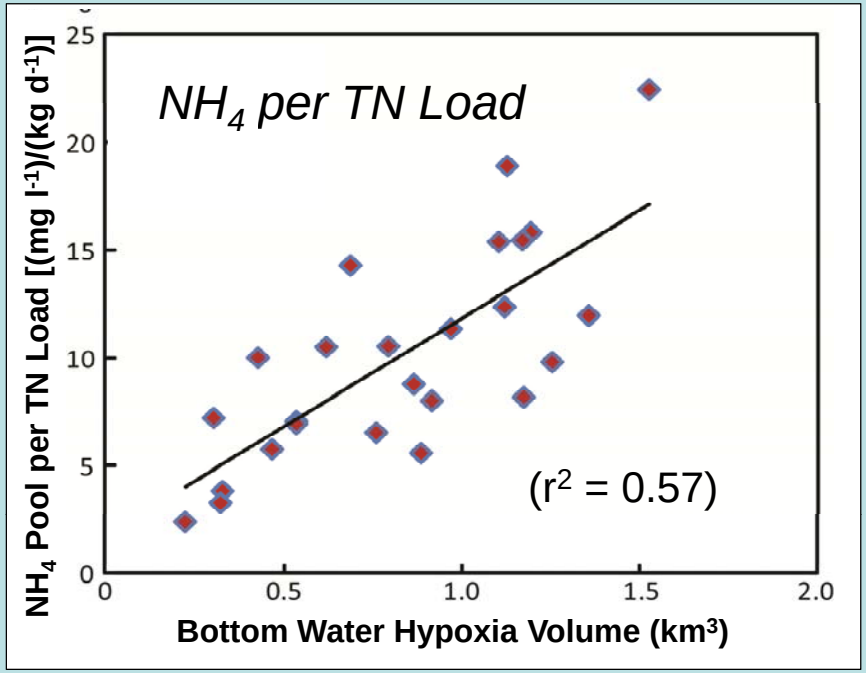
Temporal Mismatch in Fluxes Drives N:P Ratios

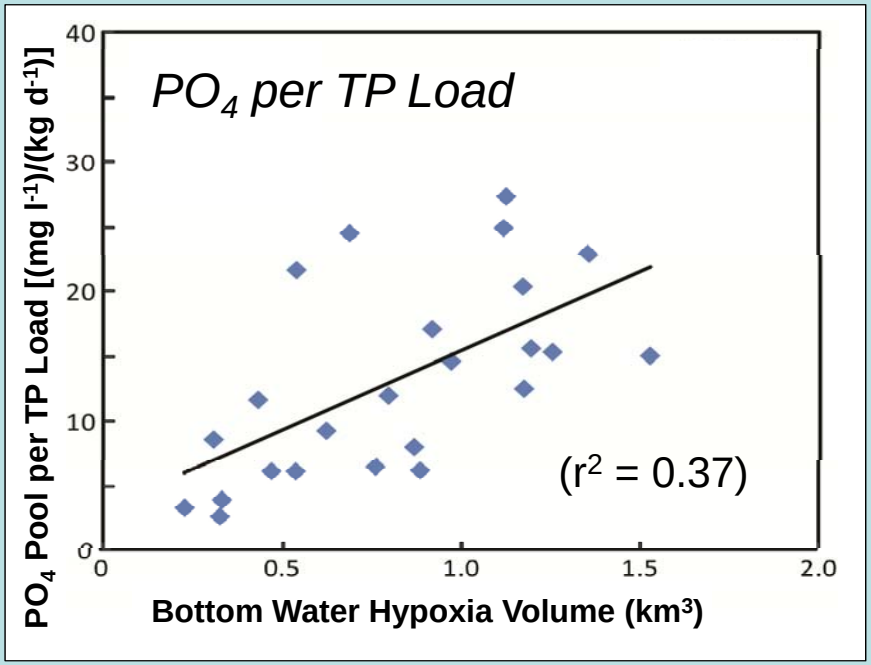


Yearly Variations in N Loading & Bottom N Pools

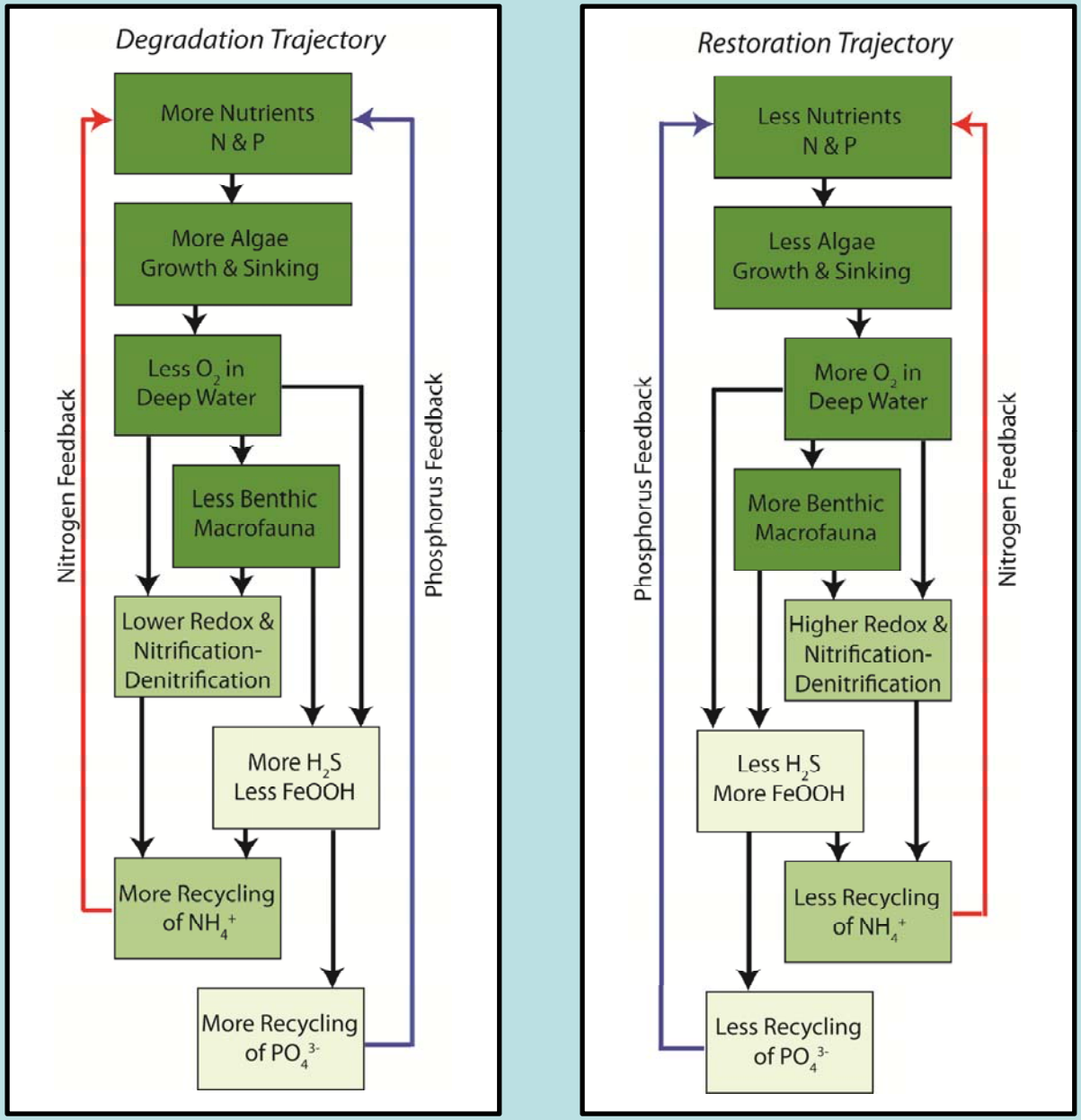


Nutrient Pools per Load vs. Hypoxia Volume





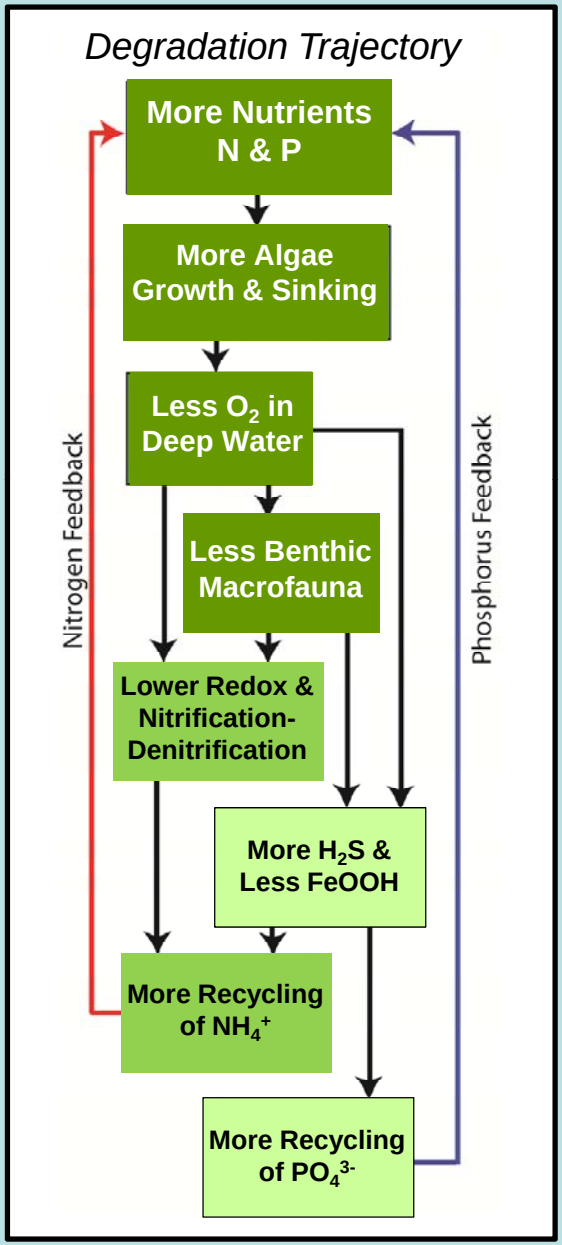
Feedback Effects Linking Hypoxia & Nutrients

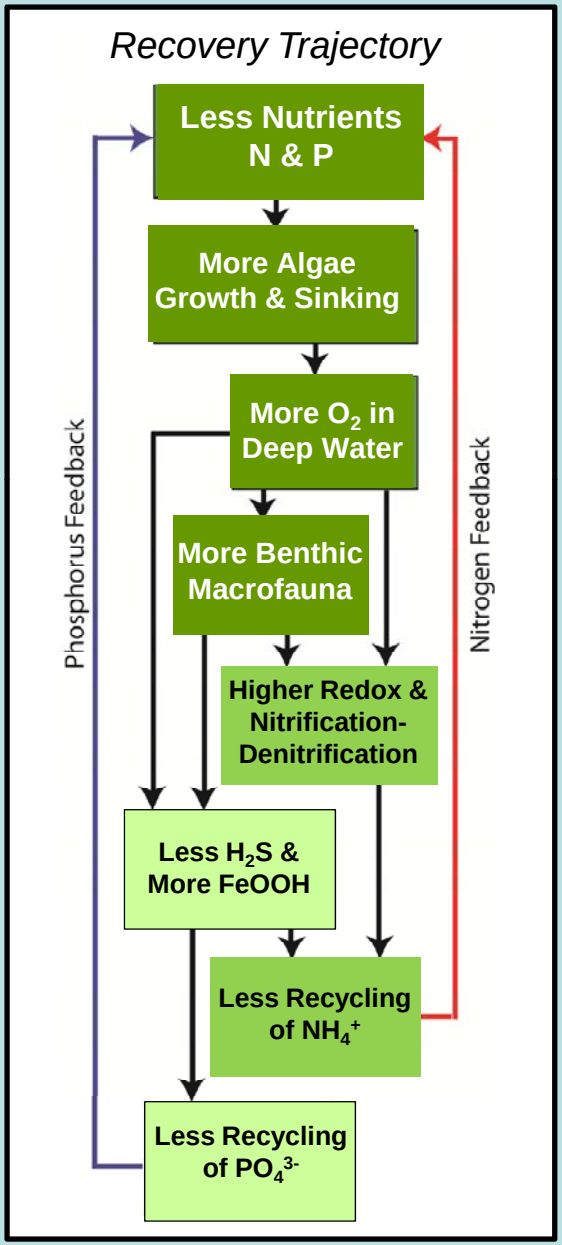


Concluding Comments

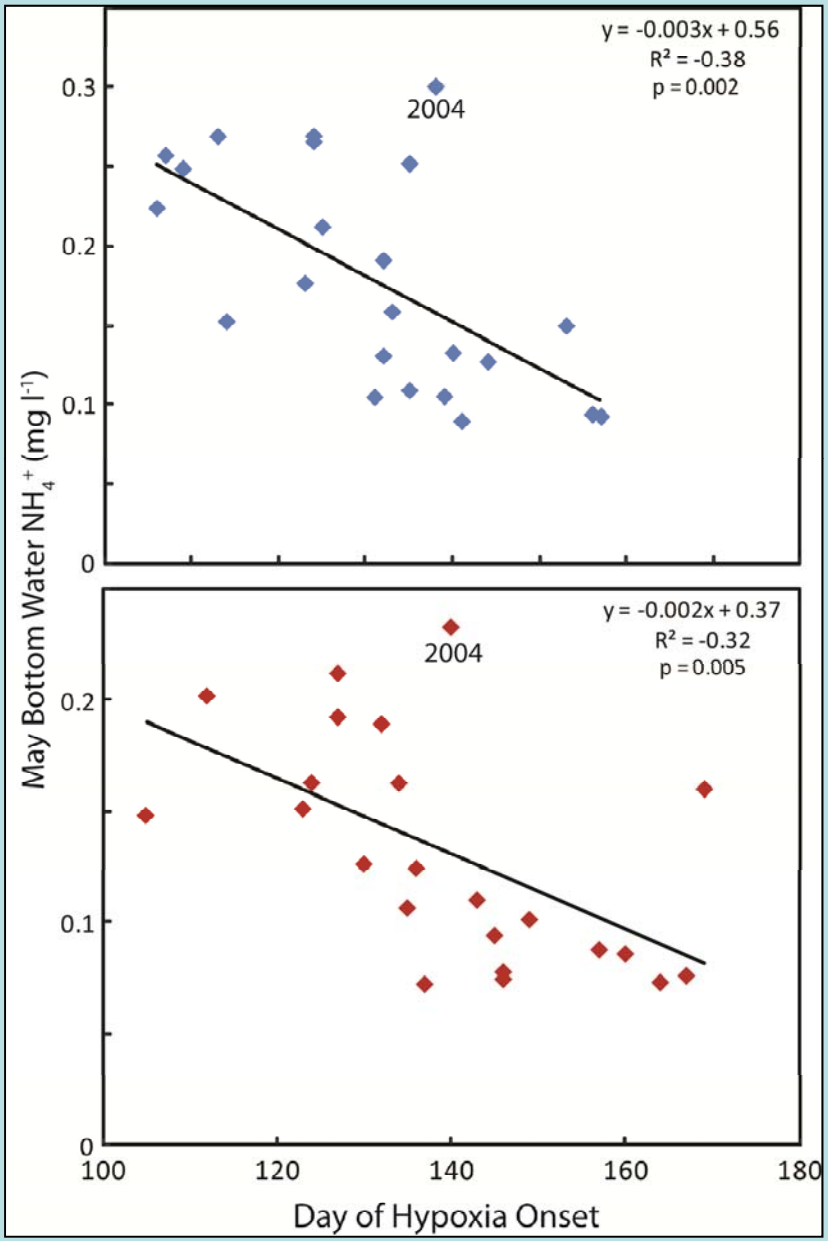
- Coastal Hypoxia is Global Problem Associated with Eutrophication
- Nutrient recycling and its link to low O_2 may affect recovery of hypoxic systems
- Chesapeake Bay hypoxia enhances N and P Recycling
- Low-O_2 effects on nutrient recycling enhance both degradation and recovery

Feedback Effects Linking Hypoxia & Nutrients

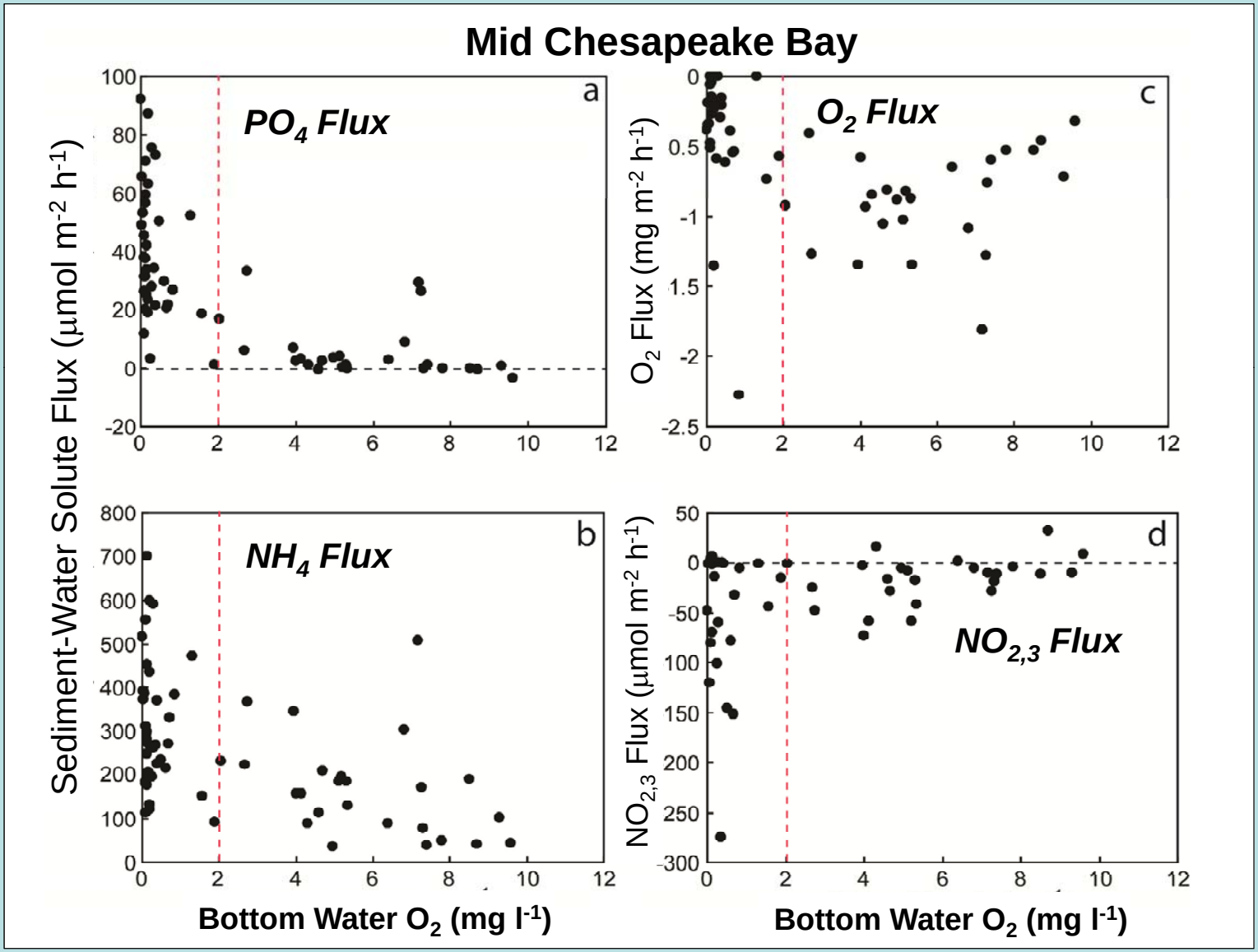




Bottom NH_4^+ Pools vs. Date of Hypoxia Onset

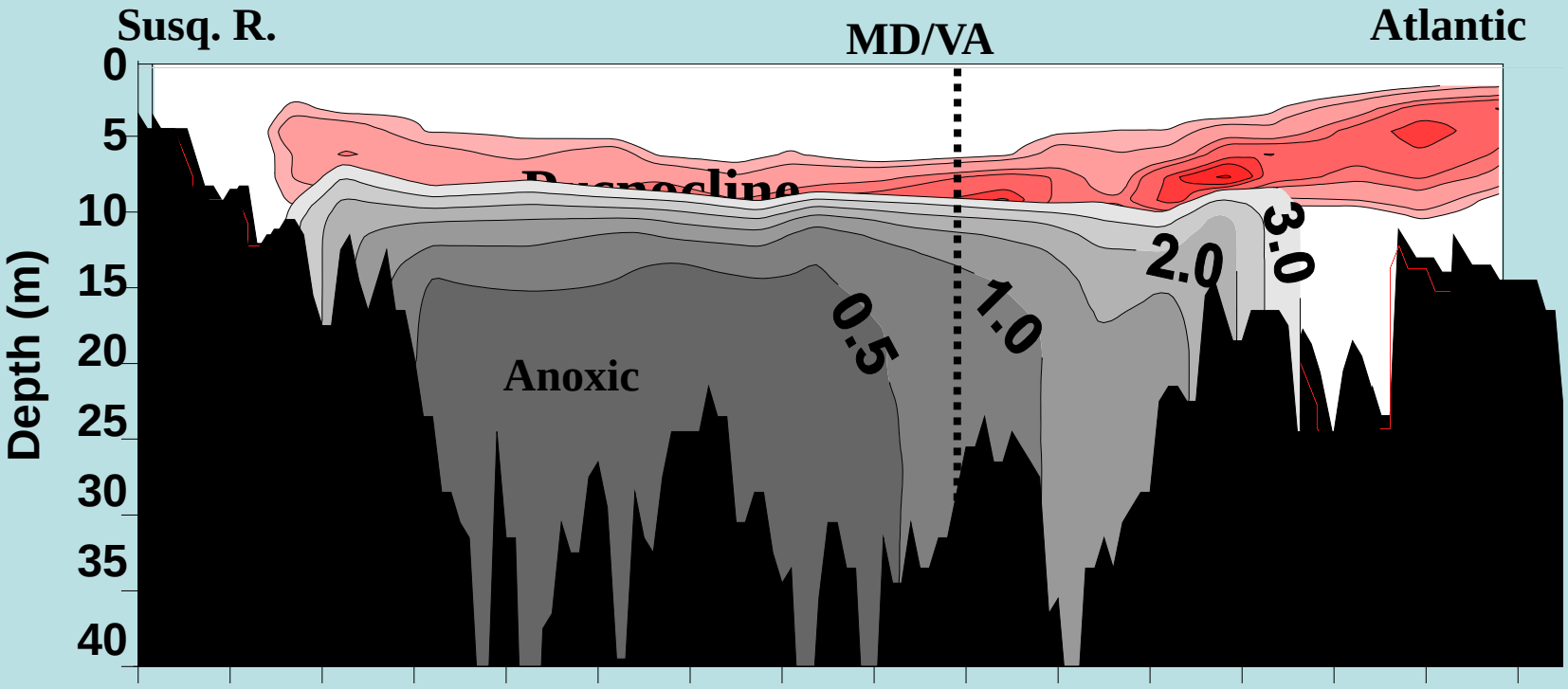


Mid-Bay Benthic Solute Fluxes vs. Bottom O_2



(Boynton et al. unpublished)

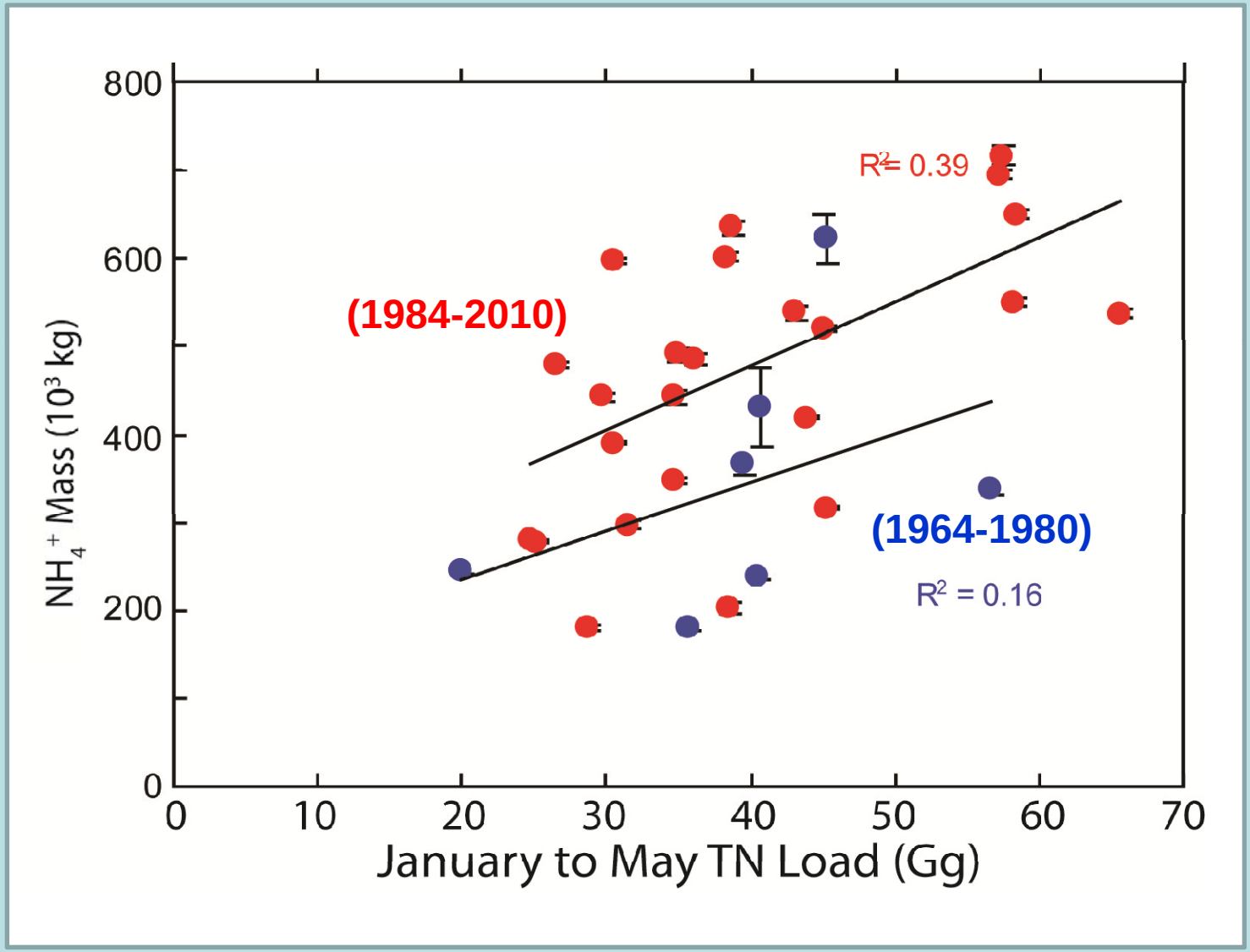
Stratification Control of Hypoxia



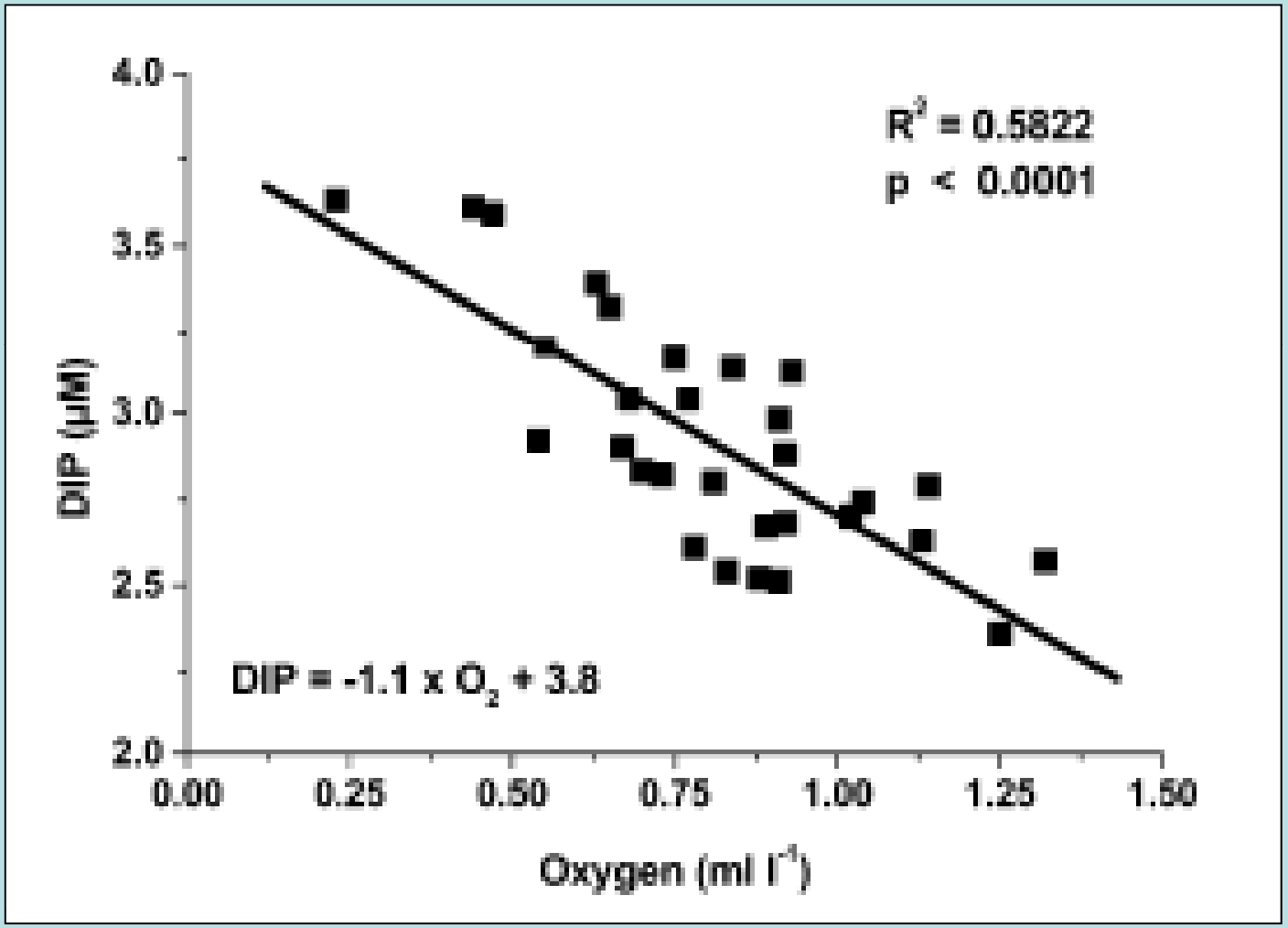
- Pynocline controls position & intensity of low O_2 water.
- Landward transport replenishes deep O_2 pools.

(Hagy 2002)

Shift in Bottom NH_4^+ Pool vs. TN Loadings?



PO_4^{3-} vs. O_2 in Baltic Sea Bottom Waters



(Conley et al. 2002)