I thought NITROGEN was a good thing?

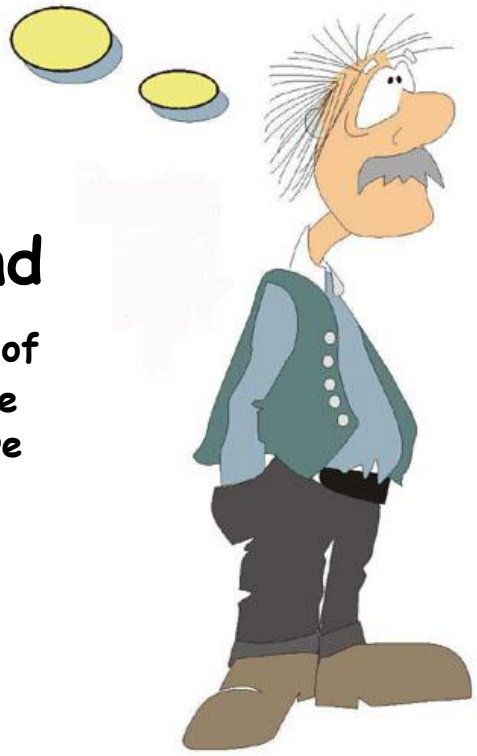
N x magic = fish

Has the Bay passed a tipping point?

All this stuff is so complicated

Do we need to do anything yet…is it that bad?

Is hypoxia such a bad thing?



Envisioning the Ecosystem Present and Future:

What are the drivers of water and habitat quality within the Bay, and what is the possible future given what we know?

in 20 minutes or less!

STAC Retreat
March, 2012

Major Points for this Talk

- Scary Things Going on in Bay and Watershed

- Signs of Hope in the Bay and Watershed

- System Responses to Management Actions…a guide to the future

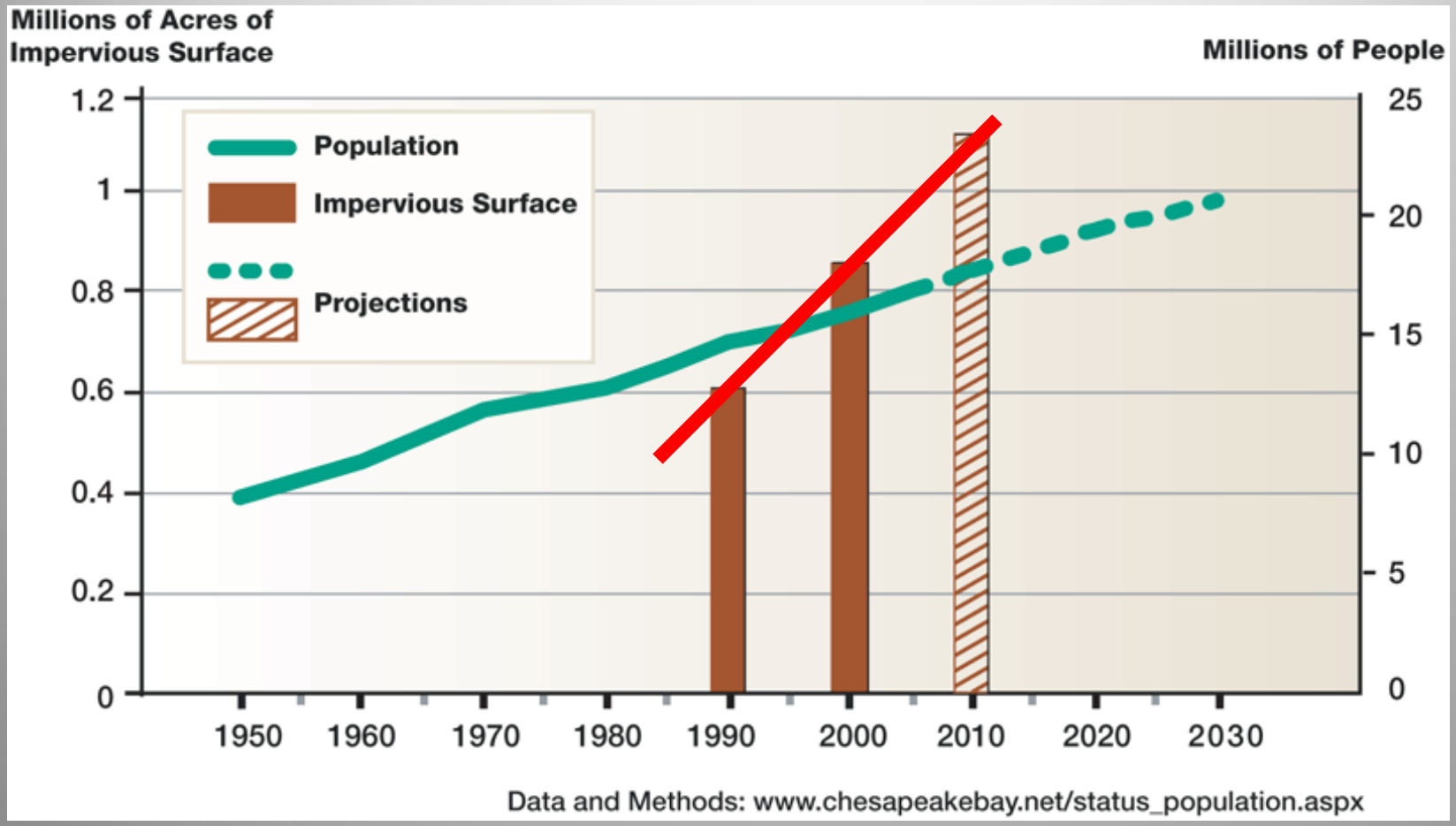
Patuxent River Estuary Circa 1832

"So transparent are its waters that far out from shore you may see, in the openings of the sea-weed forest, on its bottom the flashing sides of the finny tribe as they glide over the pearly sands." *The Old Plantation by Hungerford (1859)*

Water Quality and Habitat Conditions could be much improved…likely not to the 1832 condition and that may not be the optimal status

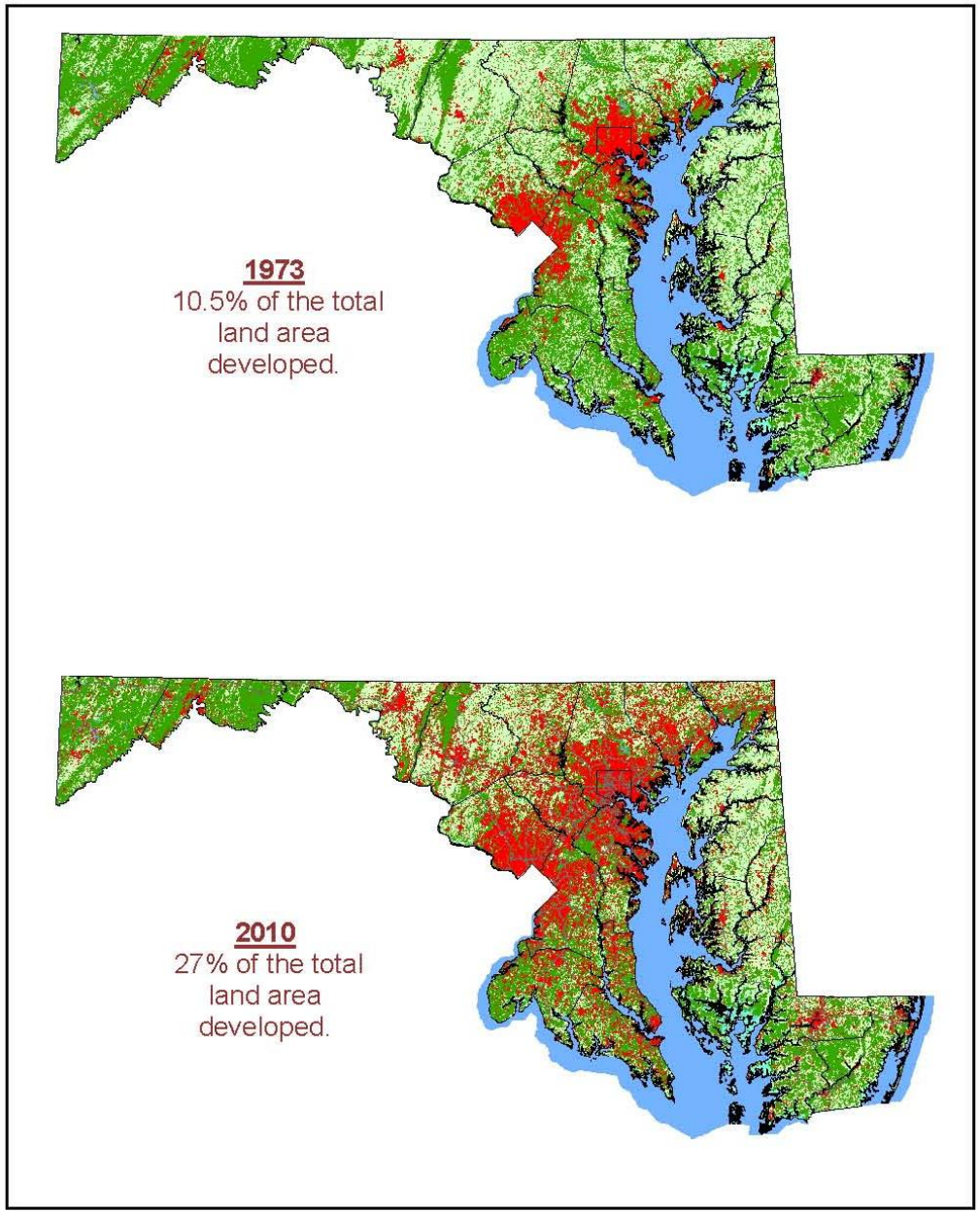
Water Quality could get worse…. there is room for plenty of additional degradation

Bay Watershed Population and Impervious Surface

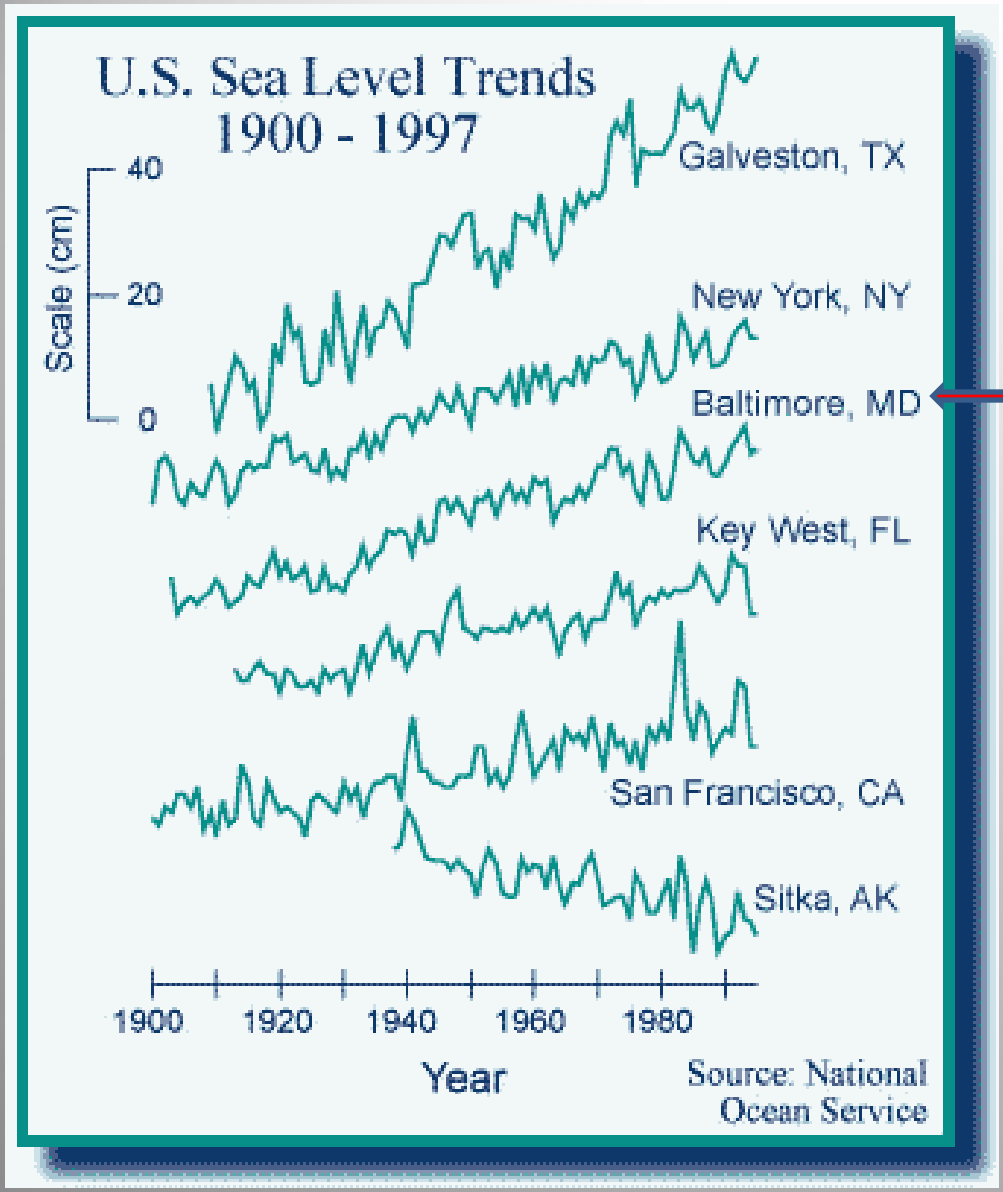


Conversion of land for DEVELOPMENT since 1970 has grown at double the rate of housing and triple the rate of population

Housing Developments



http://planning.maryland.gov/PDF/OurWork/LandUse/MDP2010_LU_Summary.pdf



Sea level has risen worldwide approximately *15-20 cm (6-8 inches)* in the last century.

Climate Projections for the Mid-Atlantic Region

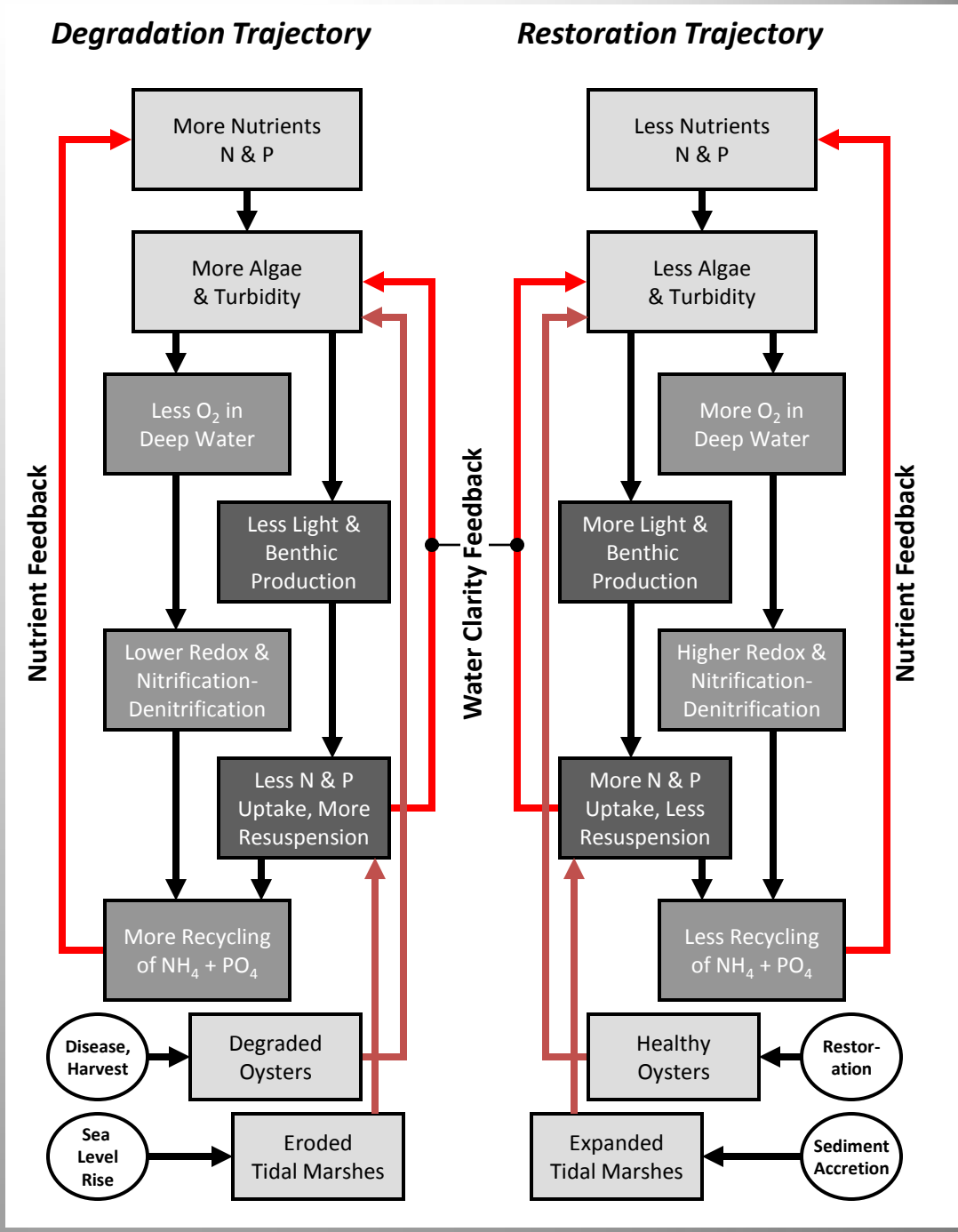
Parameter	2030	2095	Confidence in Projection
CO_2 (ppm)	+20 to +30	+50 to +120	Very high
Sea Level (inches)	+4 to +12	+15 to +40	High
Temperature (^{0}F)[c]	+1.8 to +2.7	+4.9 to +9.5	High
Precipitation (%)[c]	-1 to +8	+6 to +24	Medium
Runoff (%)[d]	-2 to +6	-4 to +27	Low

c Range given by Hadley and CCC models for the Northeast U.S.
d For the Susquehanna River Basin, using a water balance model forced with the CCC and Hadley output

Degradation and Restoration Trajectories

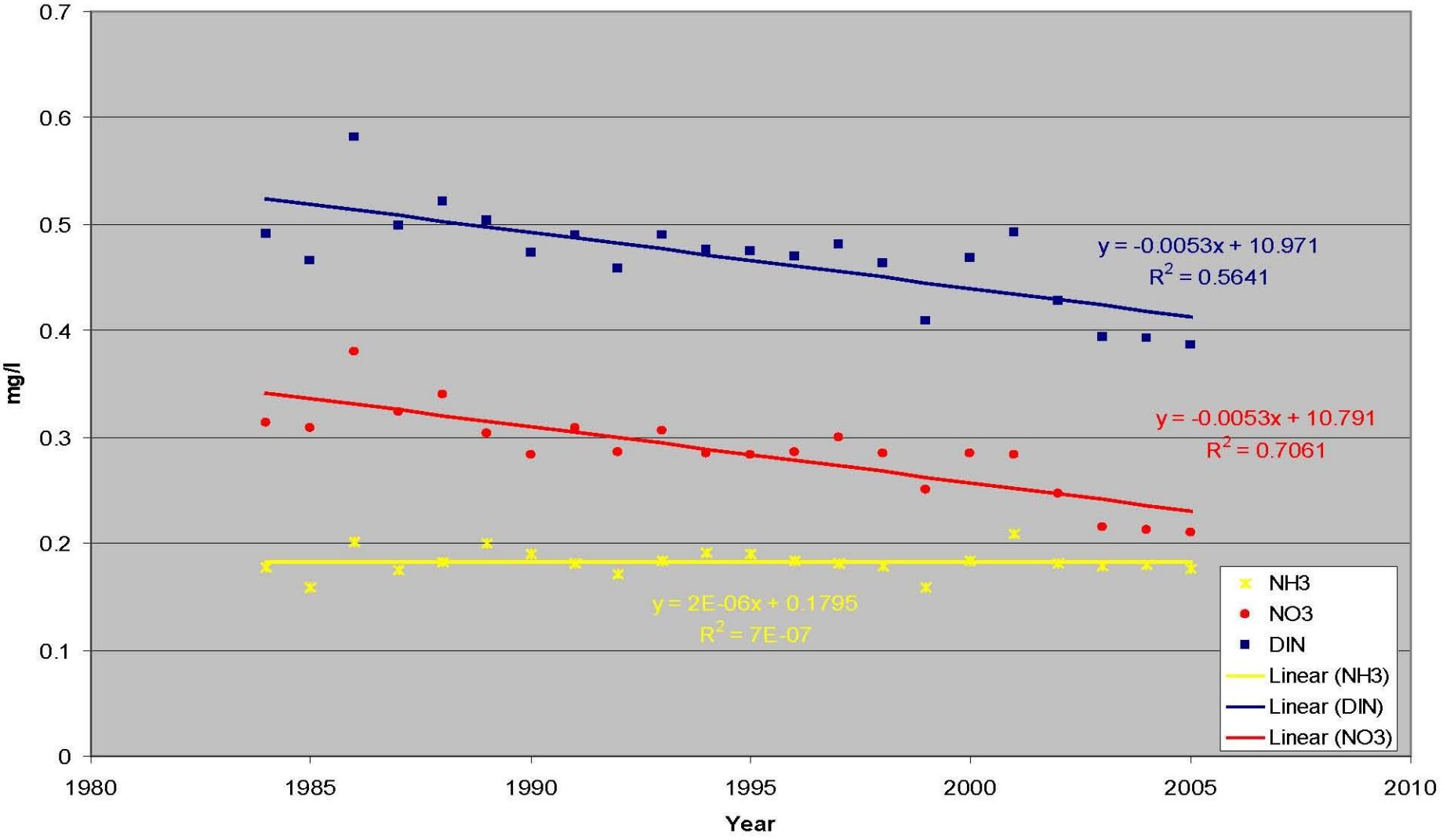
- Positive & negative feedbacks control ecosystem changes
- Among other mechanisms, N & P inputs affect hypoxia & light
- Hypoxia leads to more nutrients, more algae & more hypoxia
- Turbidity leads to less SAV causing more turbidity, less SAV
- Oysters & marshes tend to reinforce these feedbacks
- Processes reverse with restoration thus reinforcing positive trends

(Kemp et al. 2005)

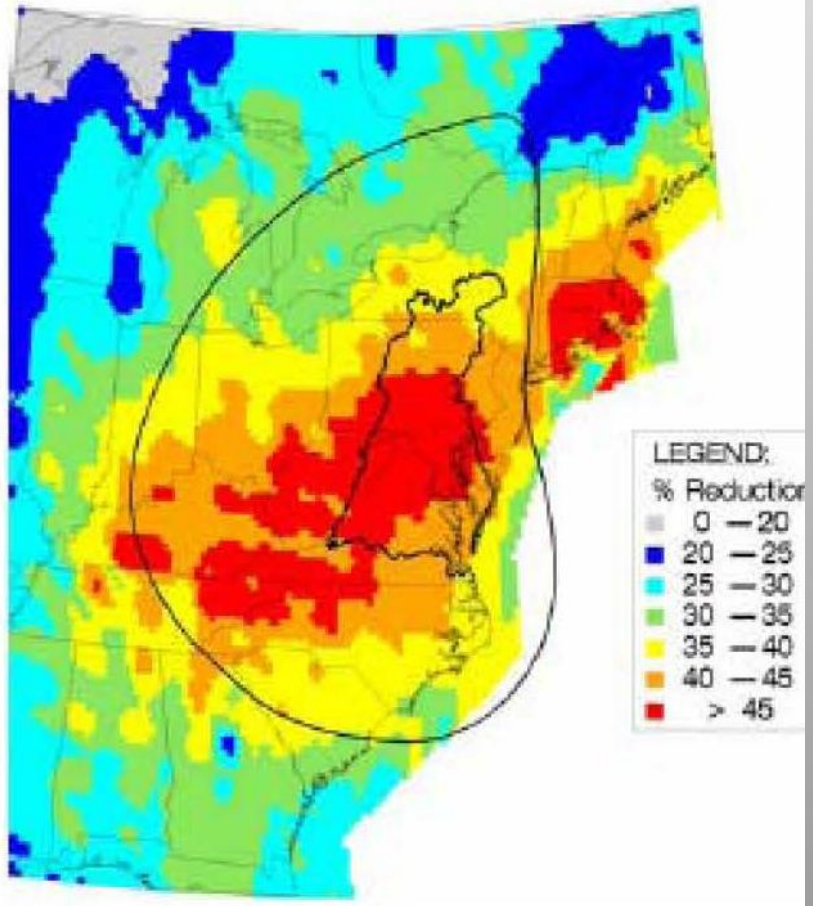


Power Generation and Atmospheric N Deposition

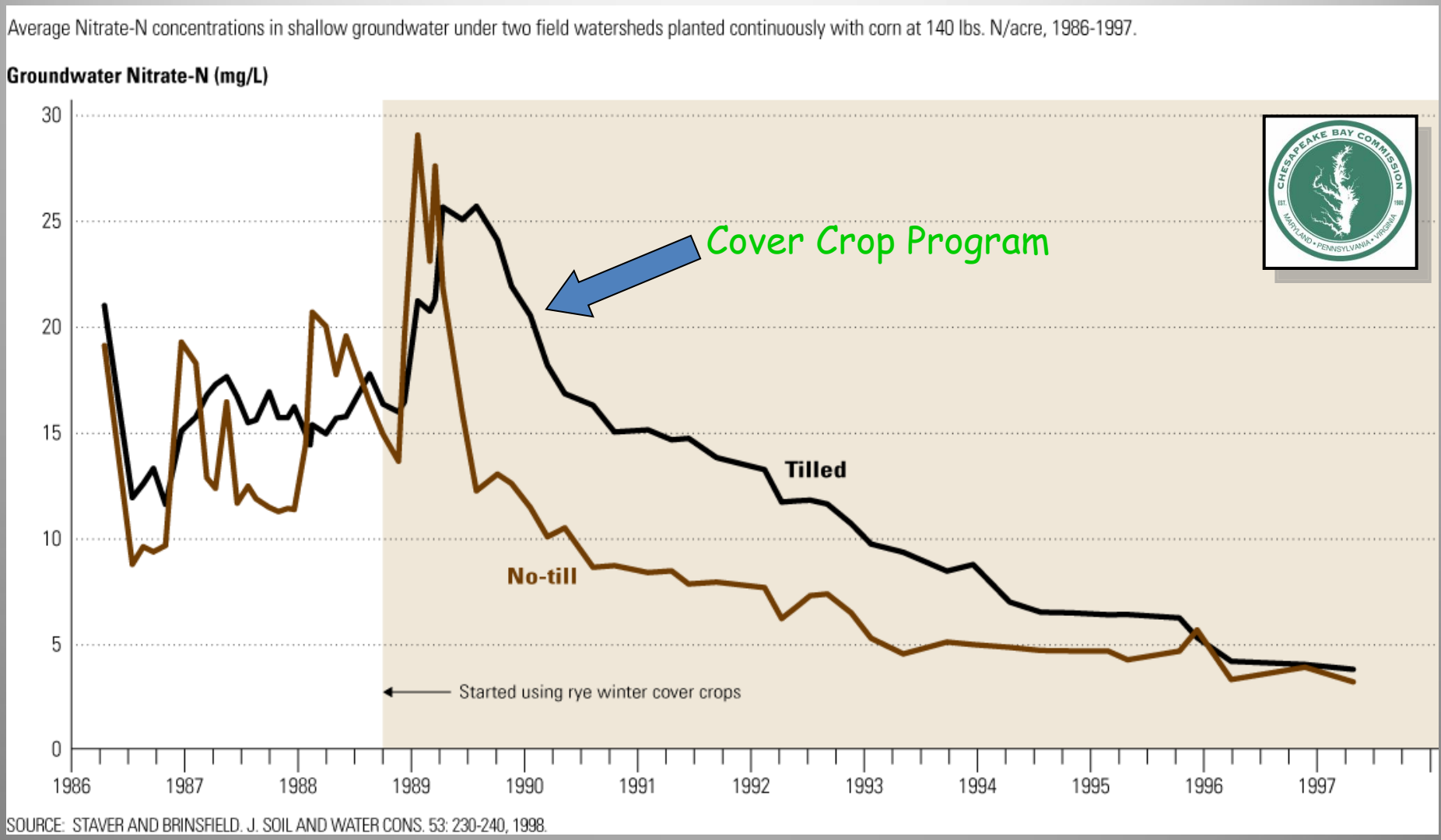
Trend of estimated average nitrate and ammonia deposition concentrations across the Bay watershed



NOx SIP Reg +
Tier II Mobile +
Heavy Duty Diesel Regs
2020
ox-N Dep % Change from 1990

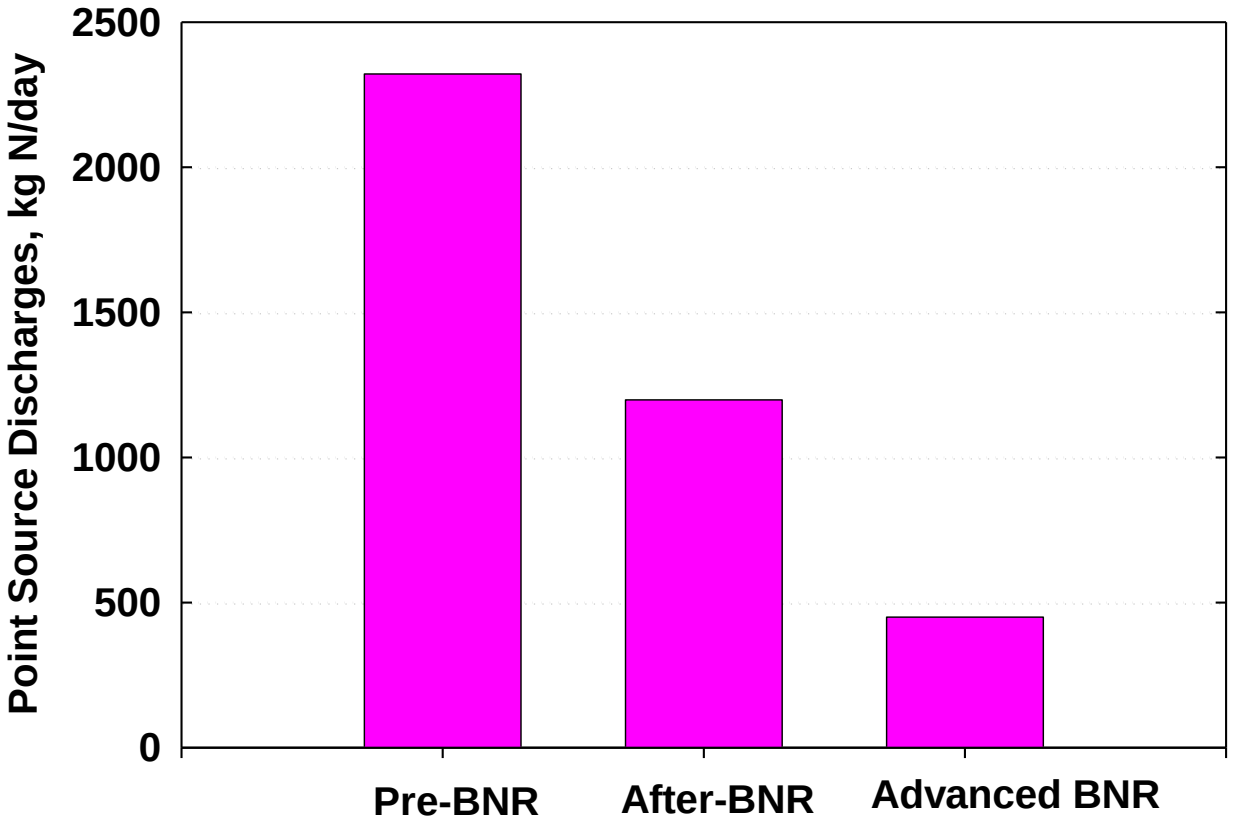


Conservation Practices Deliver Water Quality Benefits



Treatment of Wastes

Wastewater Treatment in the Patuxent River Basin

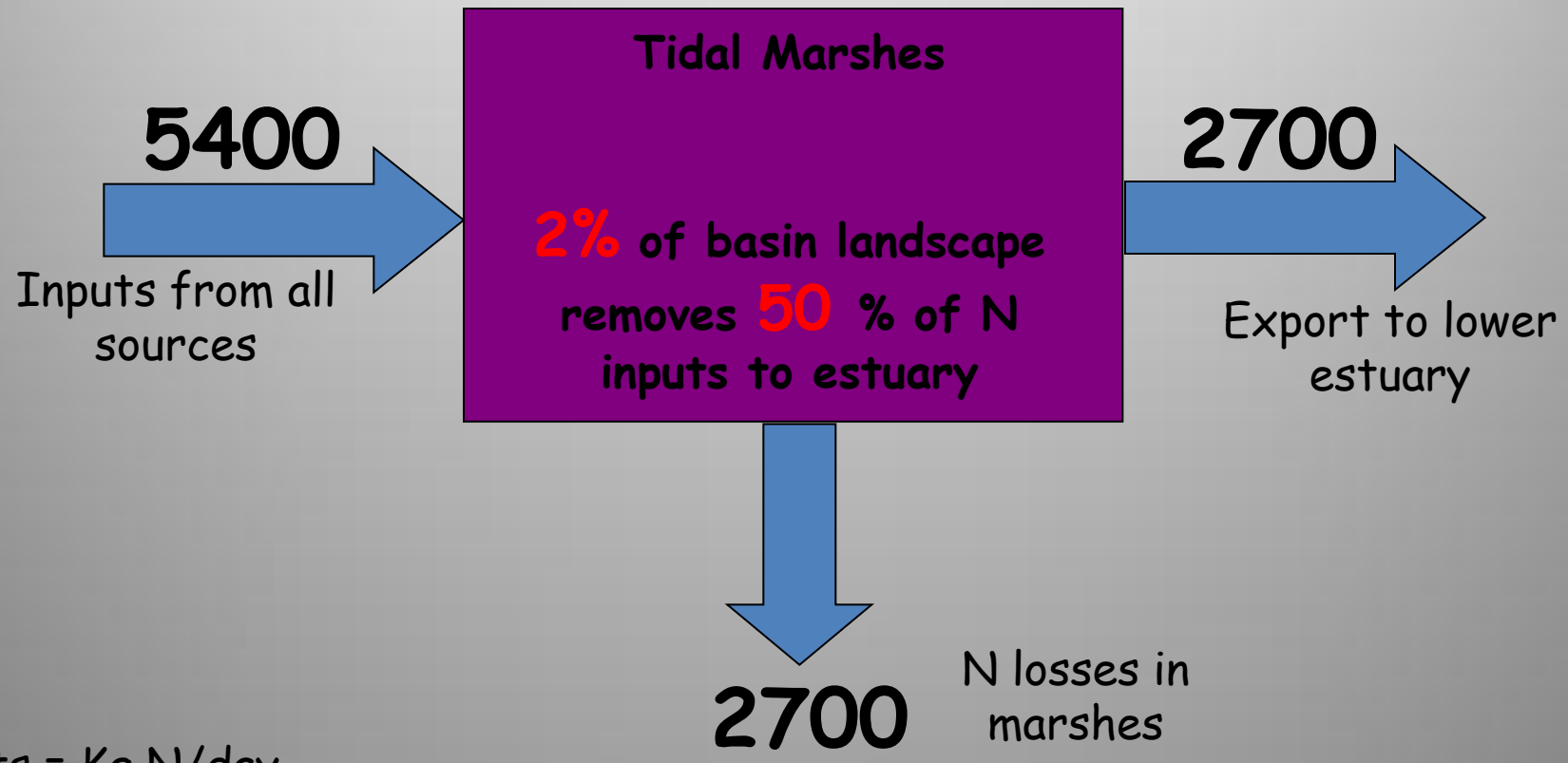


Boynton et al. 2008

We need more of these systems…

estuarine and landscape kidneys

Tidal Marshes and Other Marshes: Hotspot in the Landscape for Nutrient Removal



Boynton et al 2008

Storm Water Management: Wet Pond Example

Pollutant Removal Efficiencies:

TSS: 46%

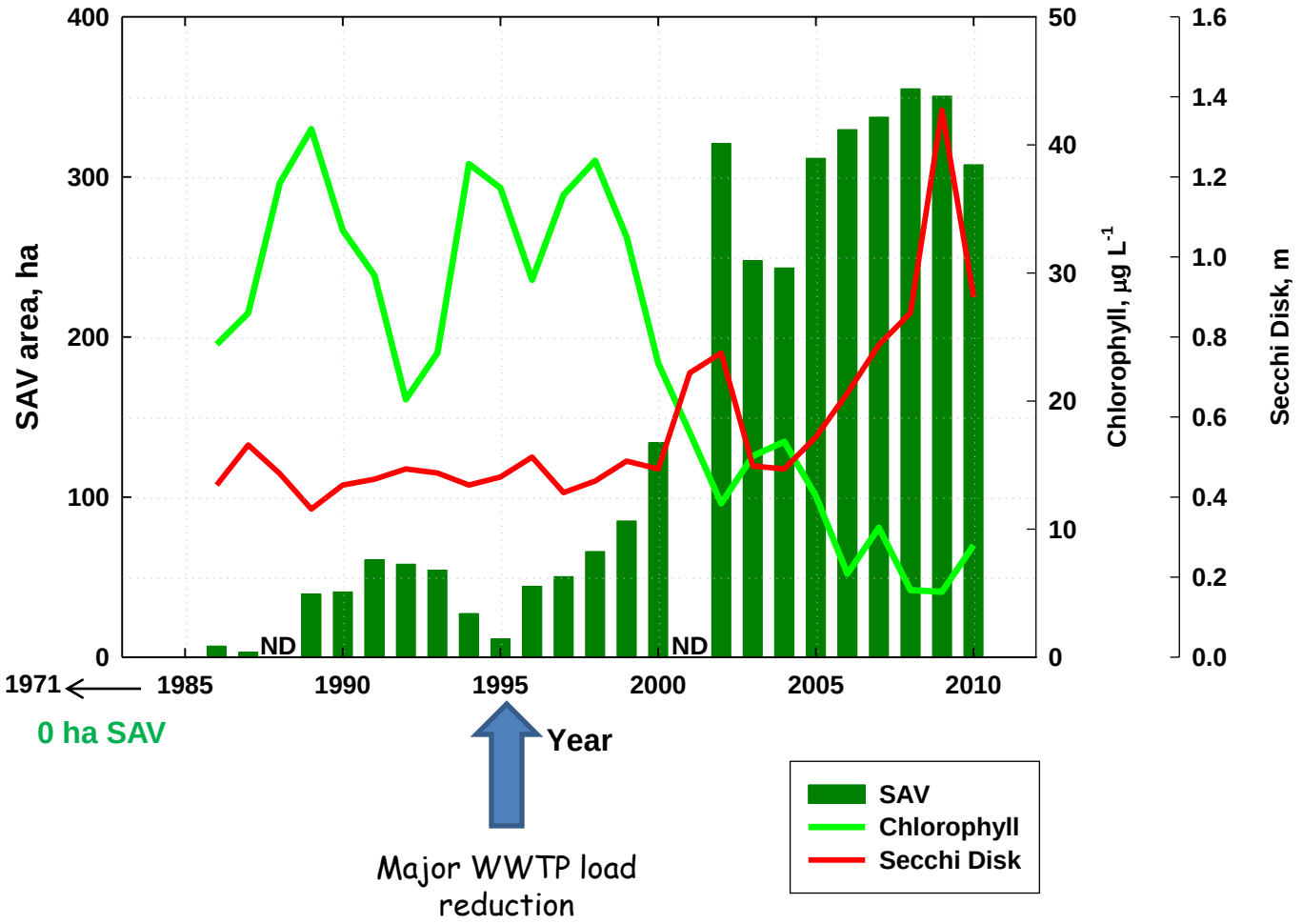
TP: 46%

TN: 32%

There have been THOUSANDS of these constructed in the Patuxent Basin…HOW or IF they work is largely unknown

Mattawoman Creek

SAV coverage; Average Annual Chlorophyll; Average Summer Secchi Disk Depth

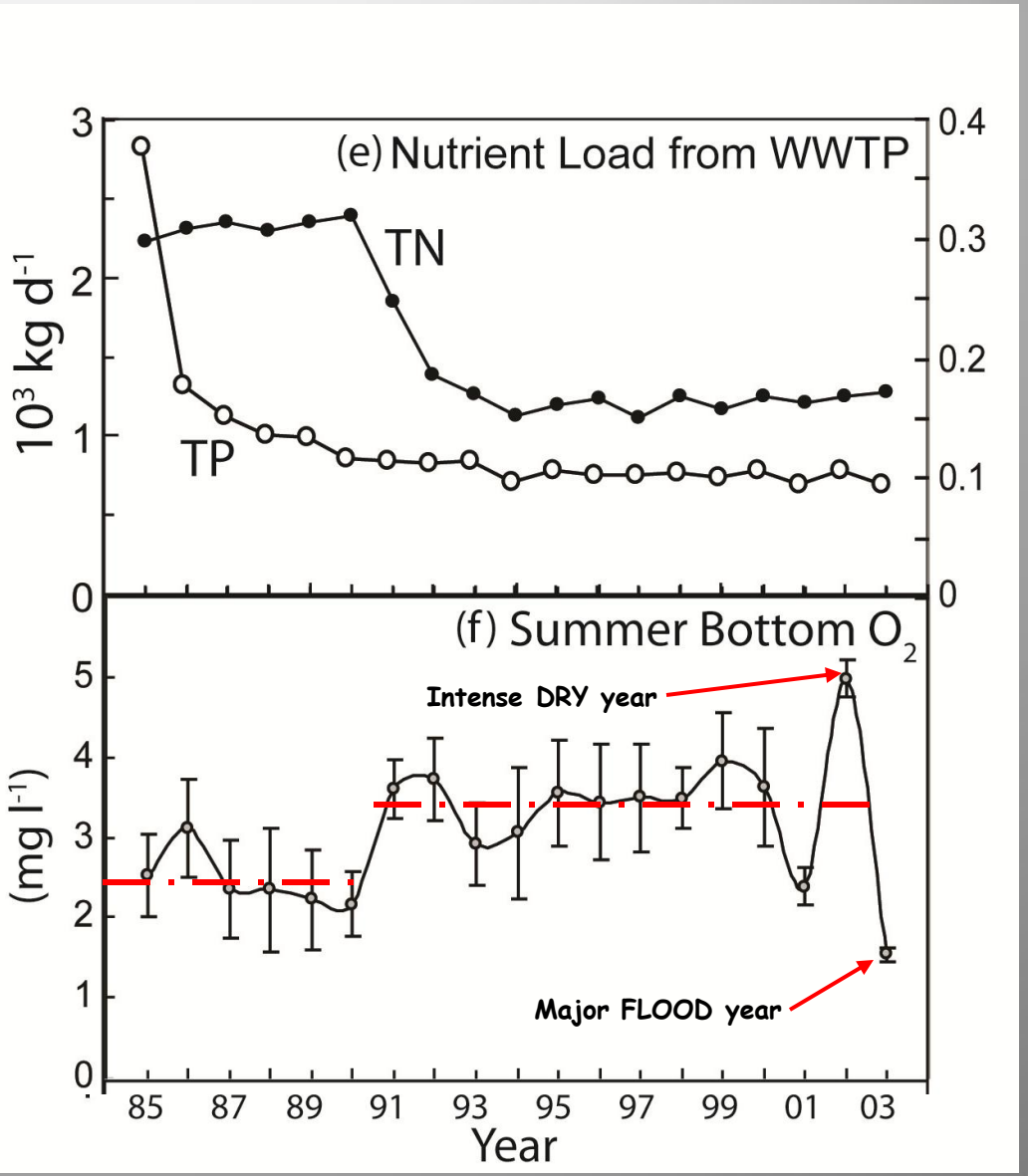


Boynton et al 2012

Monitoring Water Quality Response to Management:

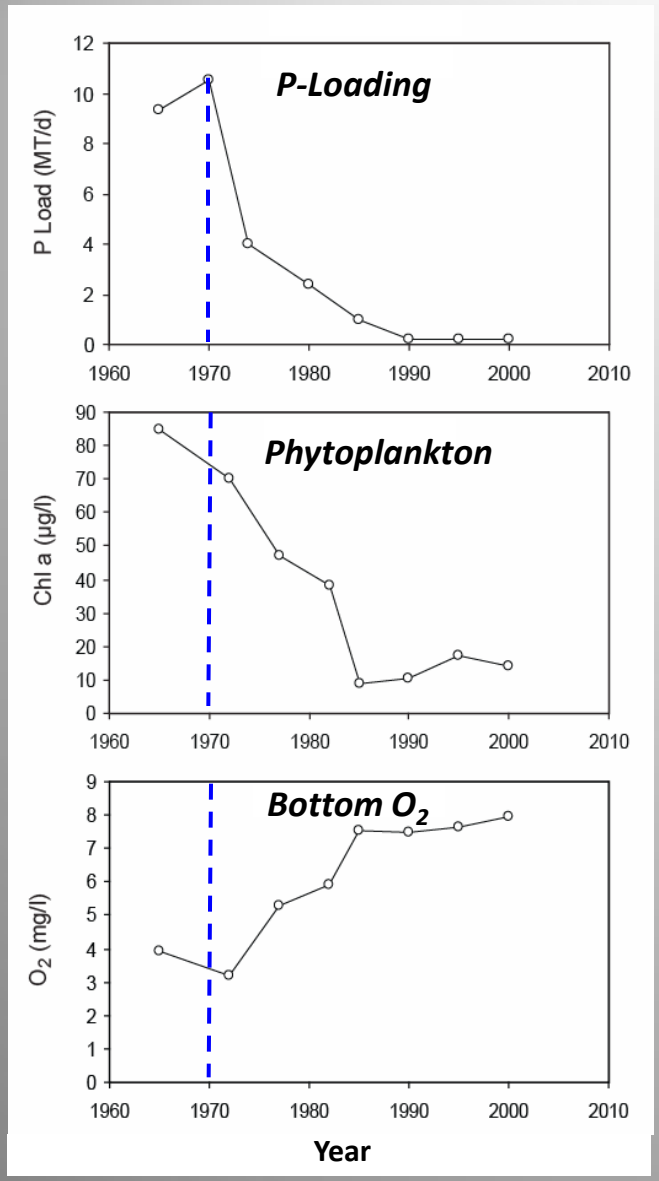
Patuxent River Estuary and POINT SOURCE Load Reductions

- Upper estuary close to most STP inputs.
- 20-year time-series reveals ~1 mg l^{-1} increase in dissolved O_2, which was enough to avoid serious hypoxia.



Kemp et al 2008

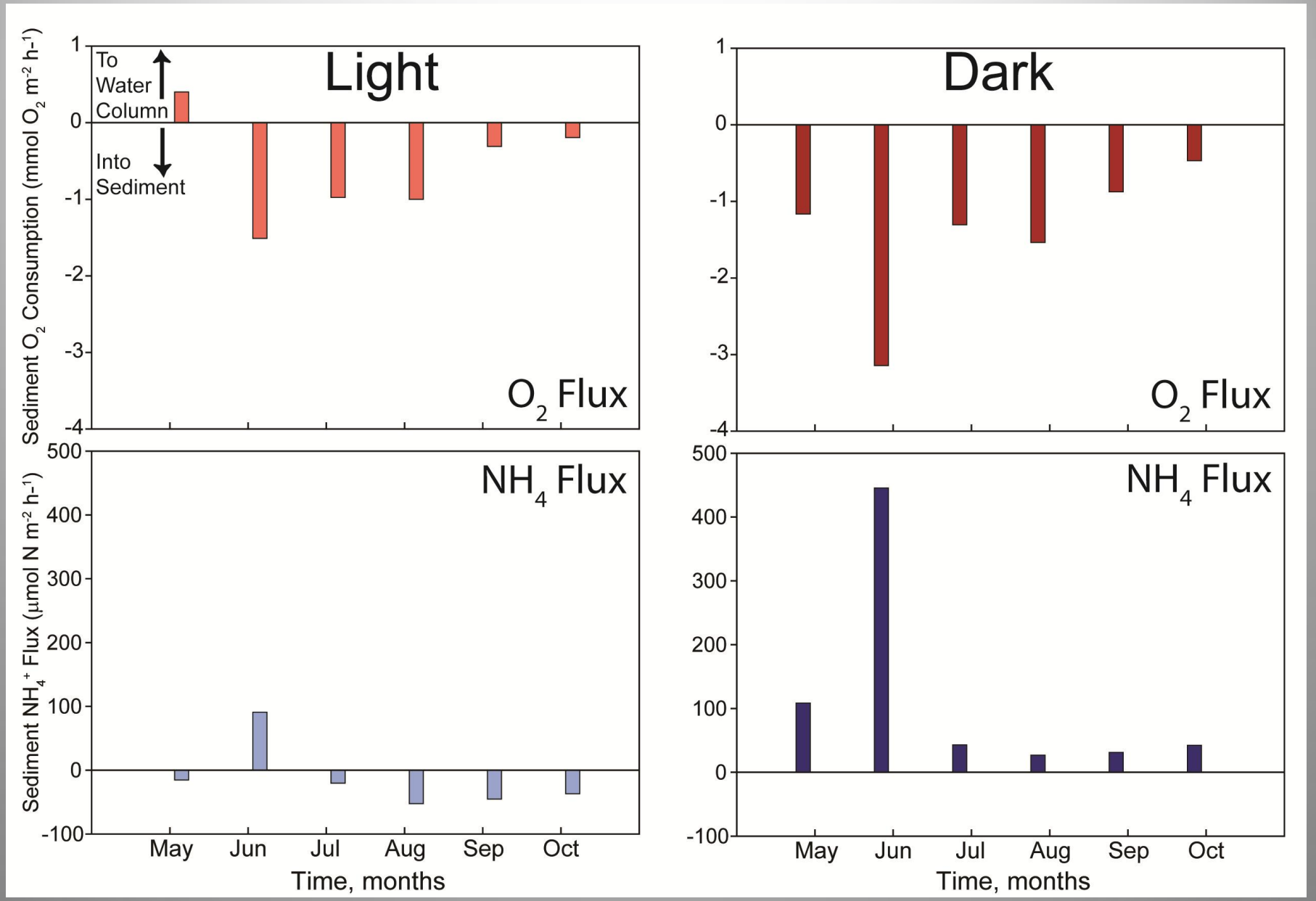
Responses to N&P-Reduction: Potomac Tidal Fresh



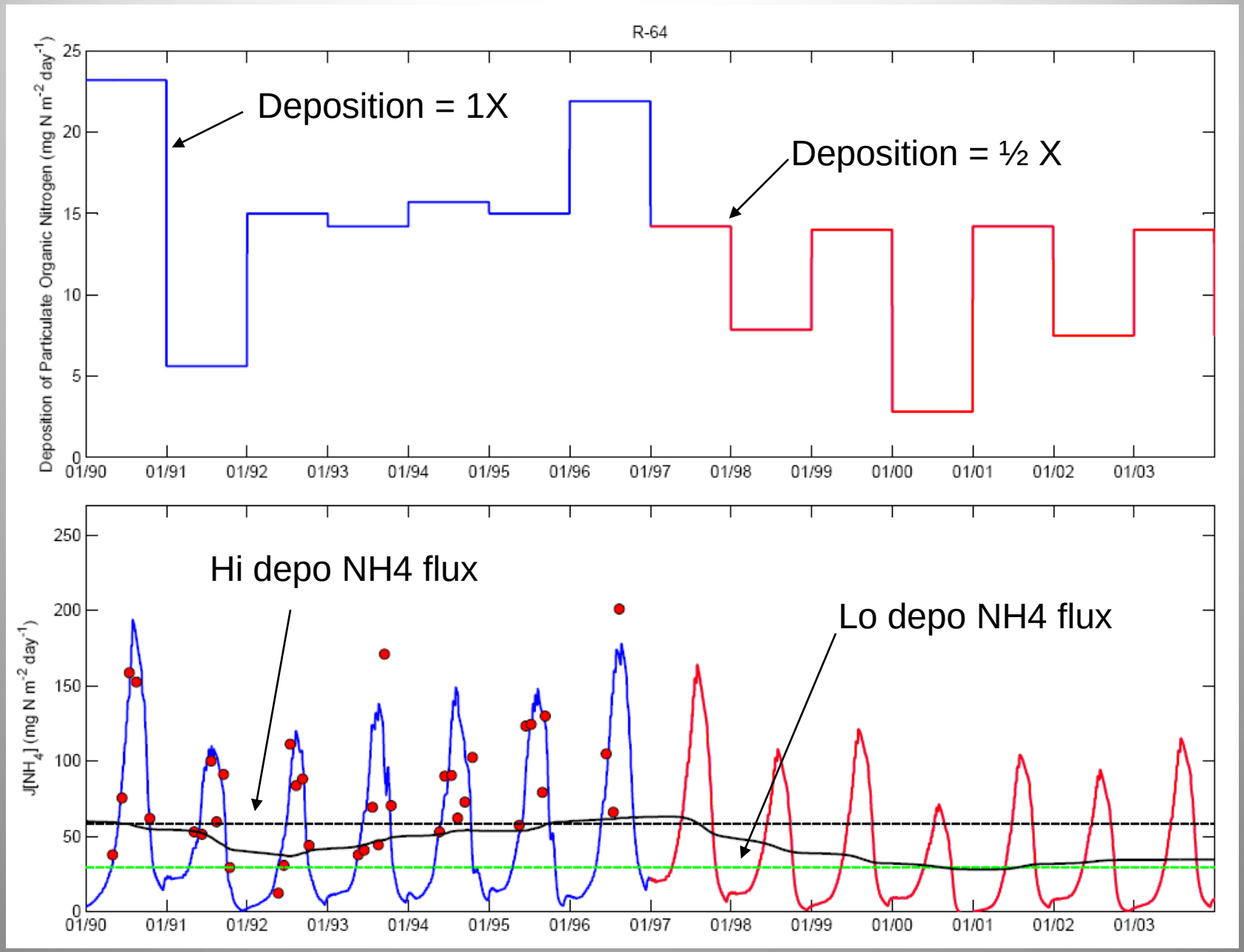
- Advanced Tertiary Treatment at *Blue Plains* WWTP reduces P-loads by >90% in 30 years
- Phytoplankton Chl-*a* and bottom O_2 respond rapidly
- N-load is also reduced by smaller fraction

(Kemp et al. 2005)

Sediment O_2 and N Releases Are Reduced With Light



Cornwell et al. 2008



Brady and Testa, pers comm

Some Take-Home Points

- My crystal ball is far from perfect…there may be some wrong-headed things here

- There is substantial evidence that Bay water and habitat quality could get better or worse…there is room for both to occur

- The basic model calling for large N and P load reductions (duel nutrient strategy) is sound and needs to be vigorously pursued

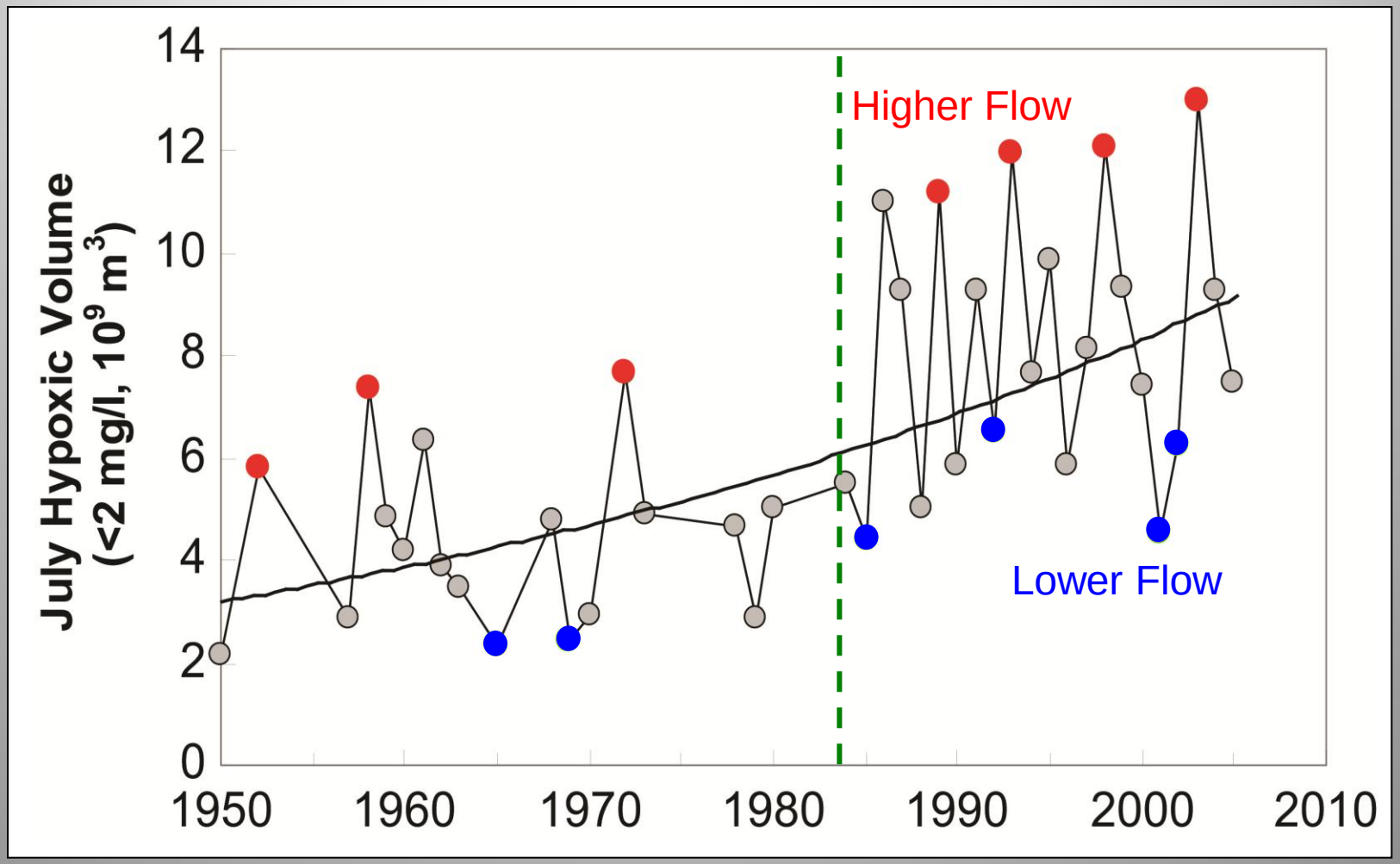
- The TMDL effort is critical in getting substantial load reductions

- There are an increasing number of examples showing that N and P load reductions deliver the expected outcomes…this is super good news!

- This system is complex…feedbacks, lags and thresholds abound…so we need to be prepared for some surprises, both good and bad

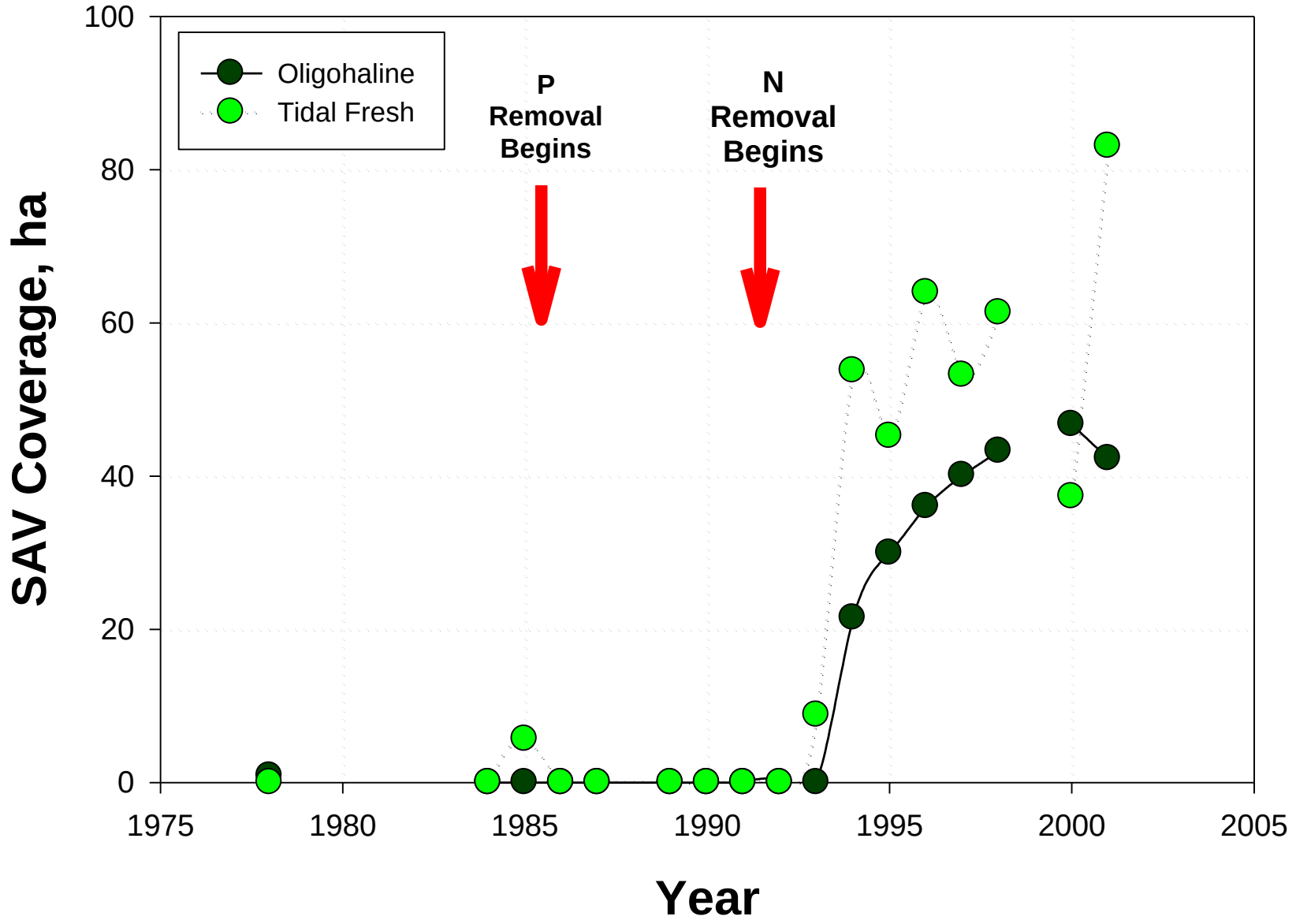
- Evidence is accumulating that the water quality and habitat response times vary BUT they tend be faster than previously expected…a cleaner Bay in some of our lifetimes is possible

Trend in Bay July Hypoxic Volume



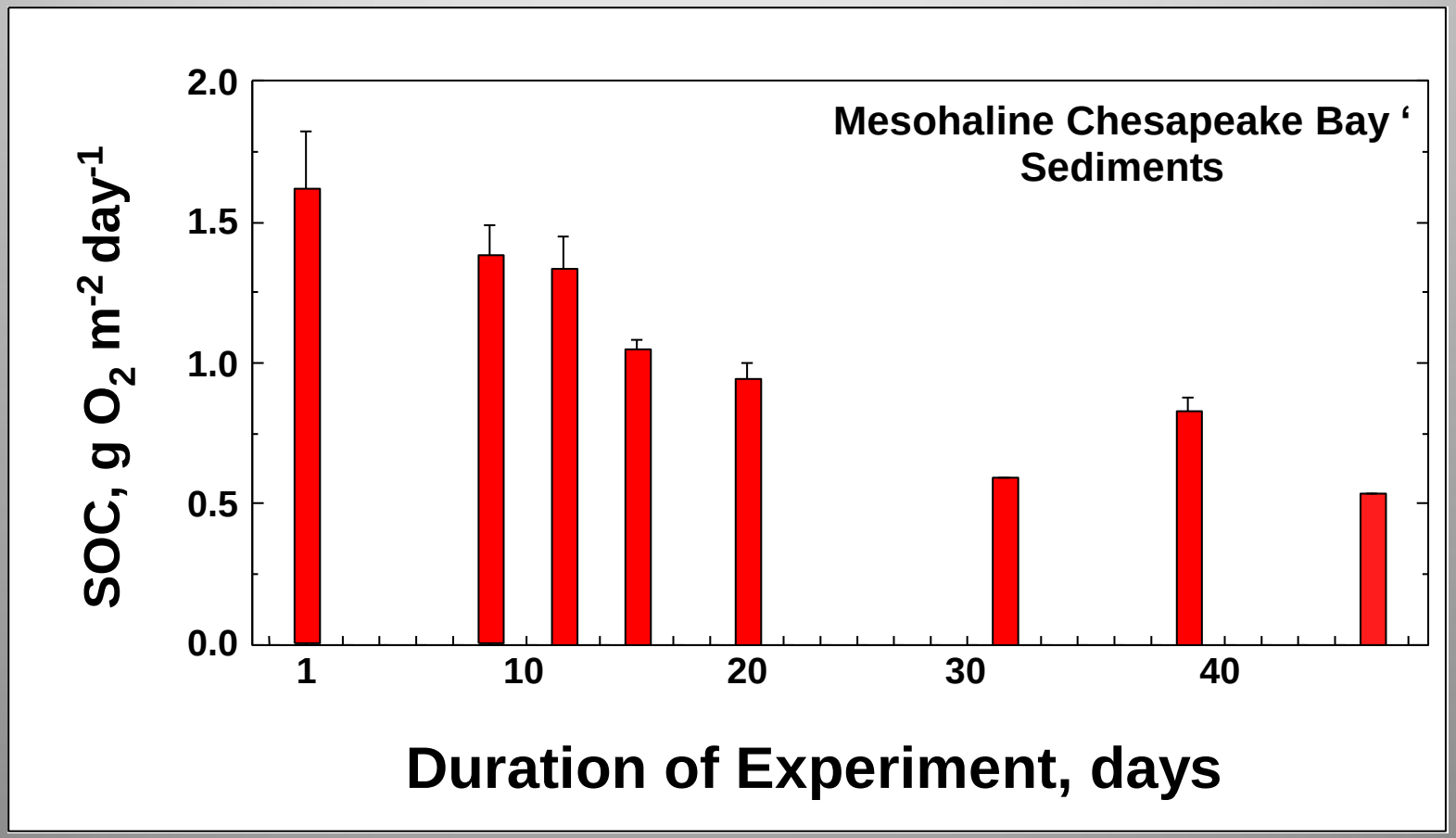
(after Hagy et al. 2004)

SAV in the Uppper Patuxent River



Sediment Memory…may be shorter than we think

Sediment Oxygen Consumption



Tidal and other marshes act as super "Nutrient Sponges" ...so, retain and build wetlands