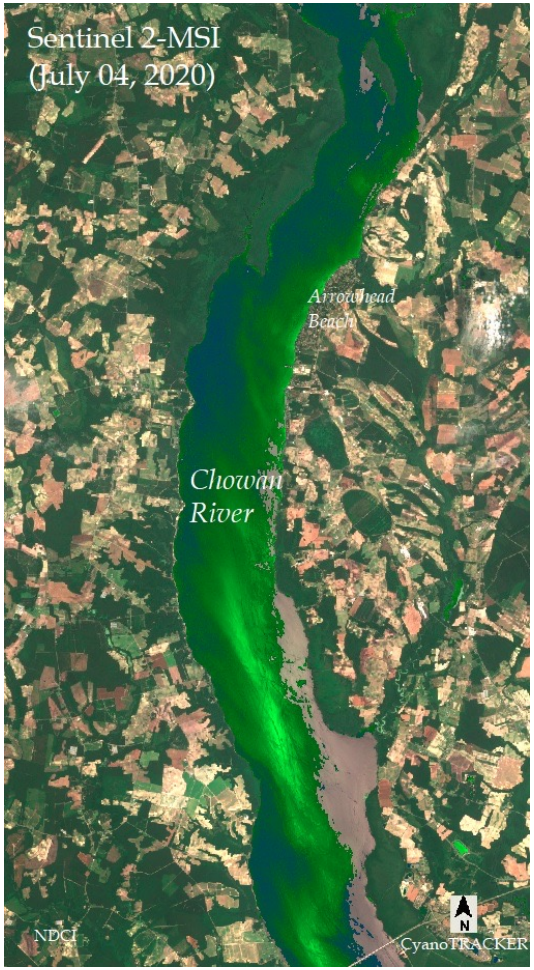
Chowan River and Albemarle Sound Nutrient-Bloom Dynamics over the past 40 years: What have we learned?

Hans Paerl, Nathan Hall (UNC-CH/IMS), numerous colleagues, graduate & undergraduate students and citizen volunteers



40 Years Ago

Using test algae (*Selanastrum*) and natural algal community to determine nutrient limitation

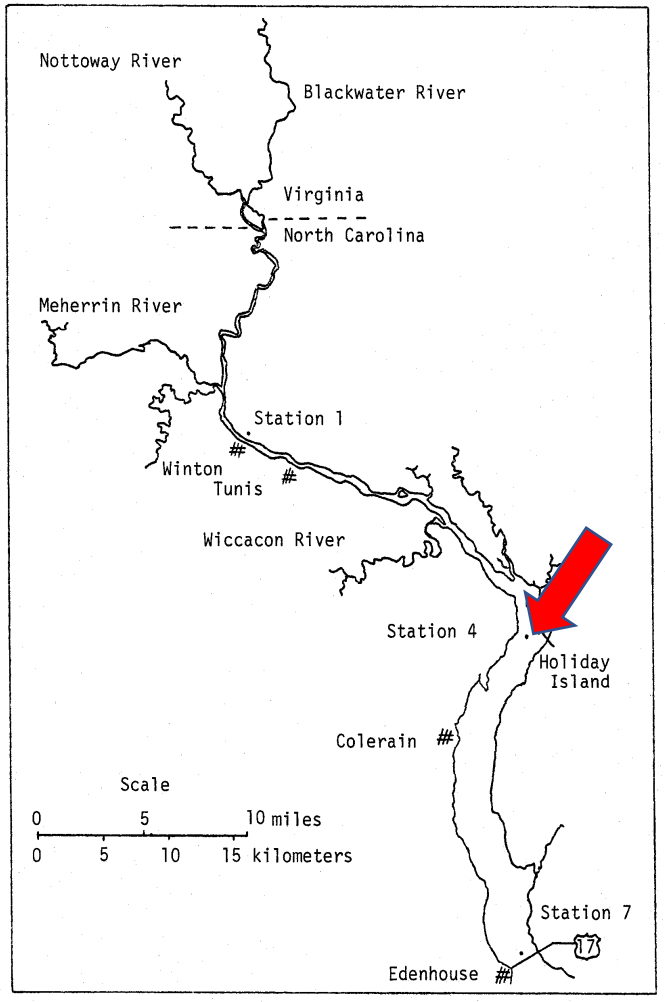


Figure 1. Map of the Chowan River and its major tributaries showing locations of sampling stations.

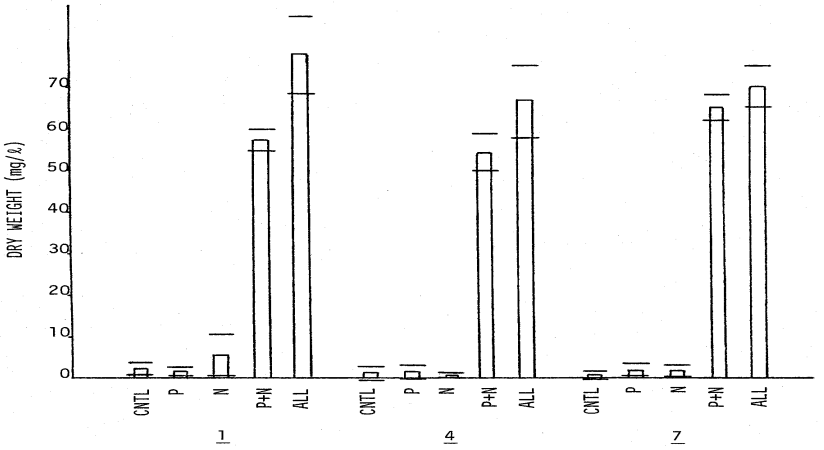
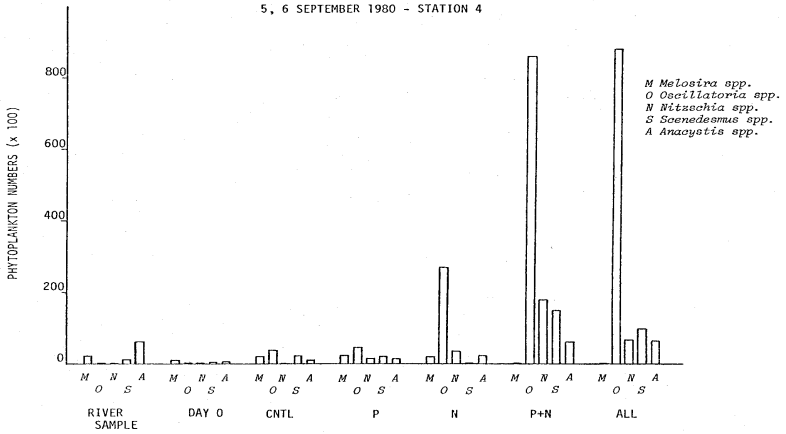
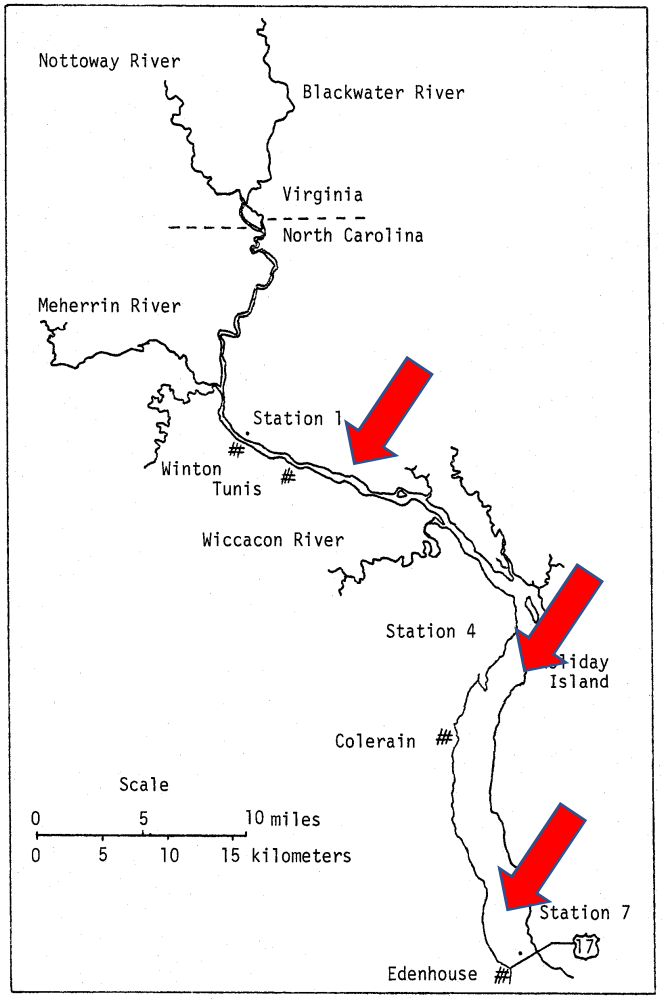


Figure 11. Mean algal dry weights ± SD for *Selenastrum* assay on water collected from Stations 1, 4, and 7 on 5, 6 August 1980.



From Sauer and Kuenzler, WRRI Report 161, 1981

40 Years Ago



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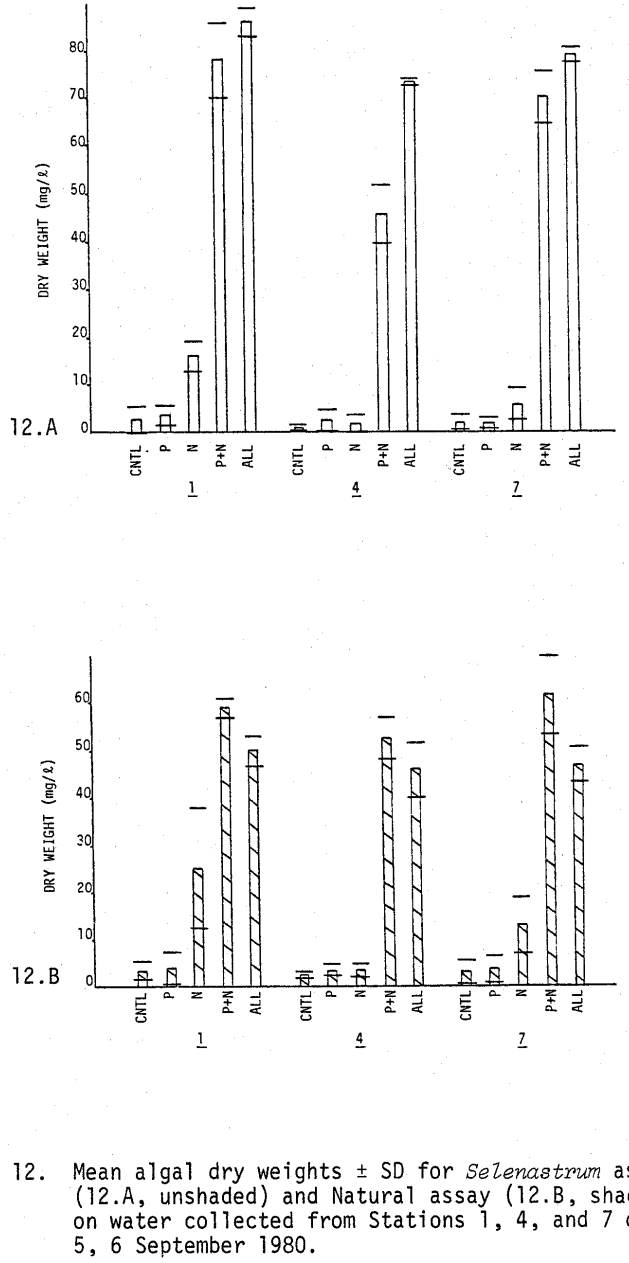


Figure 12. Mean algal dry weights ± SD for *Selenastrum* assay (12.A, unshaded) and Natural assay (12.B, shaded) on water collected from Stations 1, 4, and 7 on 5, 6 September 1980.

From Sauer and Kuenzler, WRRI Report 161,1981

Results: N limitation dominant, some N +P co-limitation

Conclusions from Sauer and Kuenzler, WRRI 161, 1981

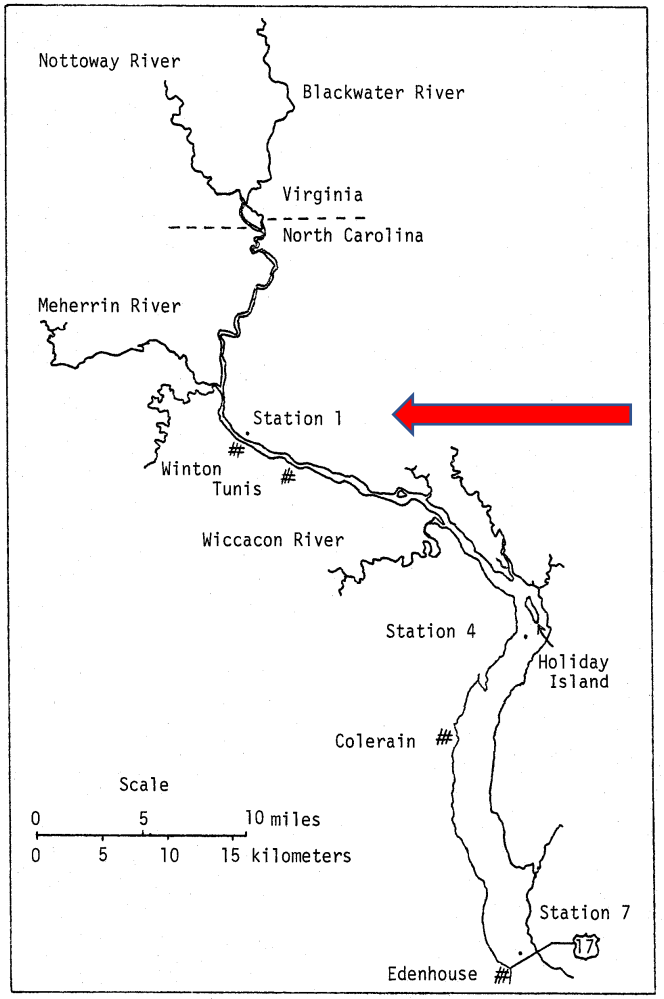


Figure 1. Map of the Chowan River and its major tributaries showing locations of sampling stations.

Simultaneous limitation of growth by N and P at most stations. P additions selected for N_2 fixing cyanobacteria, while N favored non-N_2 fixing algae.

Potential for N_2 fixing algae exist (confirmed by Paerl and Ustach 1982).

Phytoplankton at upstream Station 1 were probably only limited by "physical factors" (water flow and residence time)

High year-round inputs of N and P and favorable physical conditions sustain summer nuisance algal populations in the lower river

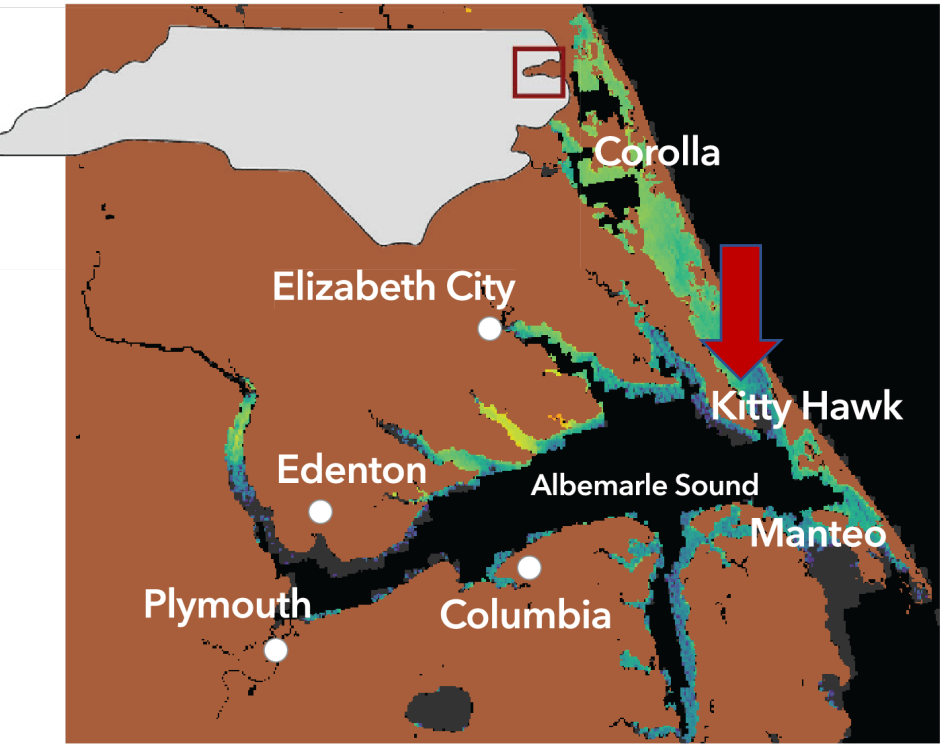
Goals: 30 to 40 percent reduction in P inputs and 15 to 25 percent reduction in N inputs successful in stemming N_2 fixing blooms"……up until around 2015.

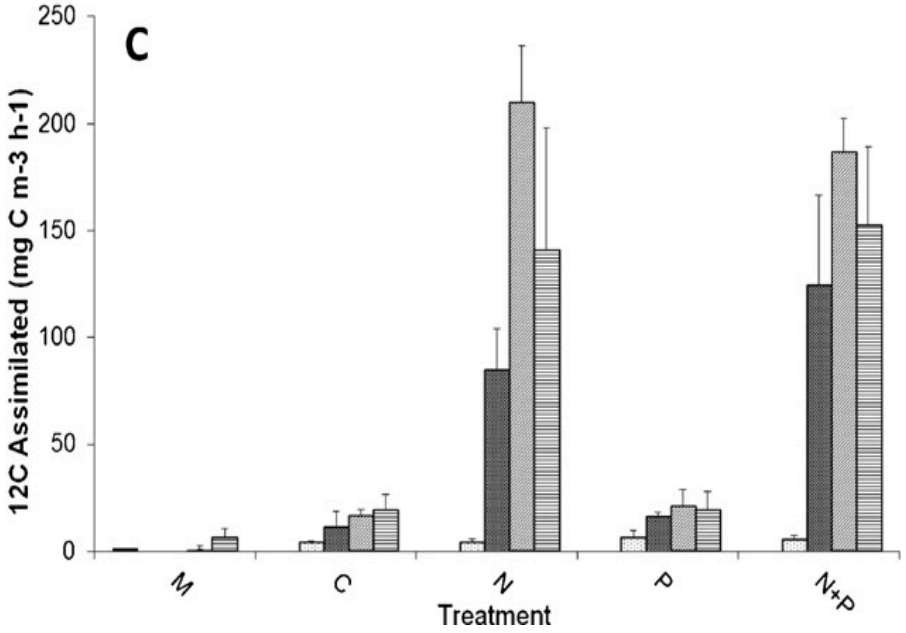
What has happened since then?


In situ bioassays on natural phytoplankton communities

Currituck Sound, Summer 2010

(from Calandrino & Paerl, 2011)



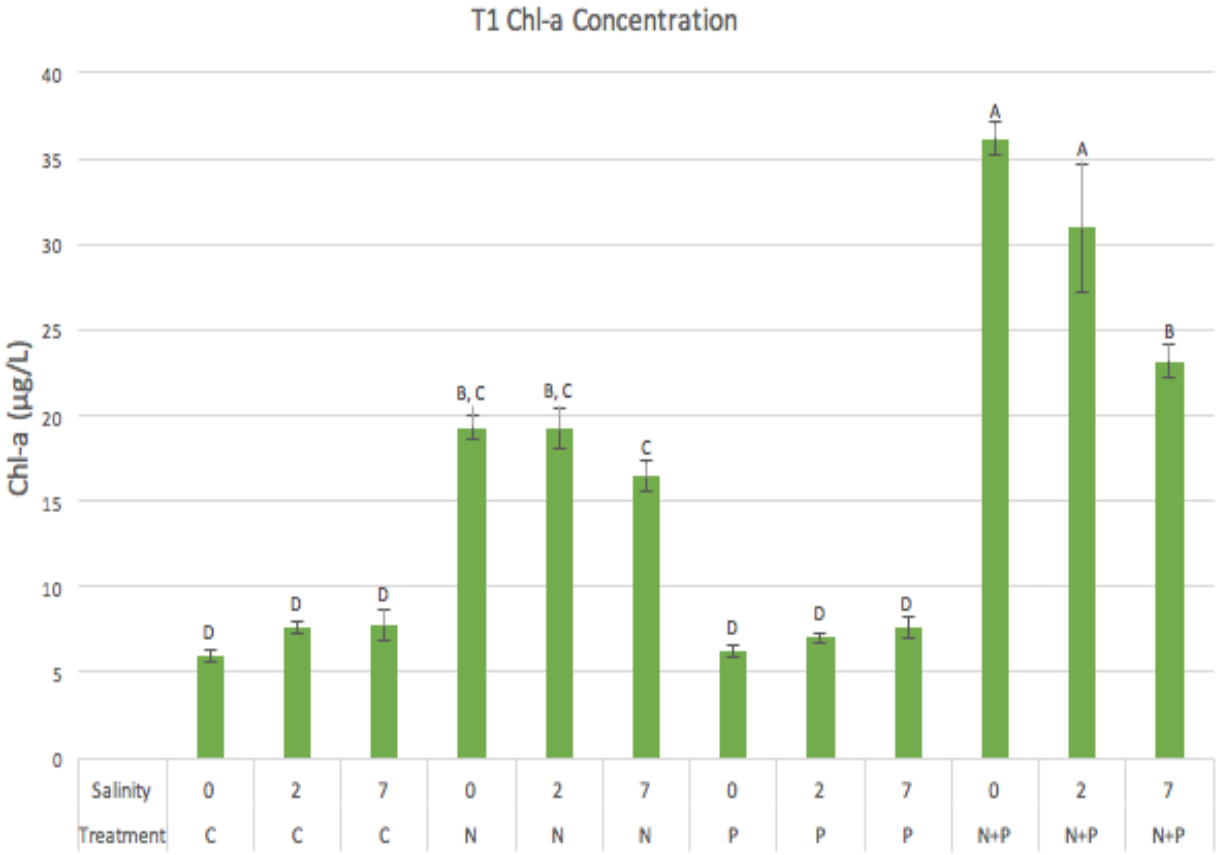


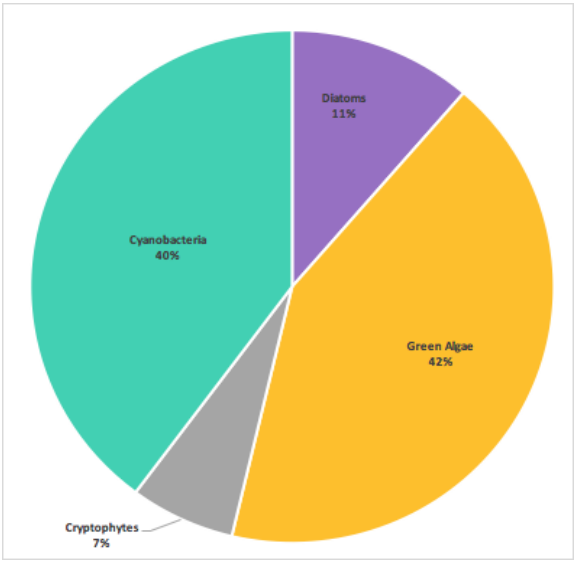
Cylindrospermopsis dominant cyanoHAB

Results: N limitation dominant

2018 Chowan River Bioassay, near Colerain, 3 Oct., 2018 (T1)

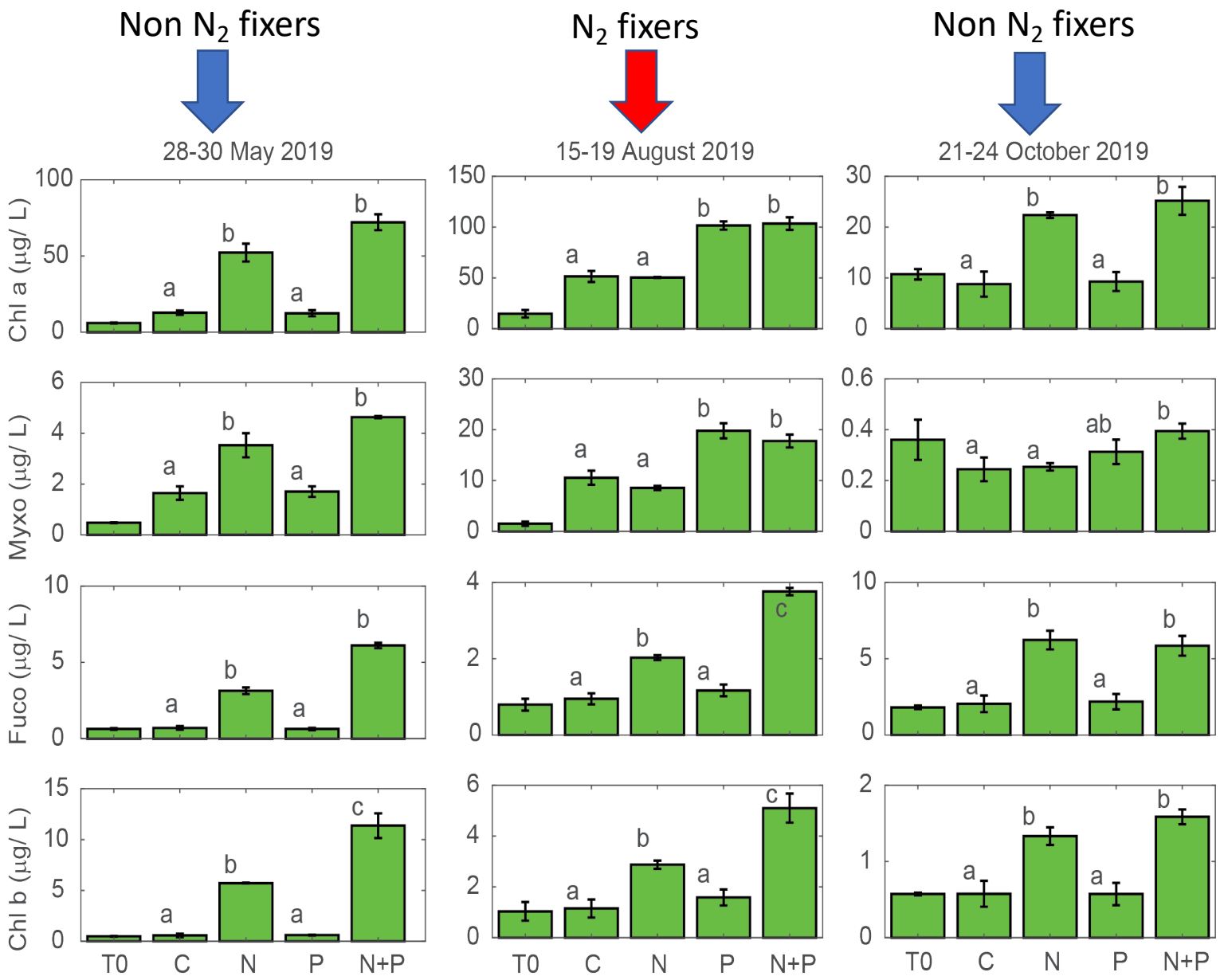
Felix Evans, UNC-CH undergraduate honors thesis, 2019





Results: N limitation dominant, N +P co-limitation also present

In situ Bioassays, Edenton Bay 2019 (in Hall & Karl 2020)



Results: N limitation dominant, N +P co-limitation, and P limitation when N_2 fixers present

DIN and DIP concentrations from beginning (To) to the end of the bioassays. Generally, P remained more available, most likely due to legacy P in sediments. Hence, N appears most limiting

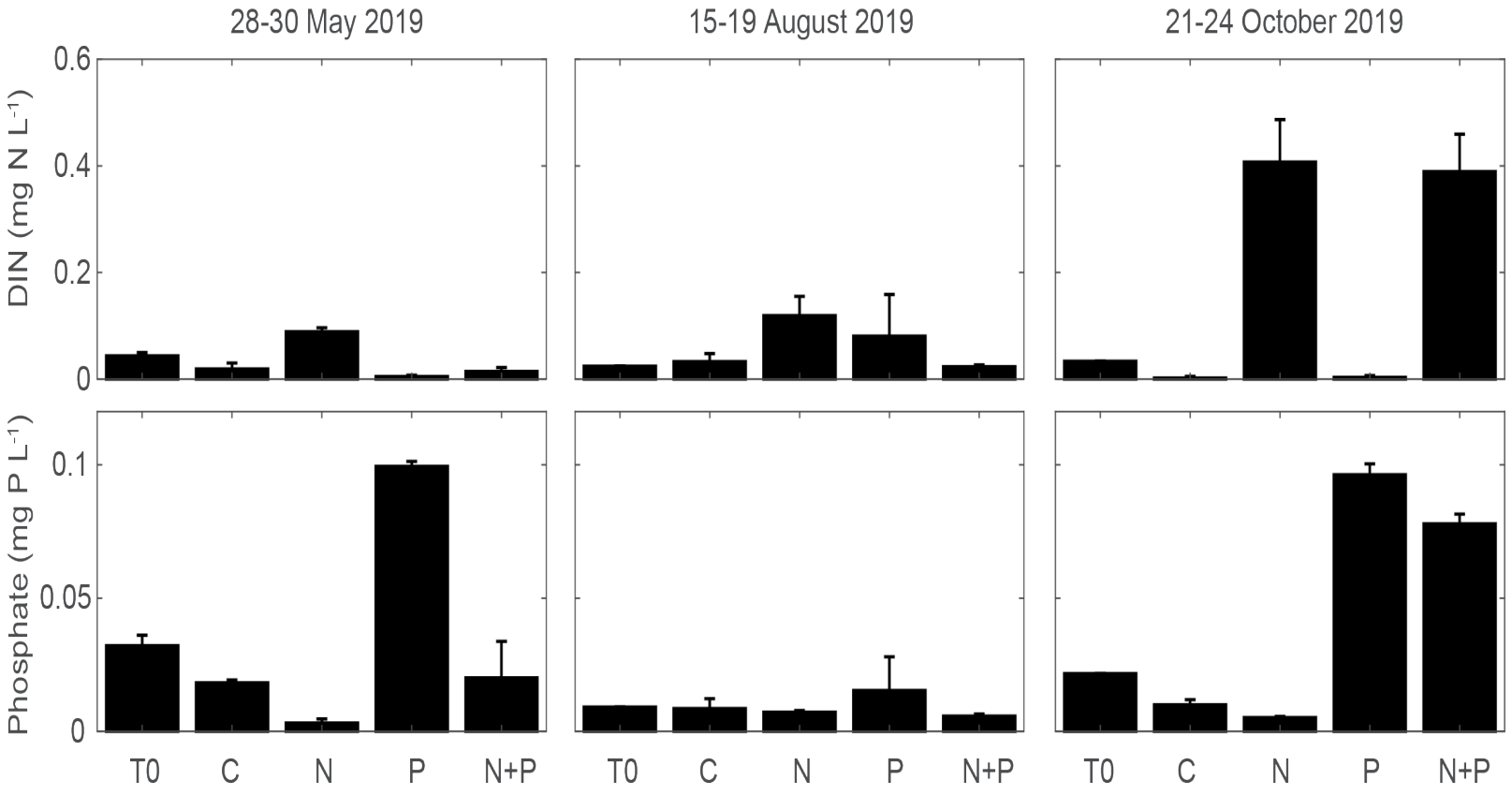
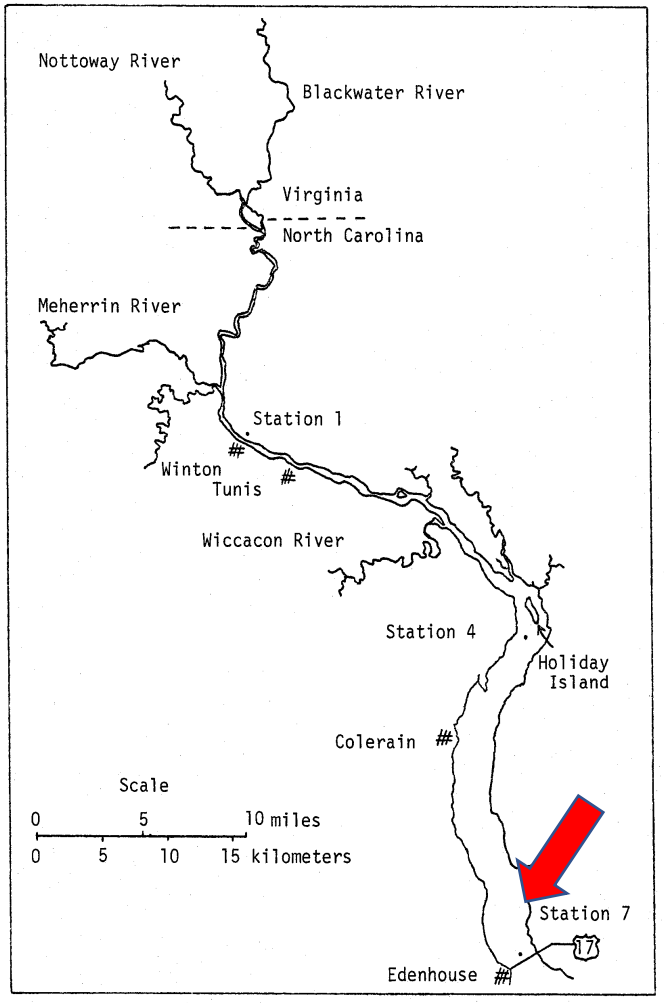


Figure 6. Dissolved inorganic nitrogen (DIN) and phosphate concentrations from the beginning (T0) and end of the three experiments Bars and whiskers represent the mean and standard deviation of triplicate values.

In situ Nutrient Bioassay, Sept. 2020

M. Barnard and UNC-IE Class



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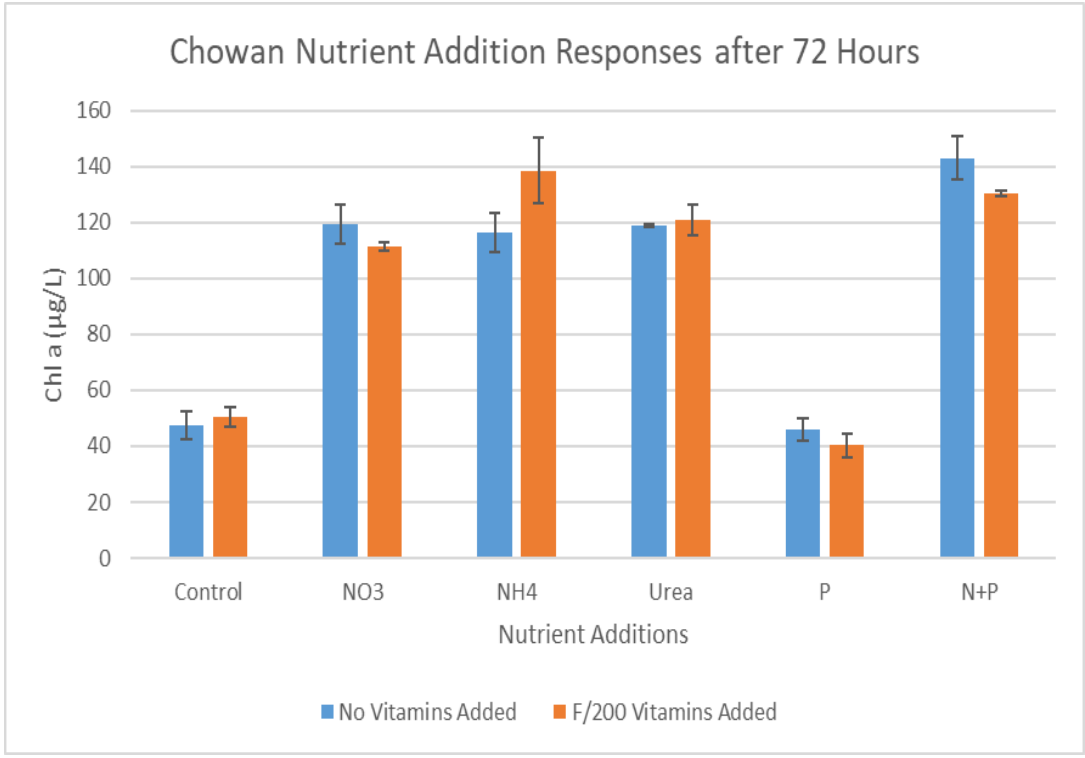
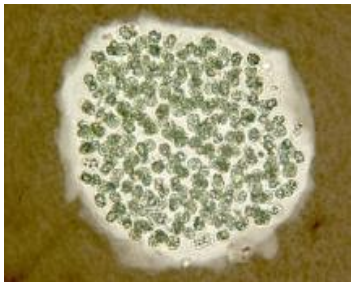
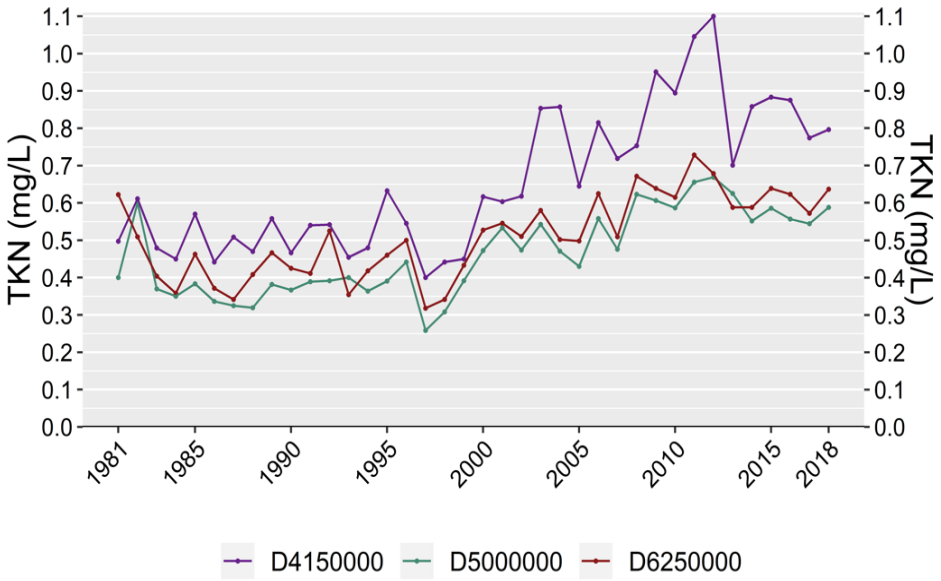


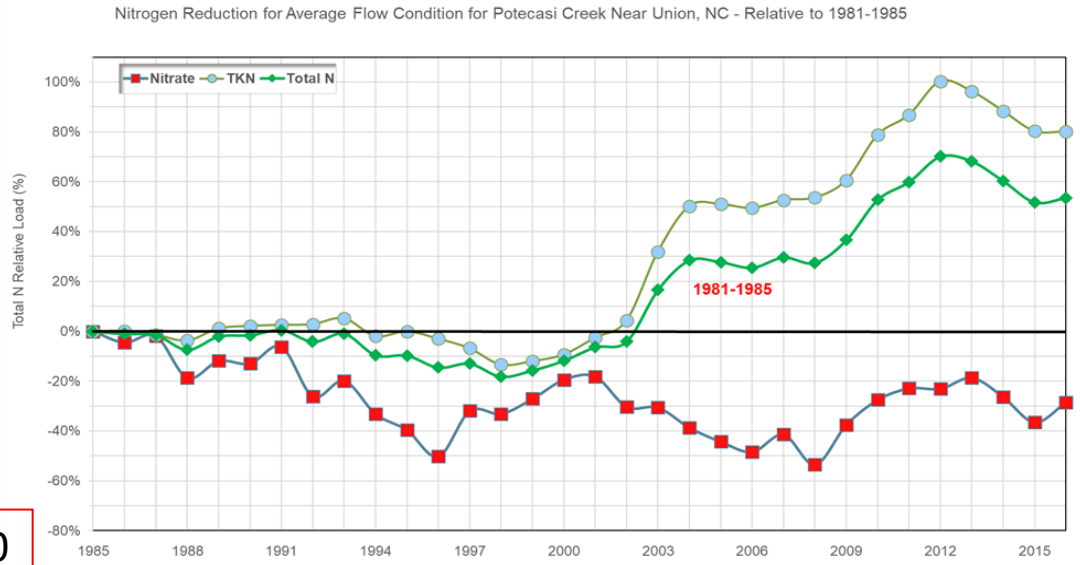
Results: N limitation dominant, marginal N +P co-limitation

Trends in TKN concentrations

Overall, increase while N limitation has persisted. Result, acceleration eutrophication

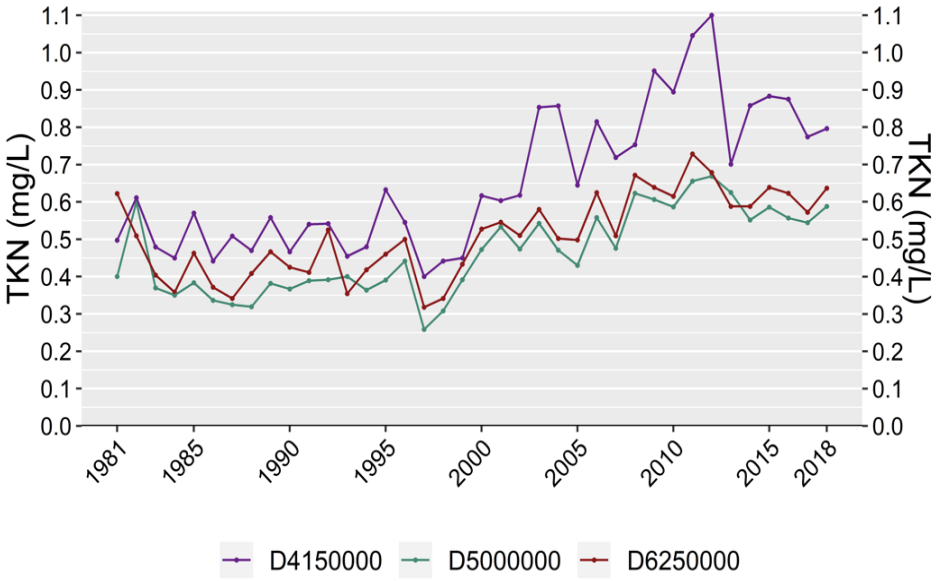


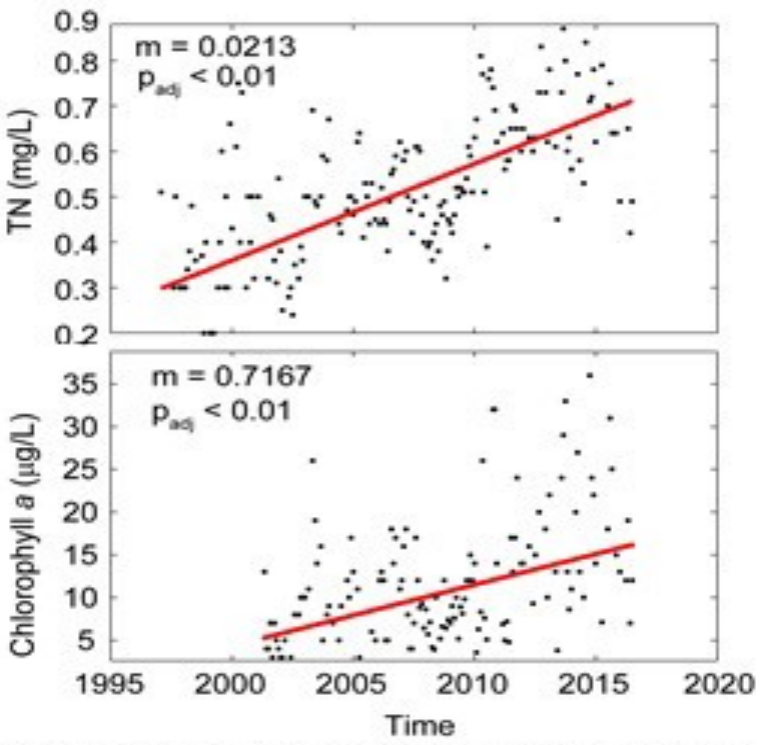




Source: NC-DEQ 2020

Linkage between increased N loading and eutrophication in Albemarle Sound

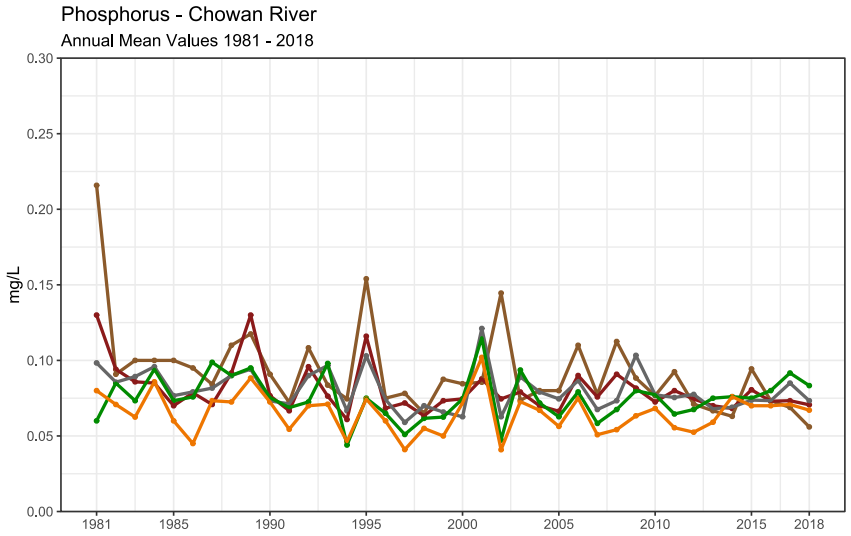


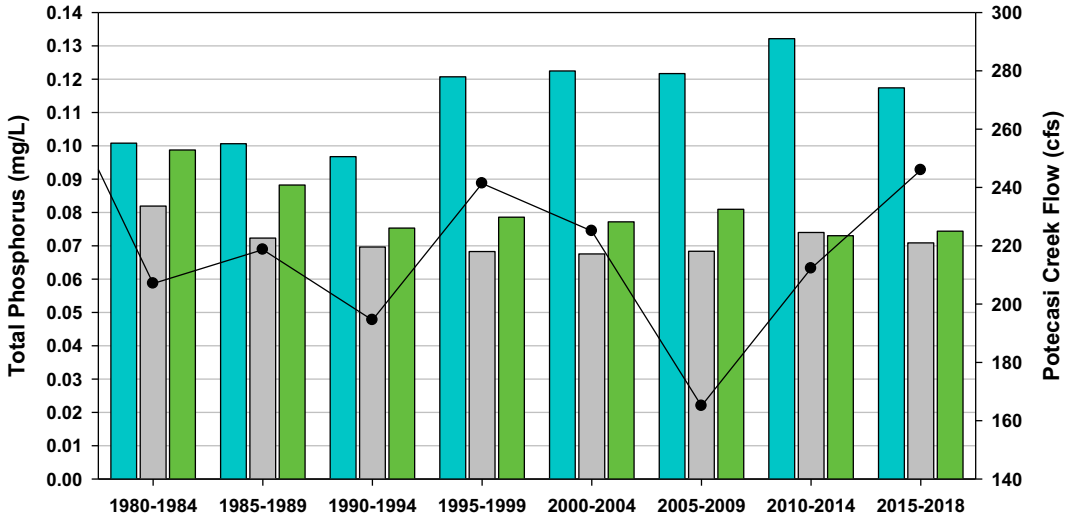


Data source: NC DEQ

Trends in Total P concentrations

No long term trend, despite reductions in inputs. This points to legacy P in system, able to support eutrophication with increases in N loading





Source: NC-DEQ 2020

Conclusions

- 40 years of bioassays has shown N to be the most limiting nutrient, but N+P colimitation and even P limitation can occur, depending on bloom magnitude and presence of N_2 fixing cyanobacteria.
- N limitation has persisted, despite increases in N loading. Most likely, due to legacy P in the system, maintaining P availability.
- N stimulation of algal production appears to have paralleled increases in chlorophyll in Albemarle Sound.
- Further N input reductions needed, while holding the line on P inputs.
- Need: Identify N inputs…external sources vs. internal sources (N_2 fixation).
- Then, determine reductions needed to get below bloom thresholds
- Climatic changes need to be taken into consideration (more episodic rainfall and extreme drought events, warming?) because they can affect nutrient-algal production relationships.