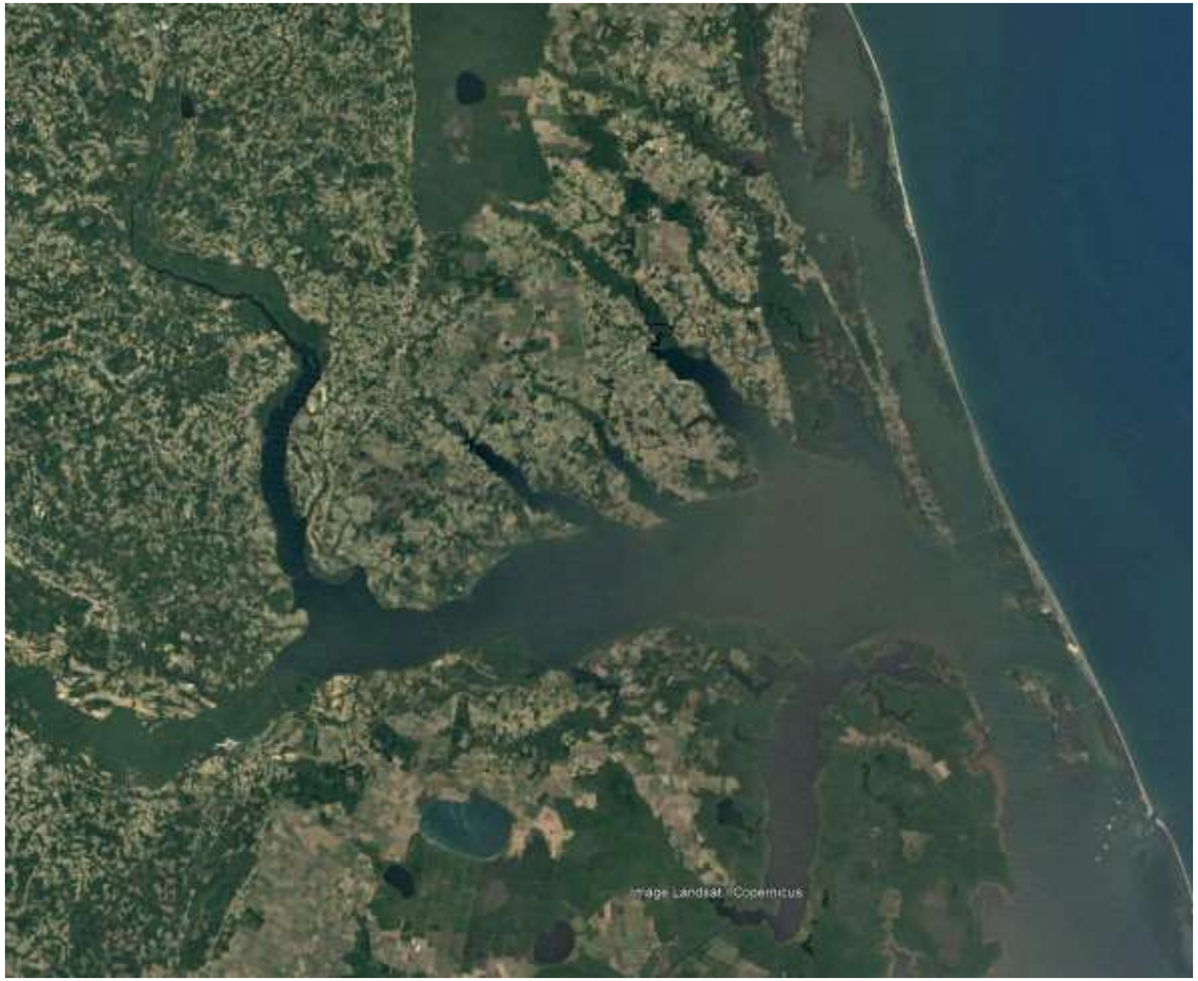
Potential causes for a system-wide change in trophic status of the greater Albemarle Sound ecosystem

Nathan Hall, UNC-IMS, 29 March 2019

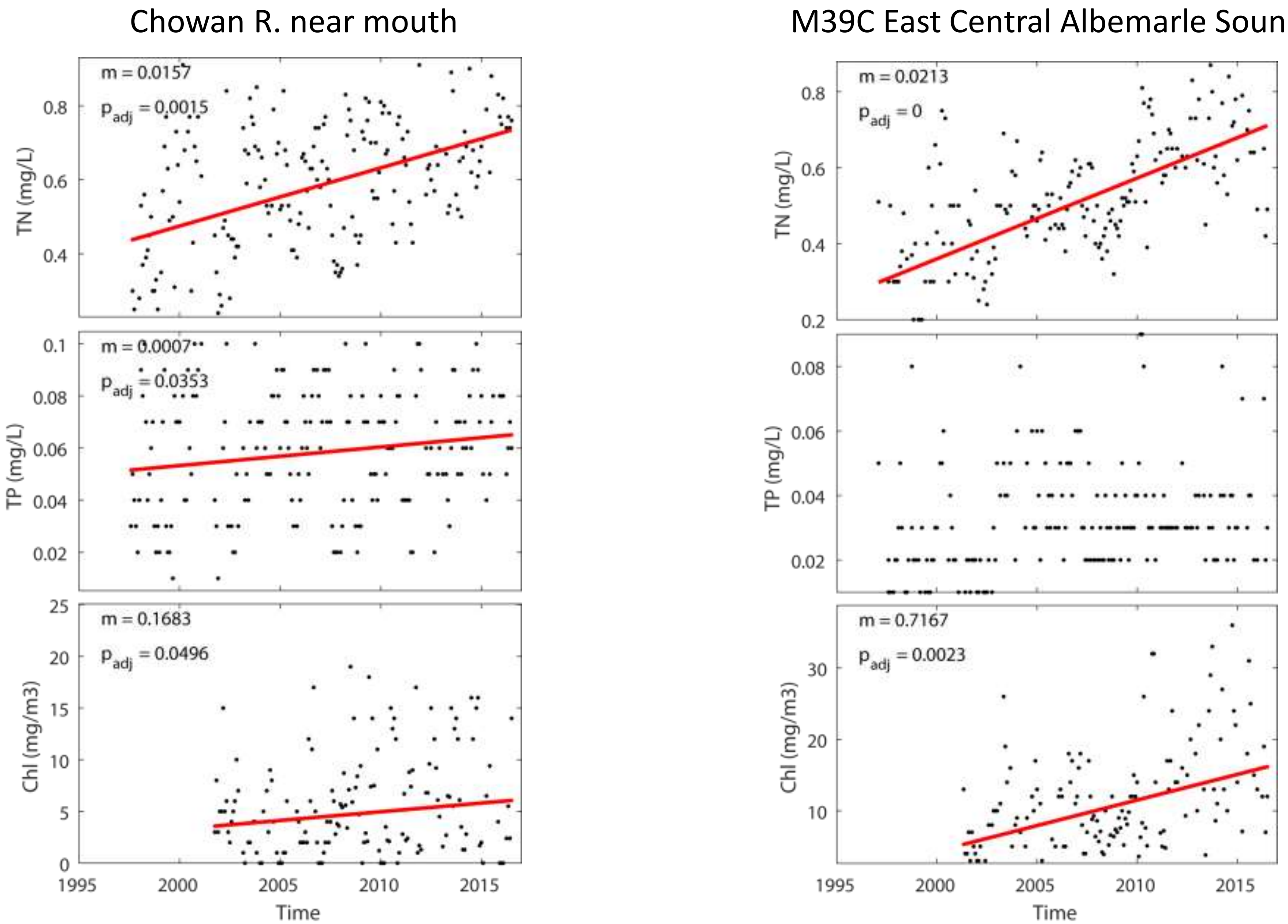


Blooms dominated by the potentially toxigenic N-fixing cyanobacteria *Dolichospermum*, a.k.a. *Anabaena sp*.

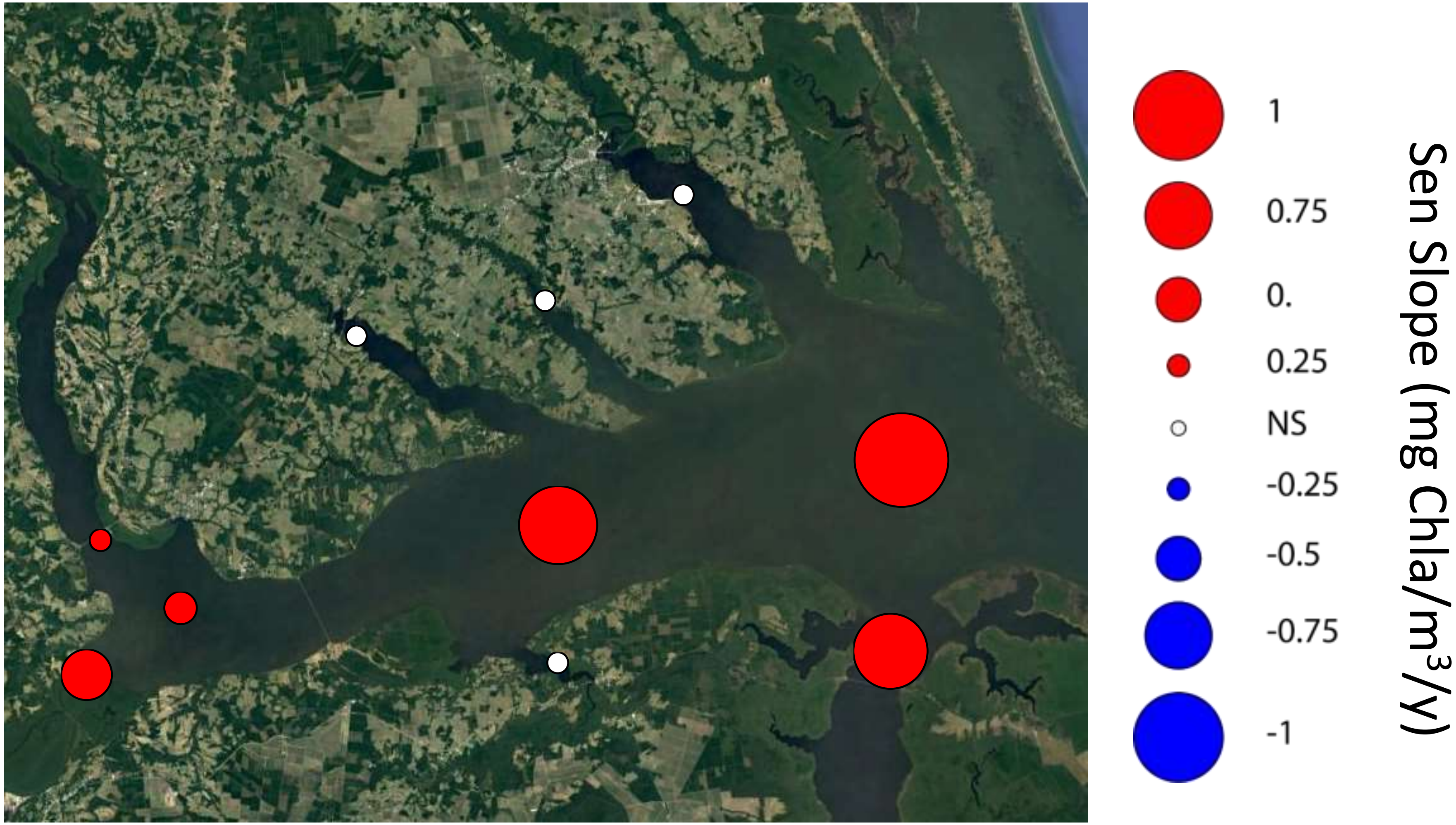
Are blooms indicative of larger-scale pattern of changing trophic status?

NC DEQ Ambient Monitoring System stations

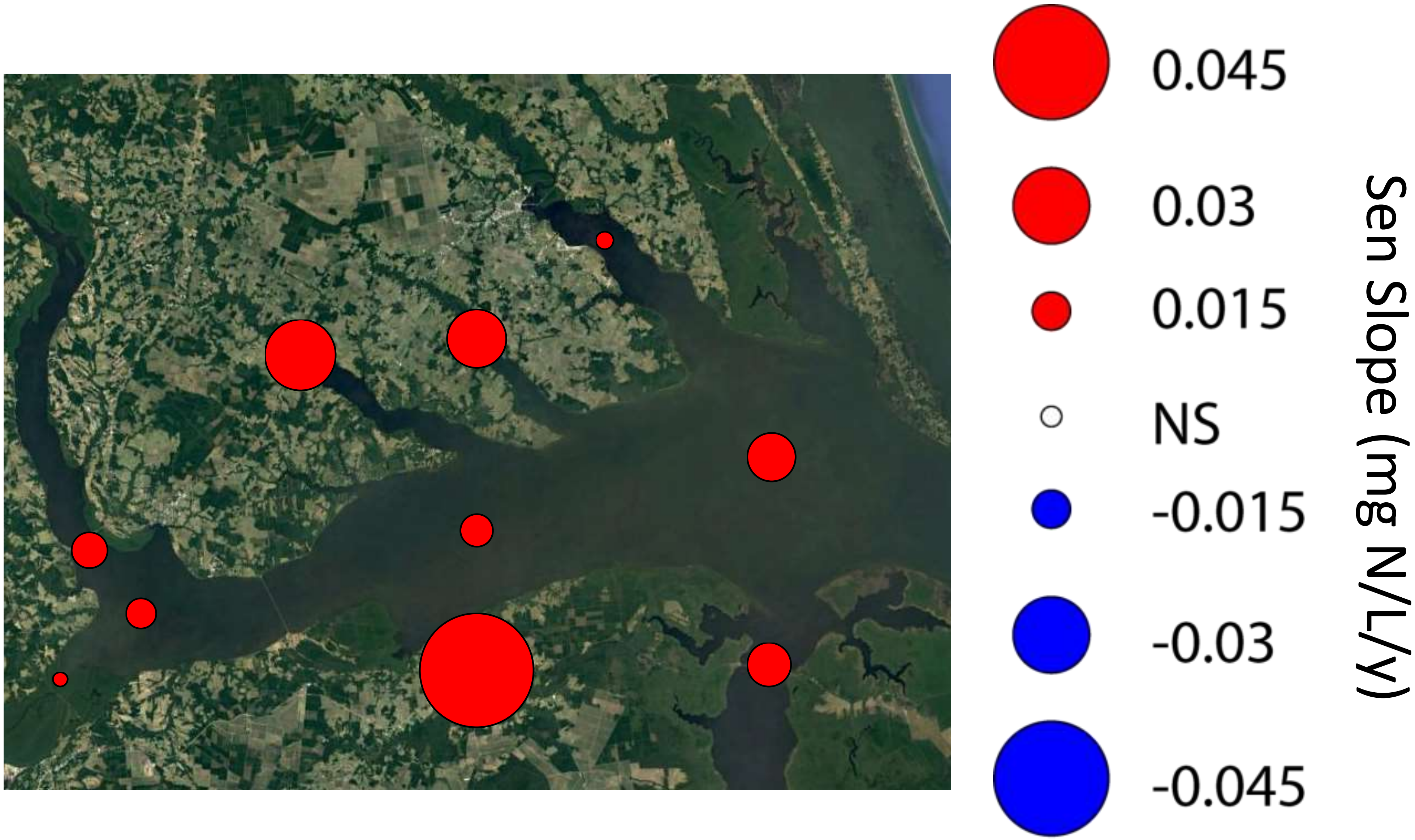
Long-term Trend Analyses Using Seasonal Kendal Tests



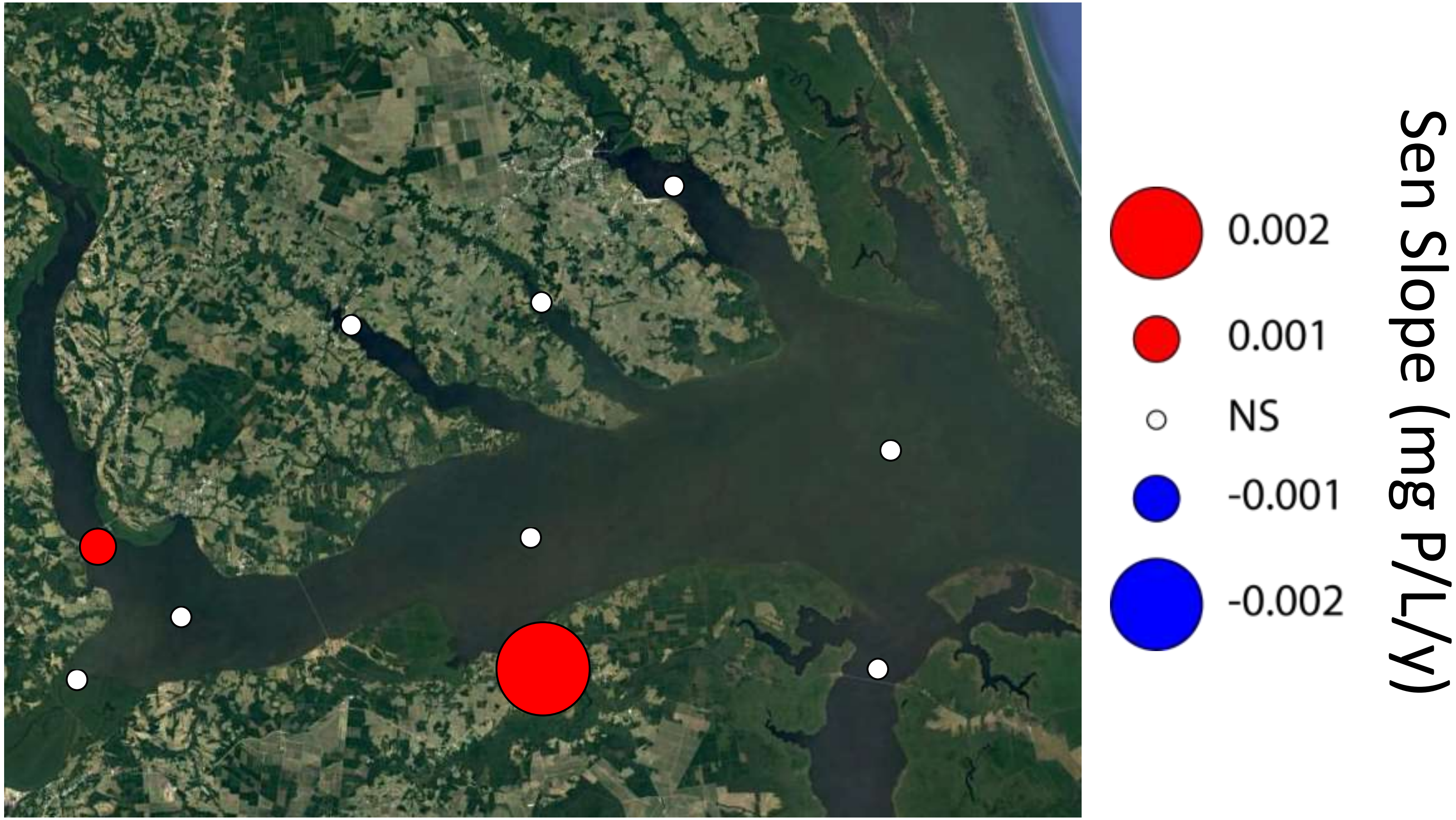
Summary Map of Trend Slopes for Phytoplankton Biomass as Chlorophyll *a*



Summary Map of Trend Slopes for Total N



Summary Map of Trend Slopes for Total P



Recap

Blooms: Recent but recurrent and awful!

Chl-a: 6 of 10 DEQ stations have increasing chl-a

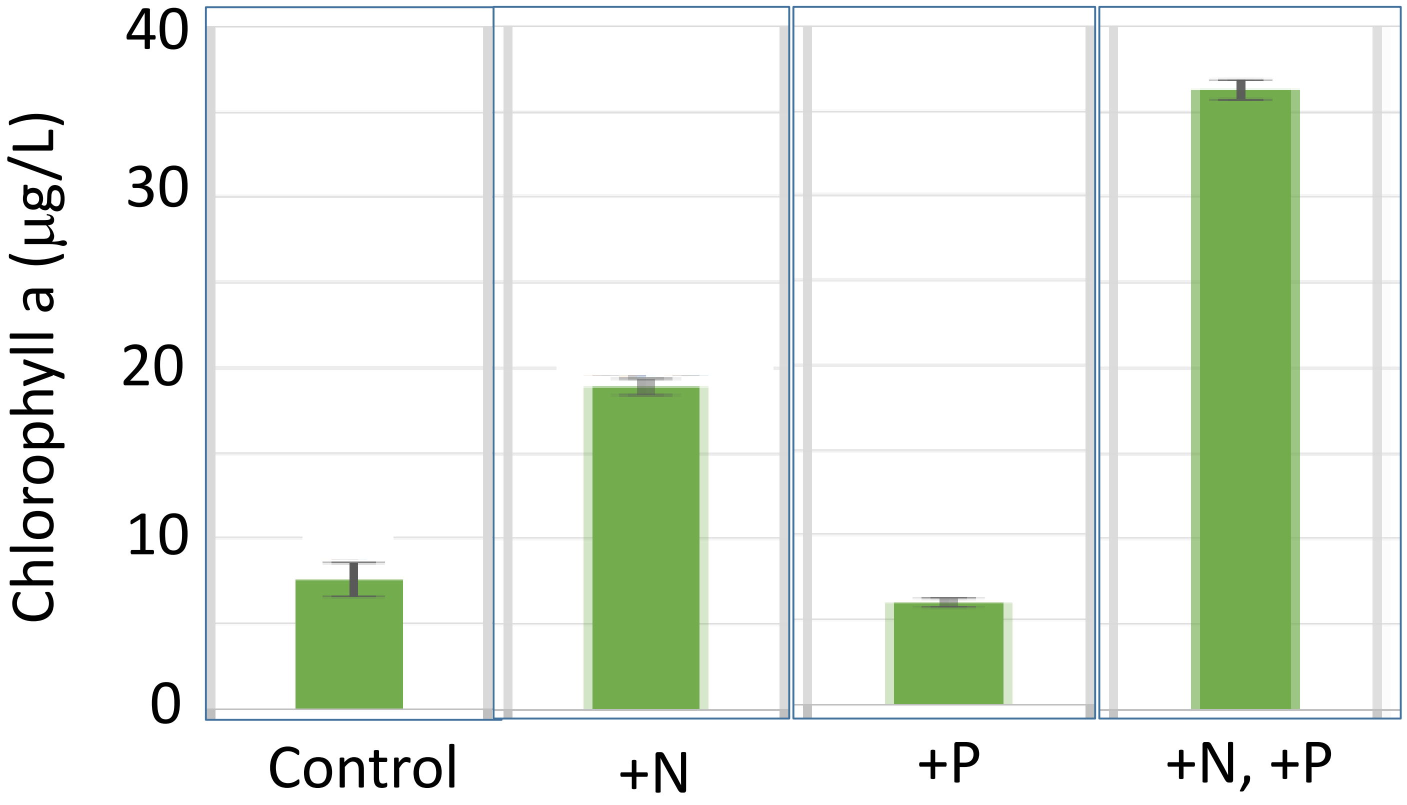
TN: 10 of 10 station have increasing TN

TP: 2 of 10 stations have increasing TP

What’s driving these changes?

Where are the nutrients coming from?

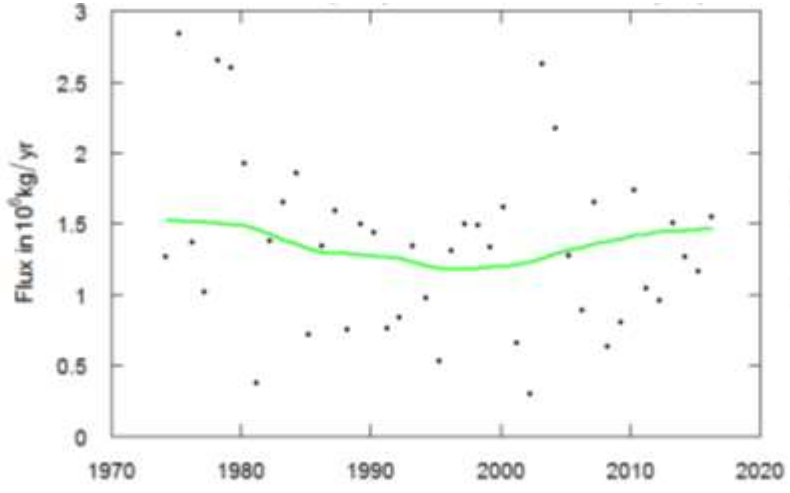
Experiments and Ambient Nutrients Indicate N-limitation of Phytoplankton Production



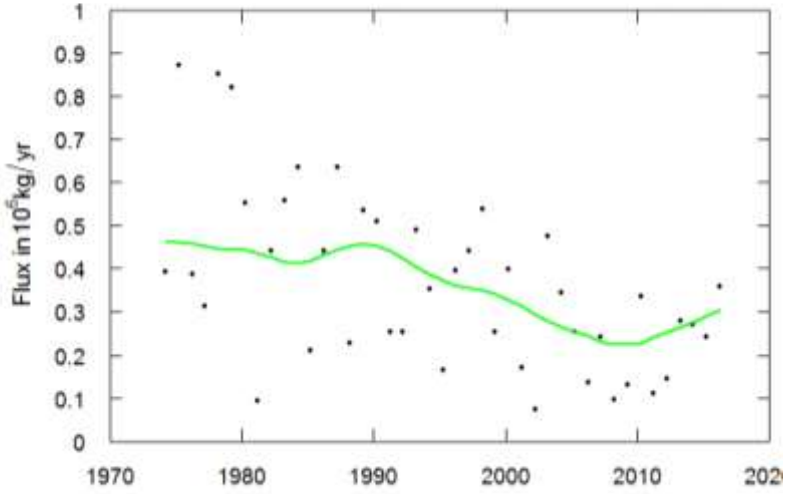
Felix Evans, Fall 2018

No major changes in nutrient loads from the major rivers

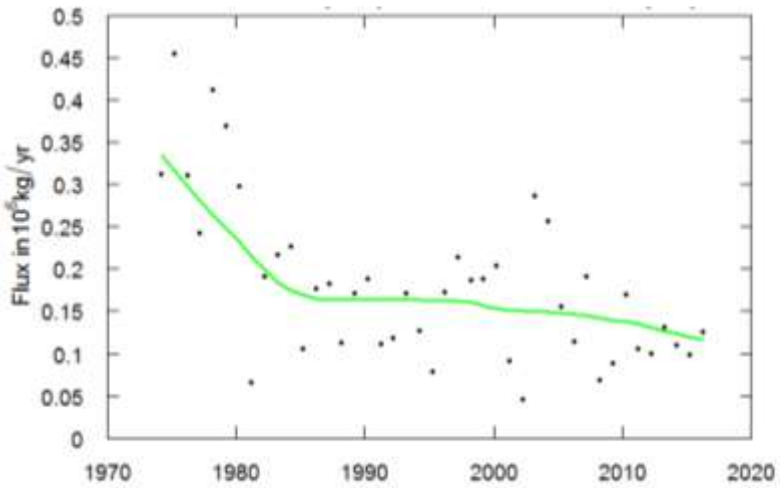
Chowan Total N load



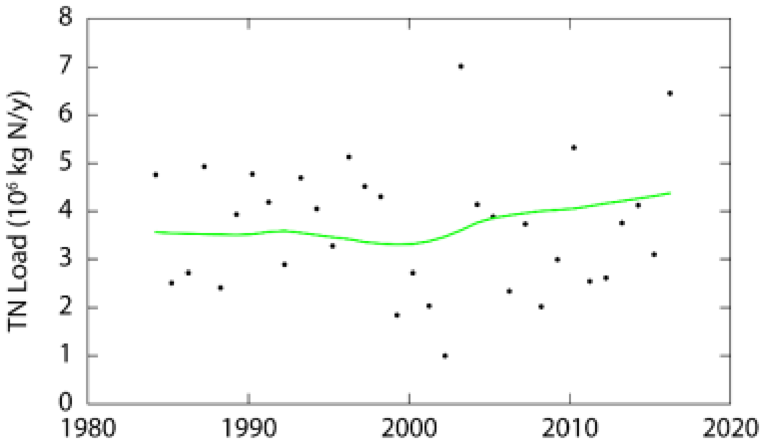
Chowan Nitrate load



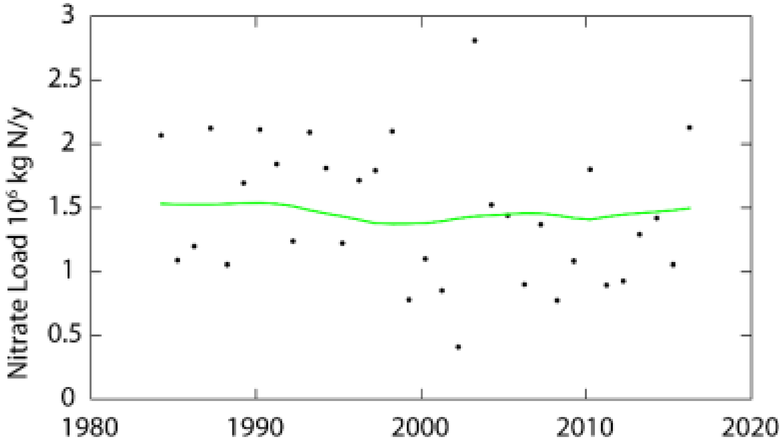
Chowan Total P load



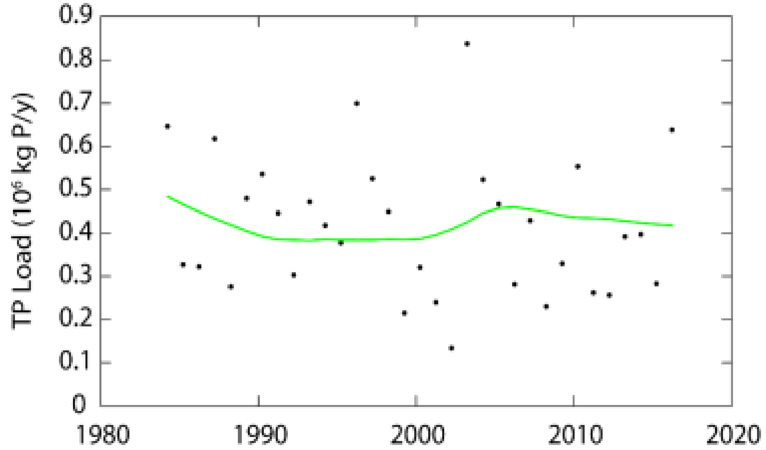
Roanoke Total N load



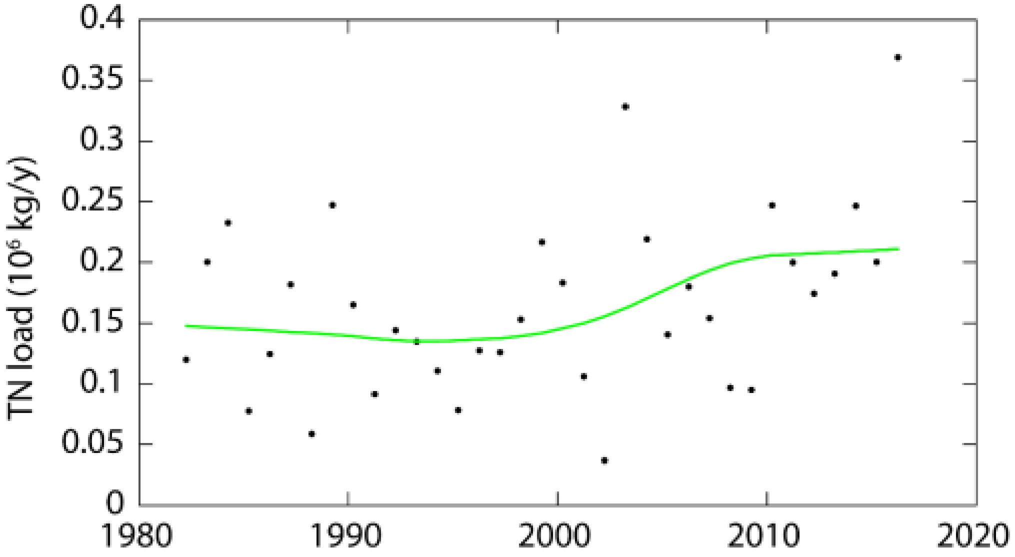
Roanoke Nitrate load

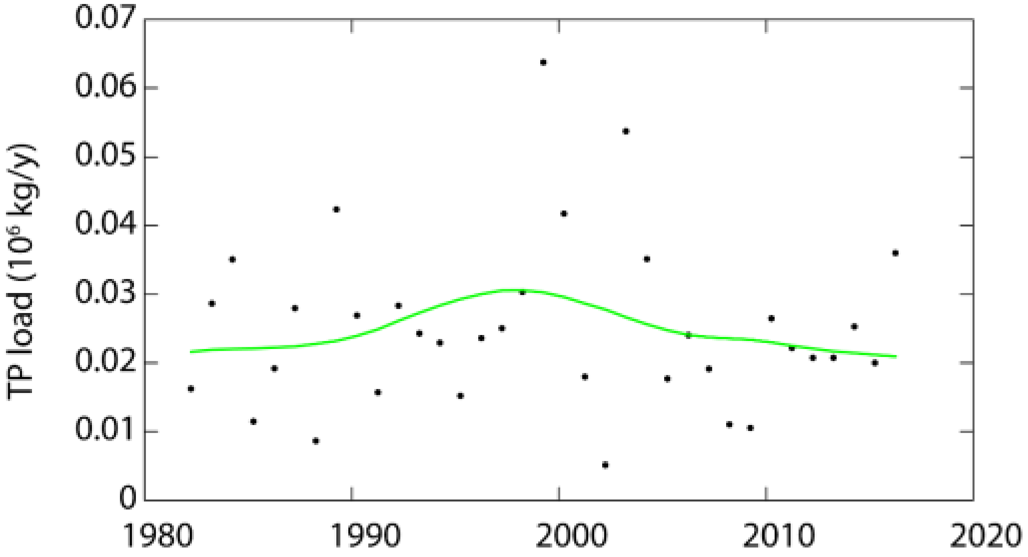


Roanoke Total P load

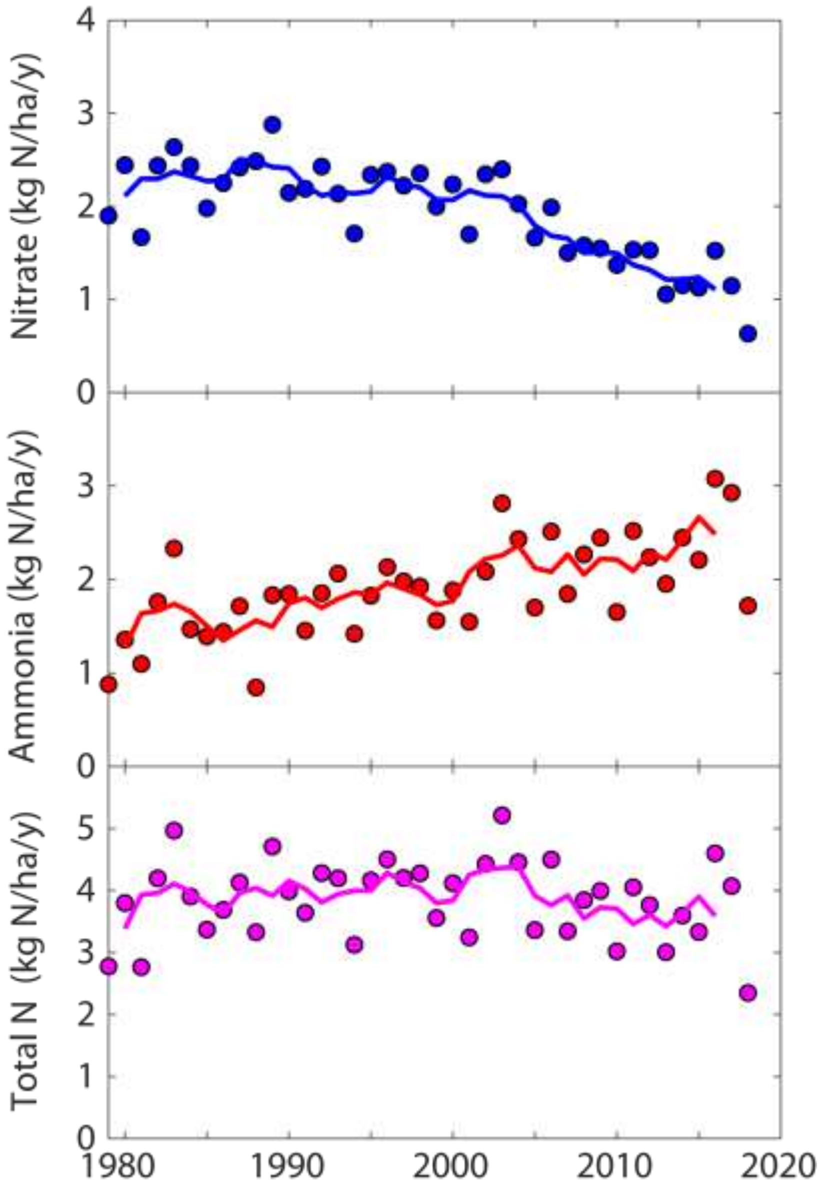


Some increase in TN in a Chowan River tributary, Potecasi Creek





Atmospheric N deposition is an unlikely culprit



Swamp forest loss as potential nutrient source

Clear cut swamp forest on Roanoke R.

Estimating Potential Impact of Swamp Forest Clearcutting

Load Increase = Clear Cut Area (ha) × Yield Increase (kg/ha/y)

Clear Cut Area

NRDC estimates 13,000 ha harvested in NE North Carolina in past three years (NRDC 2015)

Yield Increase

TP: 0.12 - 0.36 kg P/ha/y

TN: 2.1 – 2.2 kg N/ha/y pine silviculture (Lebo and Herrmann 1998)

TP: 0.2 kg P/ha/y

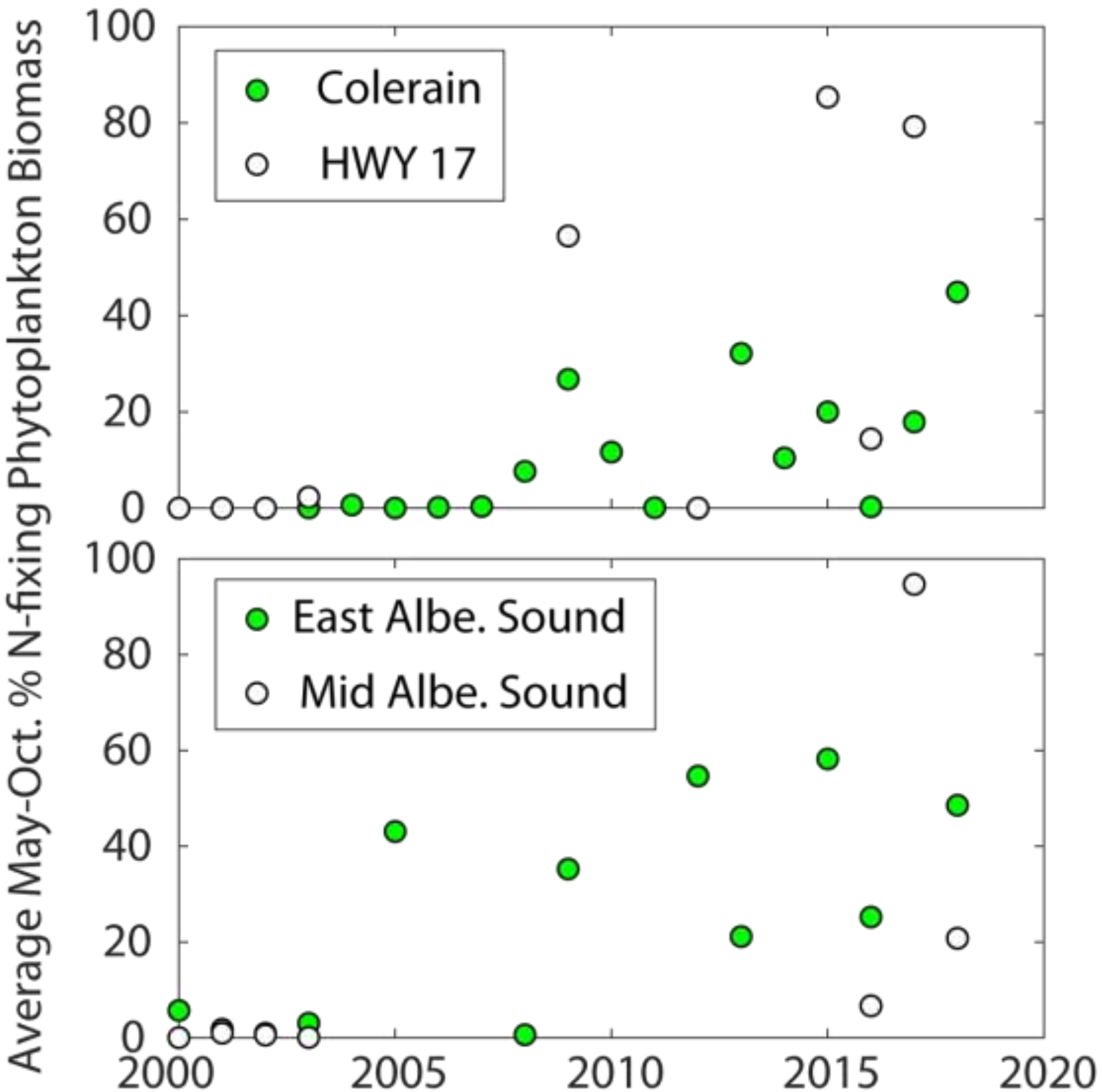
TN: 51 kg N/ha/y drained hardwood swamp forest (Grace 2004)

Load Increase

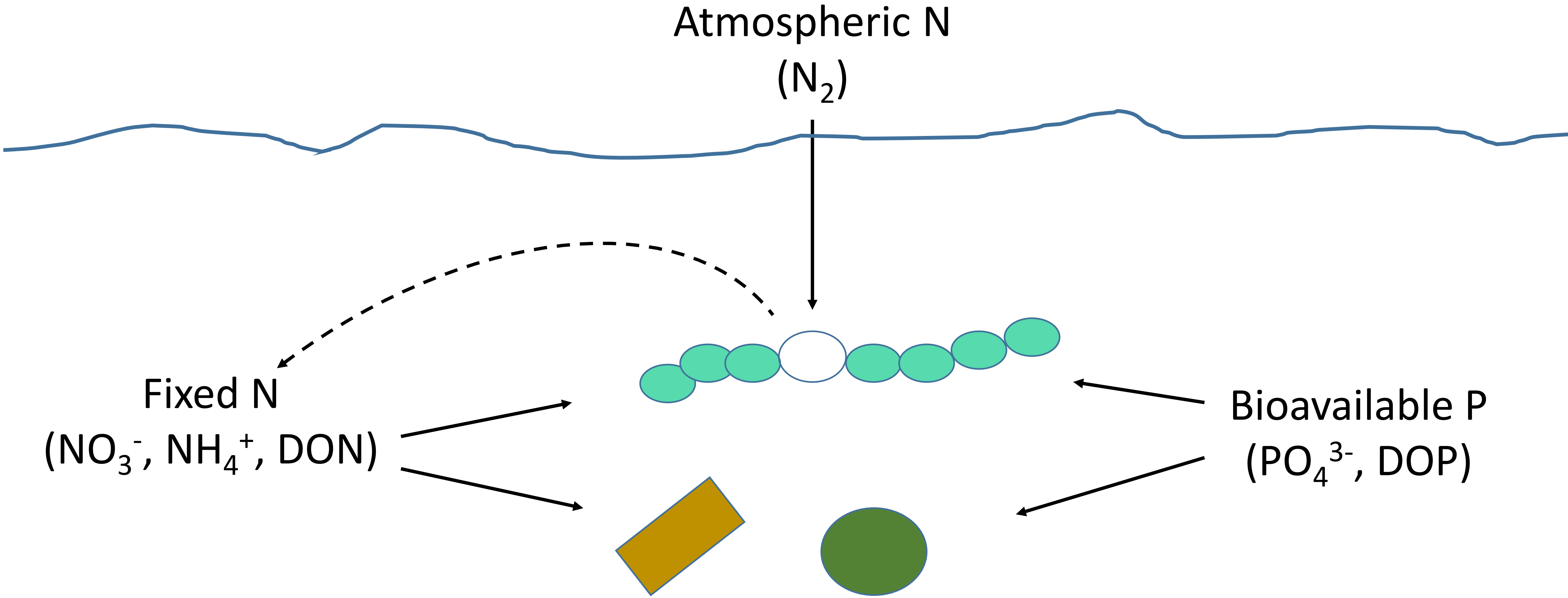
TP: 0.12 - 0.36 kg P/ha/y × 13,000 ha = 1560 - 4680 kg P/y

TN: 2.1 - 51 kg/ha/y × 13,000 ha = 27300 - 660000 kg N/y

Increases in Biomass of N-fixing Cyanobacteria



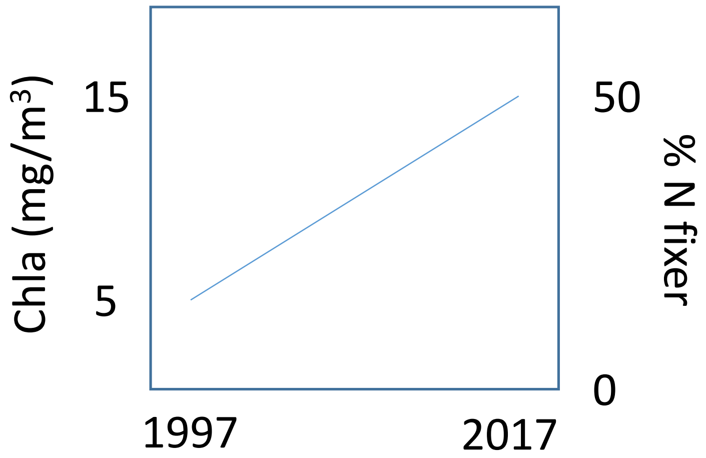
Stimulation of N fixing cyanobacteria can circumvent N limitation



Estimating Potential Increase of Internal N Load from N-Fixers

N Load Increase = N fixing biomass increase * N fixation rate

Biomass Increase



Albemarle Sound Volume

~ 5 mg/m^3 increase in N-fixing Chla * 5 × 10^9 m^3 = 25 × 10^9 mg Chla

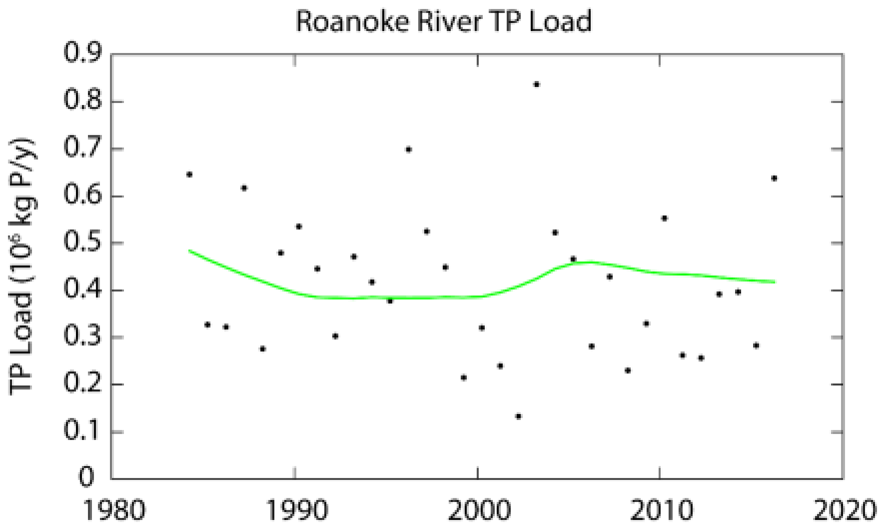
N-fixation Rate

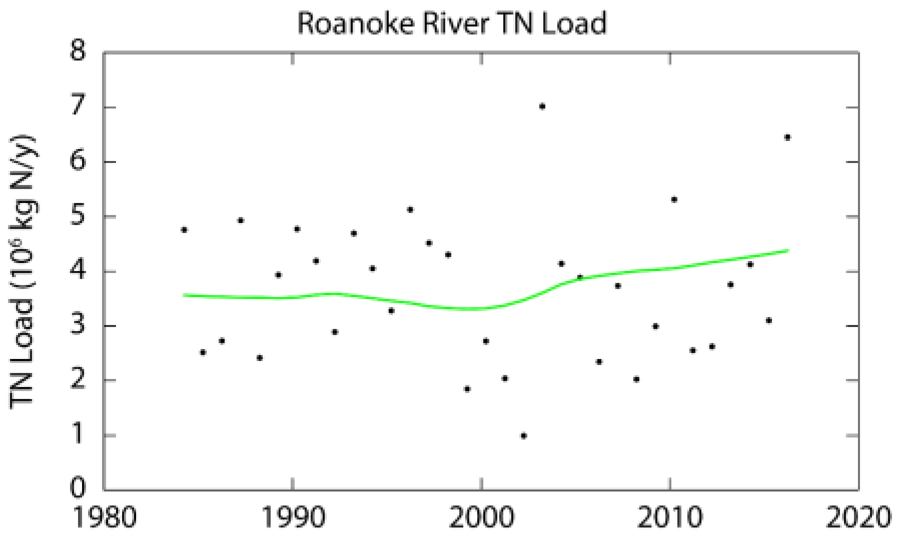
Assume growth rate of 0.3/d and cellular Chla to N ratio of 1 mmol N per 1 mg Chla

25 × 10^9 mmol N * 0.3/d = 7.2 × 10^9 mmol N/d

7.2 × 10^9 mmol N/d * 180 d/y *14 × 10^{-6} kg/mmol = 18 × 10^6 kg N/y

Estimated Internal Load Increase: 18 × 10^6 kg N/y





Estimated Load Increase Relative to Roanoke River Load

TP

Major Rivers:	0%
Potecasi Cr.:	0%
Swamp Forest Loss:	0.4-1.2%

TN

Major Rivers:	5-15%
Potecasi Cr.:	1%
Atmospheric Deposition	0%
Swamp Forest Loss:	0.7-17%
Nitrogen Fixation	450%

Conclusions So Far

1) Albemarle Sound is experiencing a system-wide change in trophic status

2) Small TN increases in rivers, creeks deserve more attention

3) Nutrient loads due to swamp forest loss are probably minor but deserve more study

4) Nitrogen fixation is a possible explanation for increases in TN and chlorophyll *a* – we need actual measurements of N fixation to see if they are actively fixing N

5) Factors underlying the shift toward higher proportions of N-fixing cyanobacteria are not clear

6) Though uncertainty abounds, increases in either N or P are likely to stimulate productivity in this low salinity estuary