Chowan River and Albemarle Sound Nutrient-Algal Bloom Dynamics over the past 45 years: What have we learned?

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

UNC INSTITUTE OF MARINE SCIENCES

CEEG CHOWAN EDENTON ENVIRONMENTAL GROUP

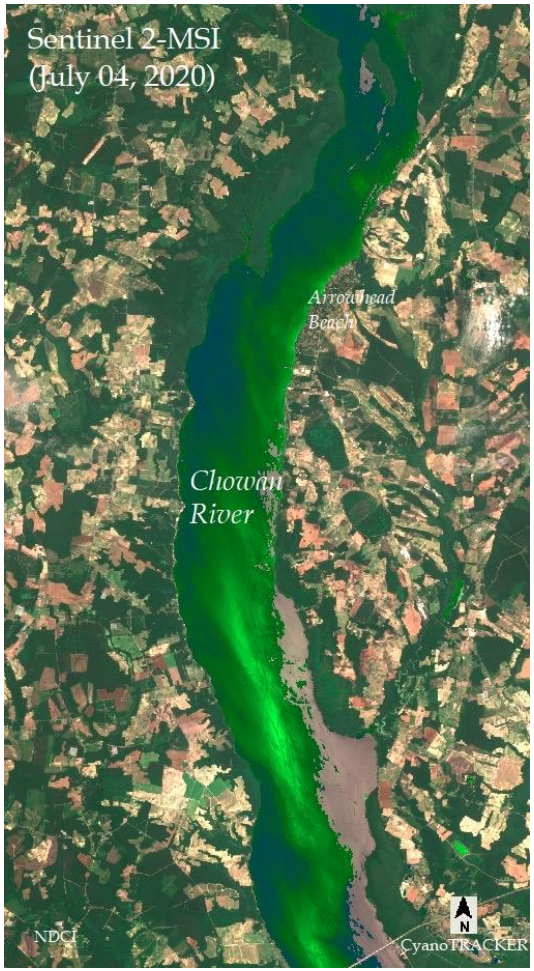
NC Environmental Quality

Sea Grant North Carolina

WRRI

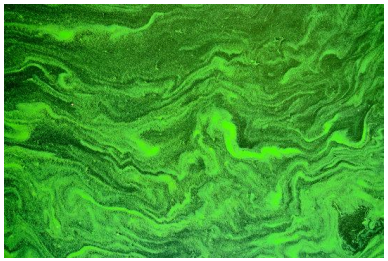
Albemarle-Pamlico National Estuary Partnership

NSF National Science Foundation



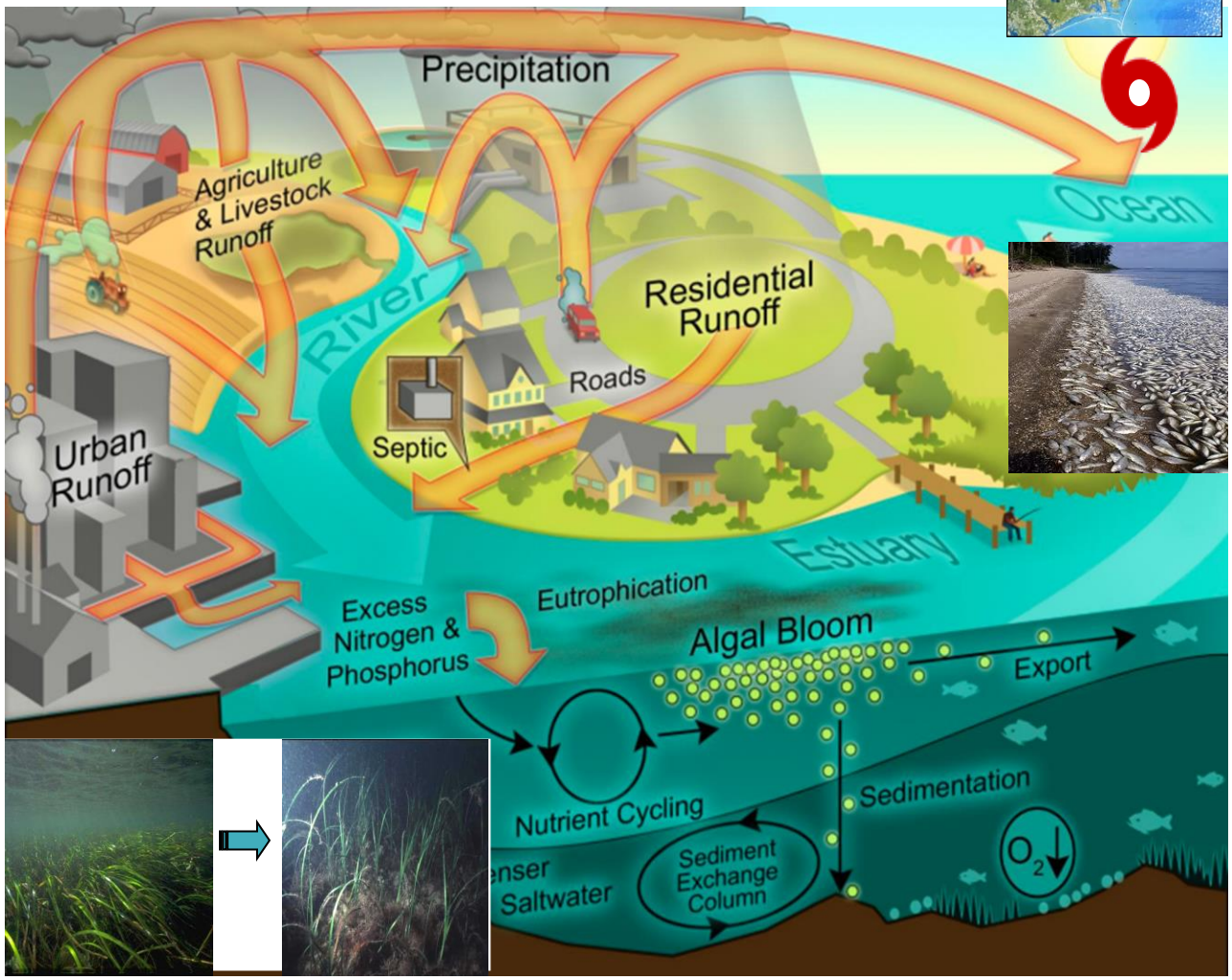
Chowan River-Albemarle Sound: CyanoHAB expansion in E. North Carolina

- Excessive nutrient inputs
- Semi-lagoonal, long water residence time
- Harmful/ toxic algal blooms
- Hypoxia/ anoxia
- Fish kills
- Shellfish closures
- Loss of critical SAV habitats



1980's

2010's
2020's



Chowan R. has been plagued by CyanoHABs since the late 1970's

>40 Years Ago

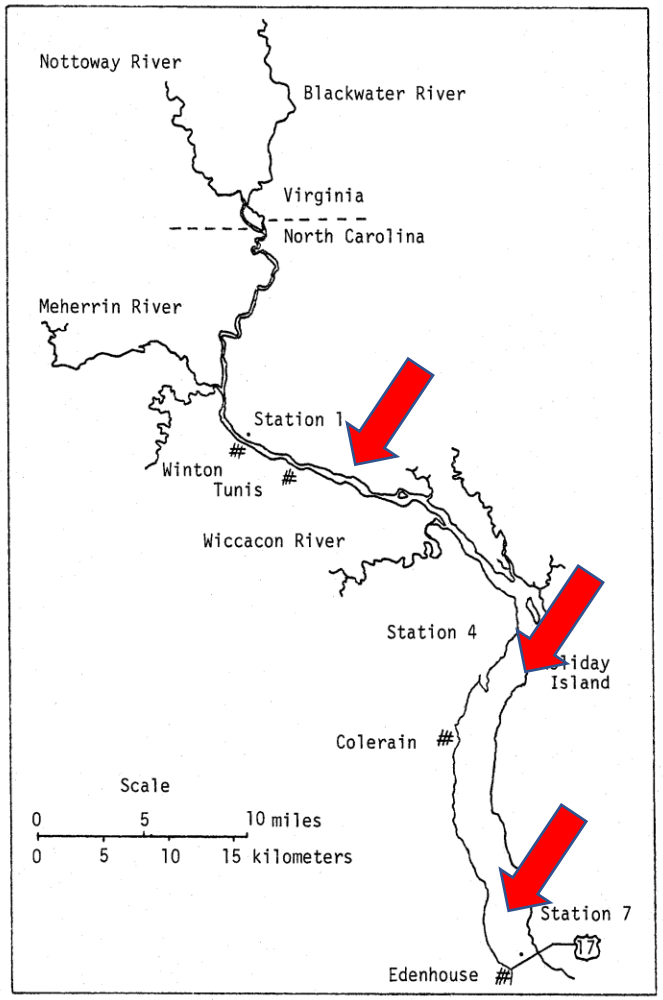
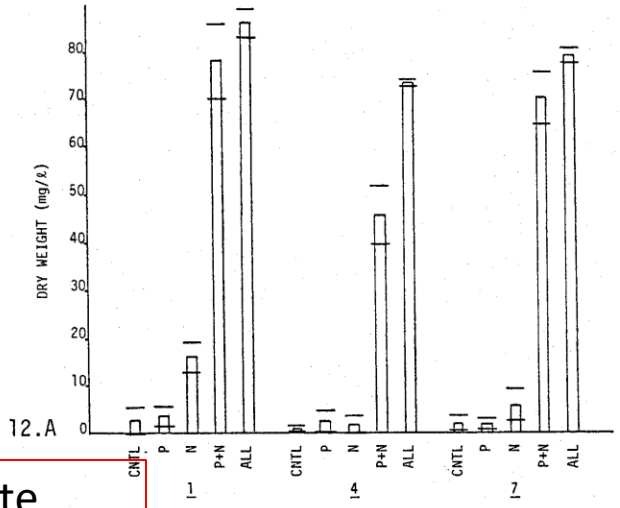


Figure 1. Map of the Chowan River and its major tributaries showing locations of sampling stations.

Lab bioassay



N and N +P stimulate Algal growth (in EPA lab and in situ bioassays)

In situ bioassay

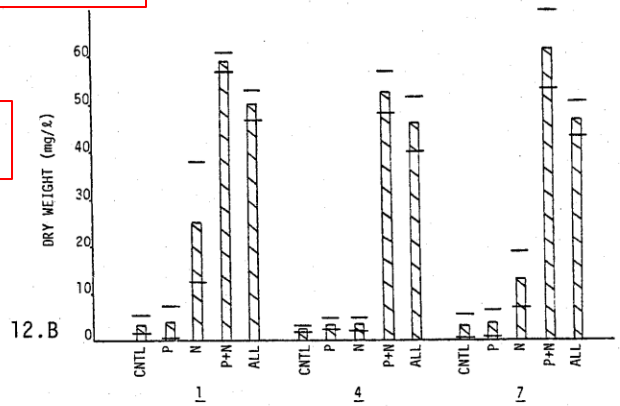
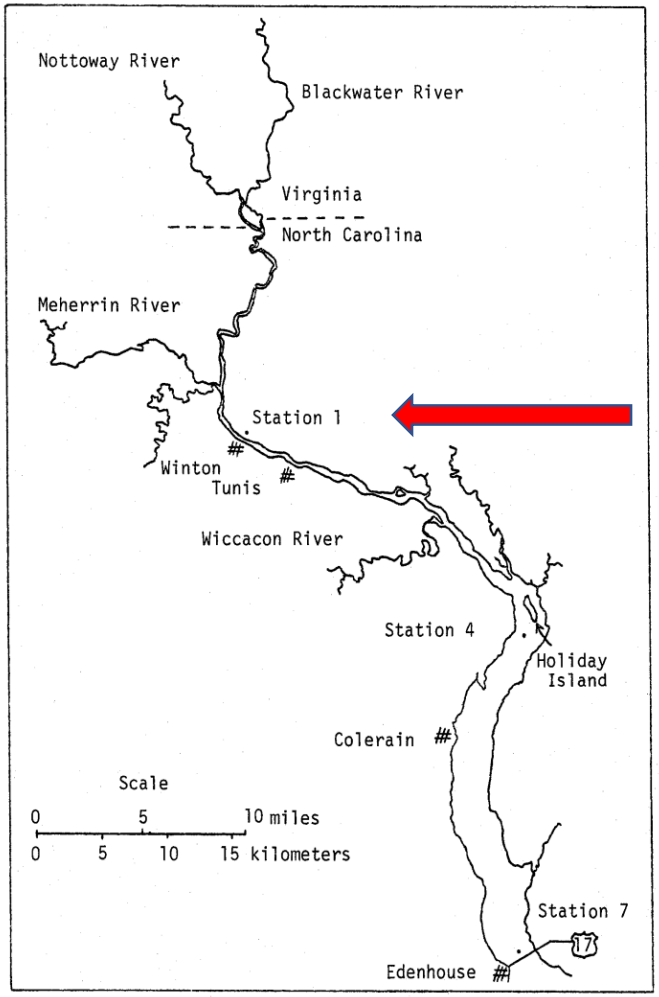


Figure 12. Mean algal dry weights ± SD for *Selenastrum* assay (12.A, unshaded) and Natural assay (12.B, shaded) on water collected from Stations 1, 4, and 7 on 5, 6 September 1980.

From Sauer and Kuenzler, WRRI Report 161,1981

Conclusions from Sauer and Kuenzler, WRRI 161, 1981



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

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

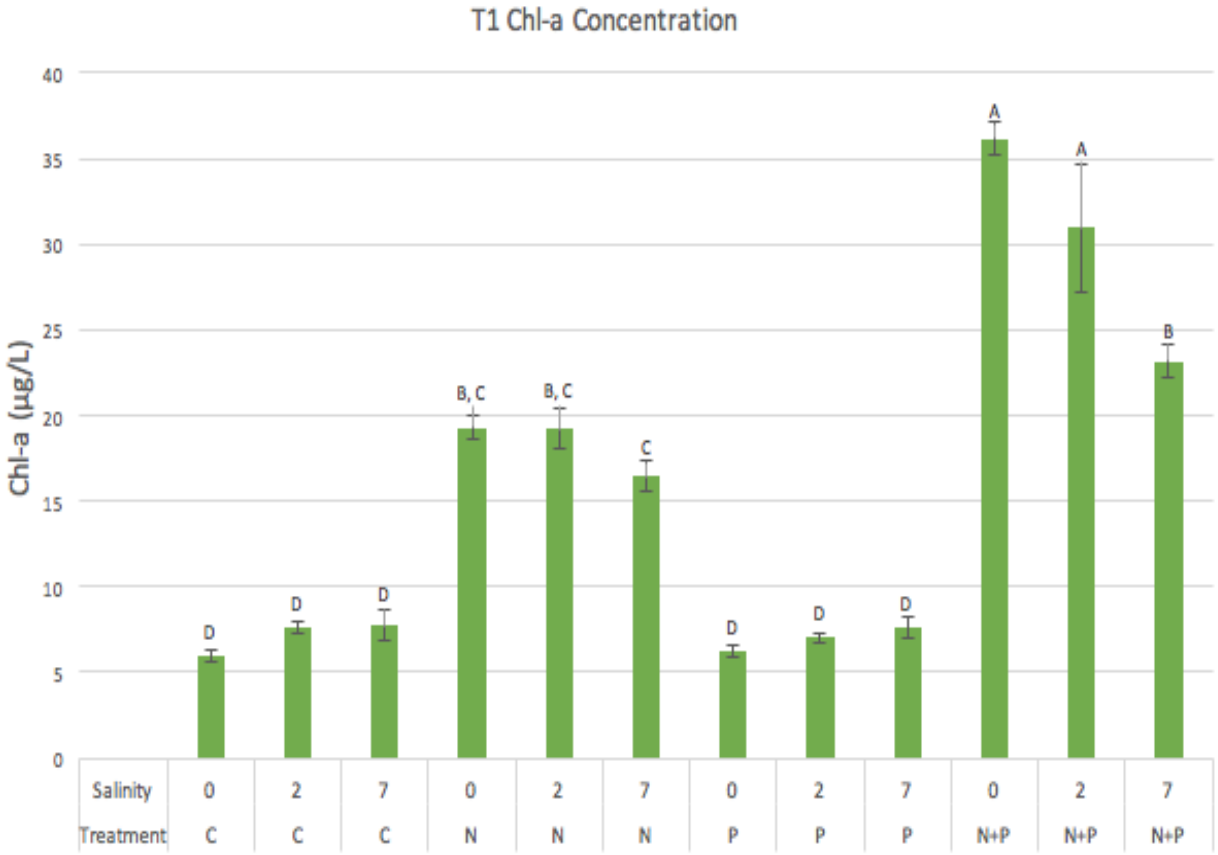
Recommendation: **30 to 40 percent reduction in P inputs and 15 to 25 percent reduction in N inputs needed to stem blooms"**

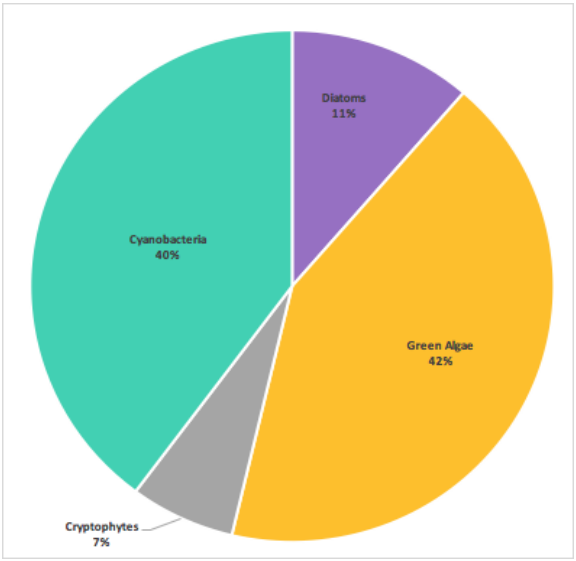
What has happened since then?


2000-2020: In situ bioassays on Chowan R. phytoplankton communities

2018 Chowan River Bioassay, near Colerain, 3 Oct., 2018

Felix Evans, UNC-CH undergraduate honors thesis, 2019





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

In situ Nutrient Bioassay, Sept. 2020

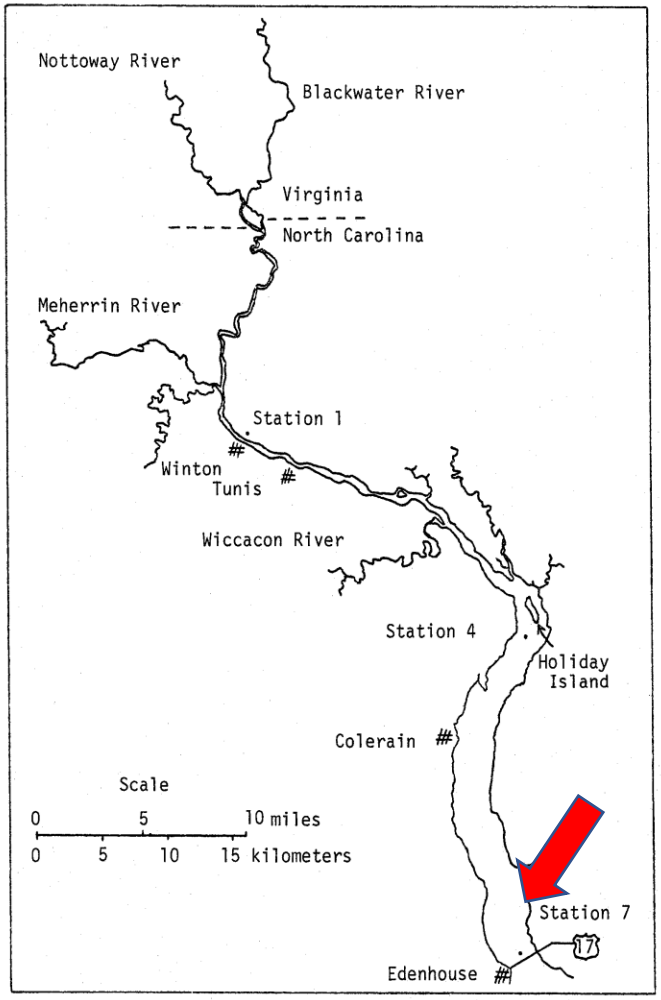
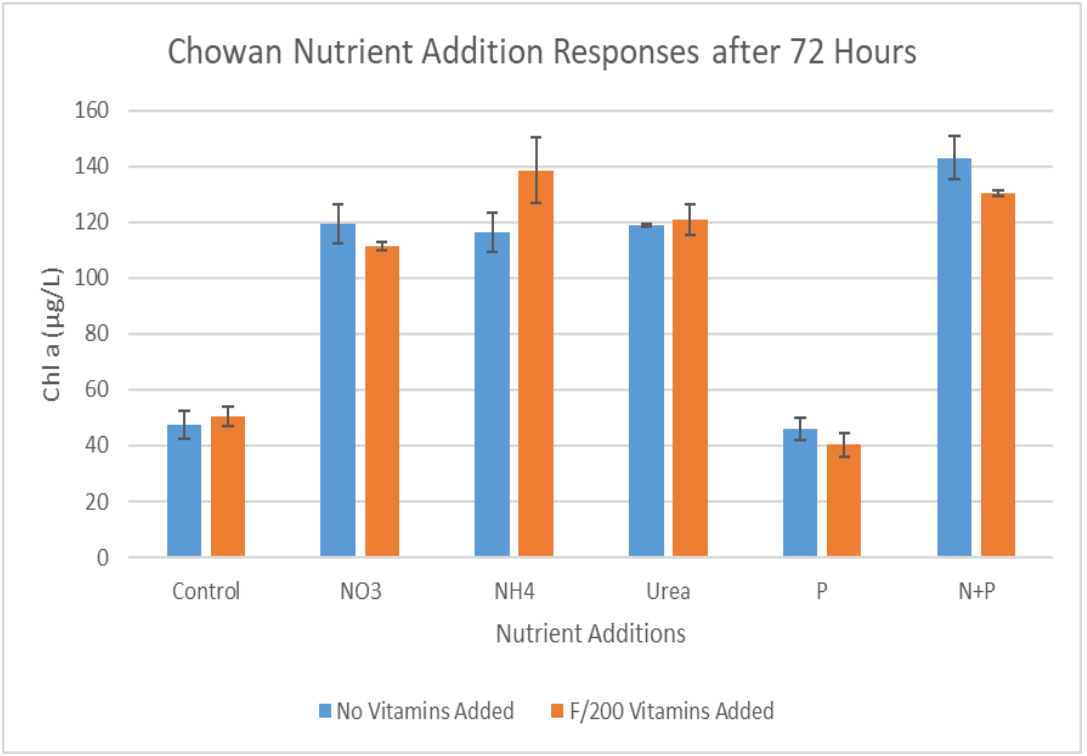


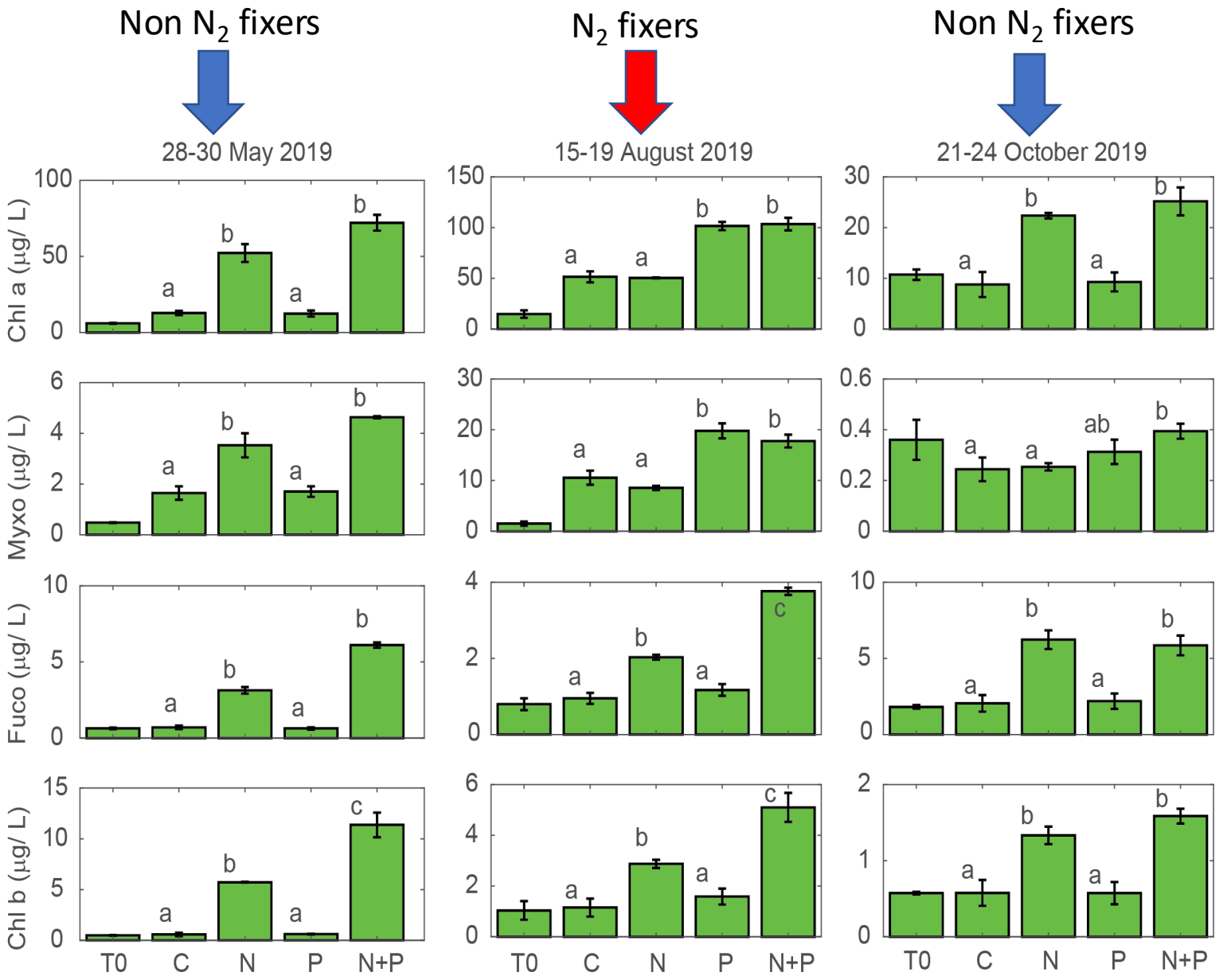
Figure 1. Map of the Chowan River and its major tributaries showing locations of sampling stations.



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

Barnard et al. 2020

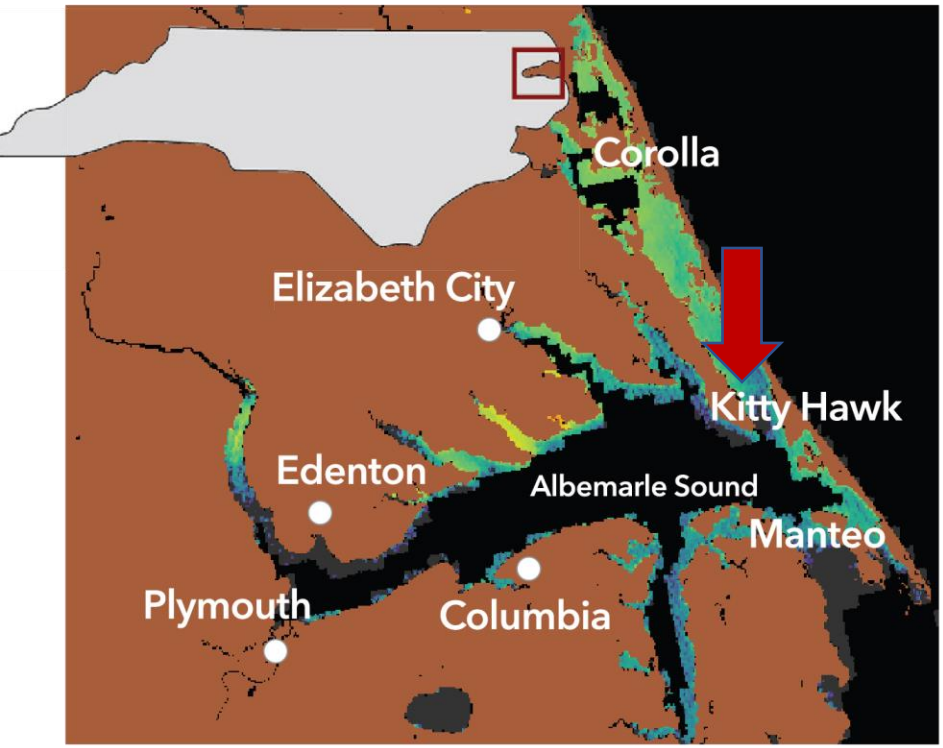
In situ Bioassays, Edenton Bay 2019 (in Hall & Karl 2020)

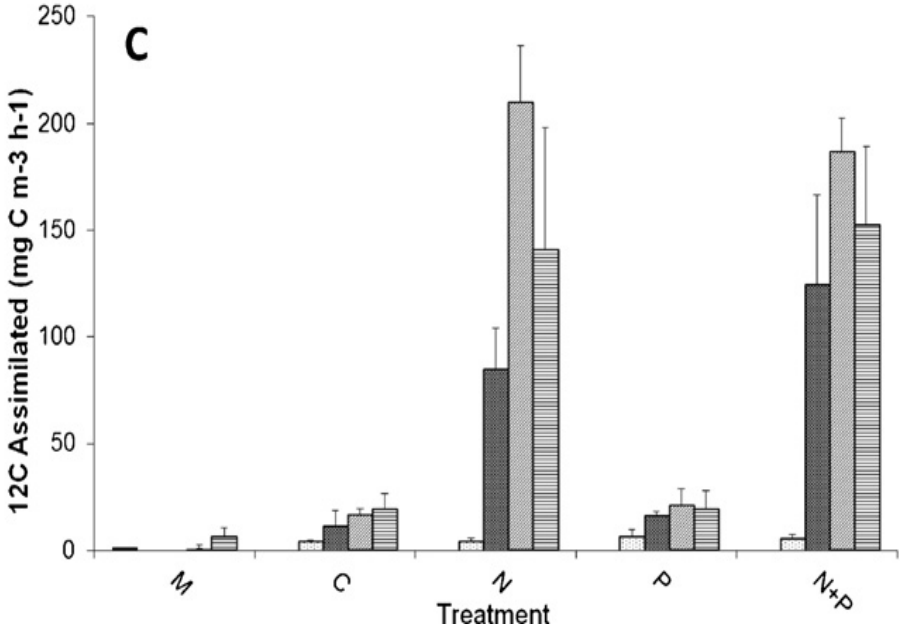


Results: N limitation dominant, N +P co-limitation, and P limitation when N_2 fixers present

Currituck Sound, Summer 2010

(from Calandrino & Paerl, 2011)

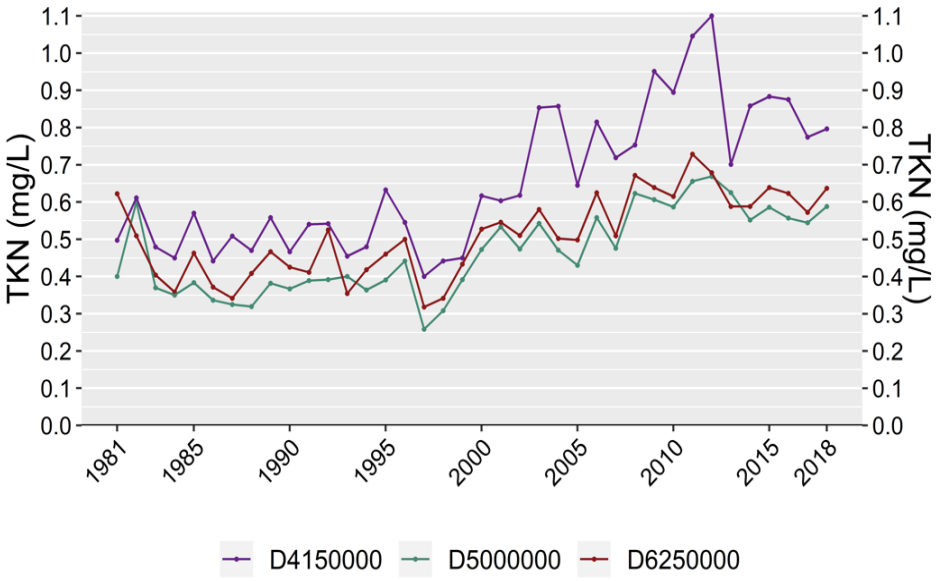


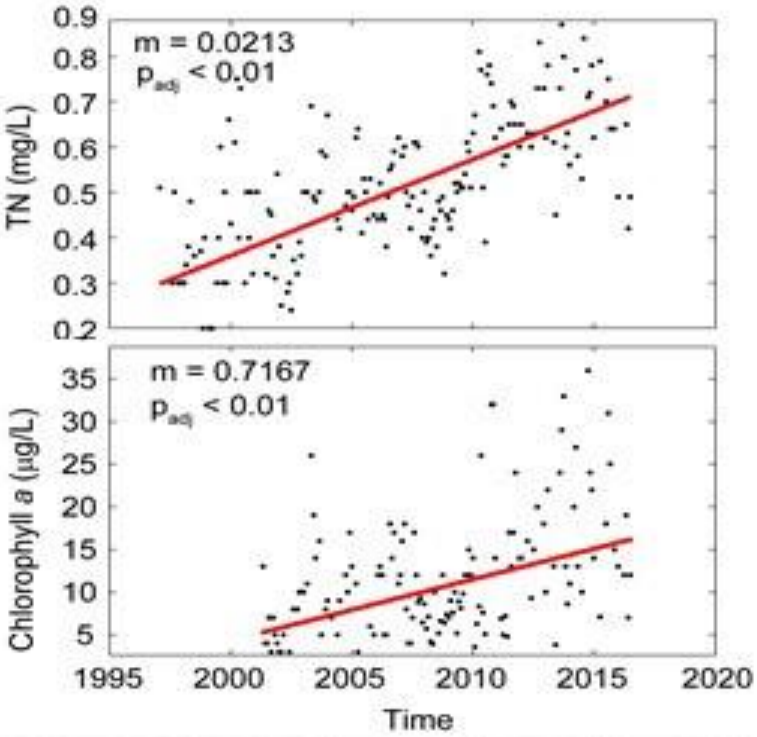


Cylindrospermopsis dominant cyanoHAB

Results: N limitation dominant

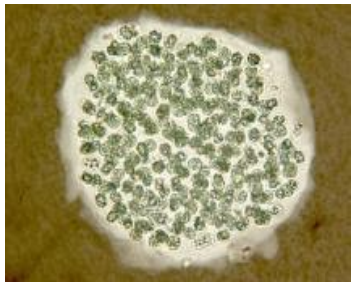
Linkage between increased N loading and eutrophication in Albemarle Sound

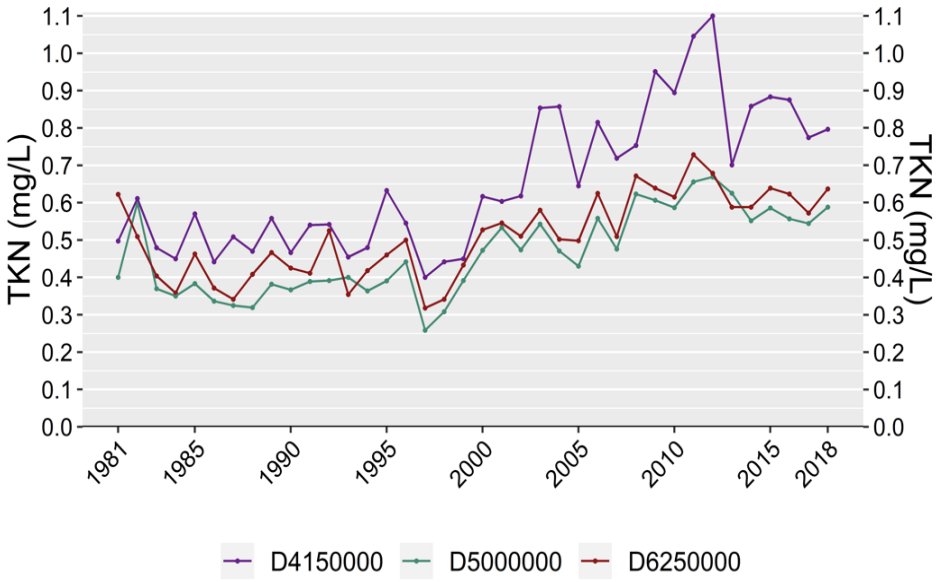


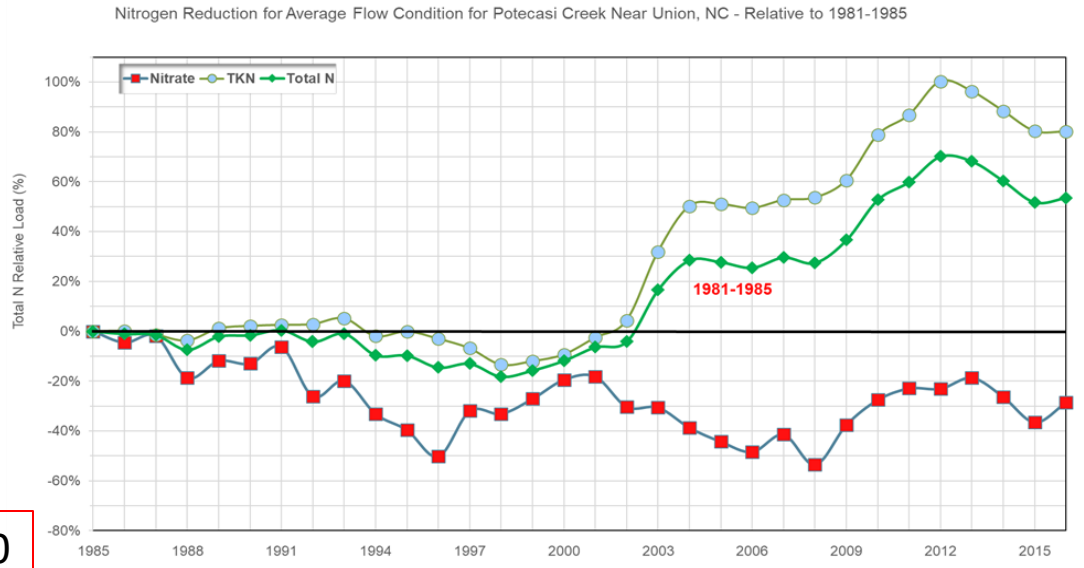


Hall & Paerl, Unpubl.
Data source: NC DEQ

Organic N (TKN) loading has increased most noticeably: Link to eutrophication?



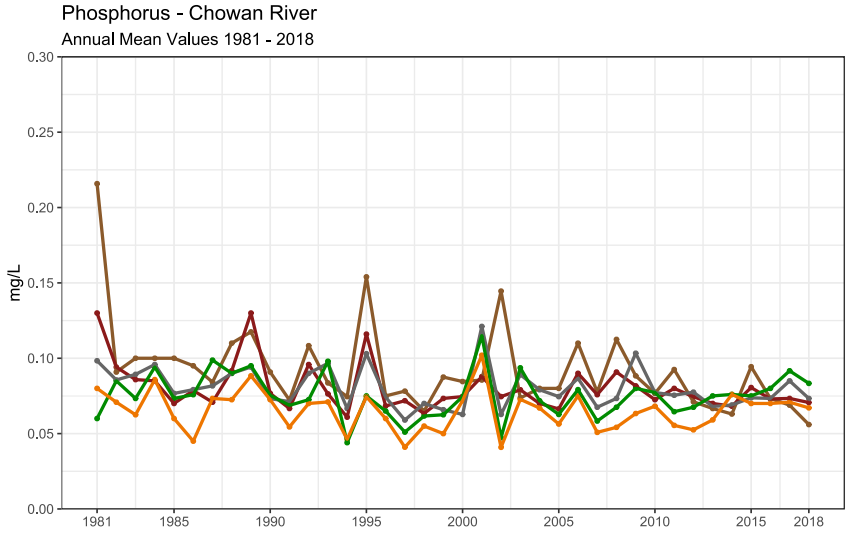


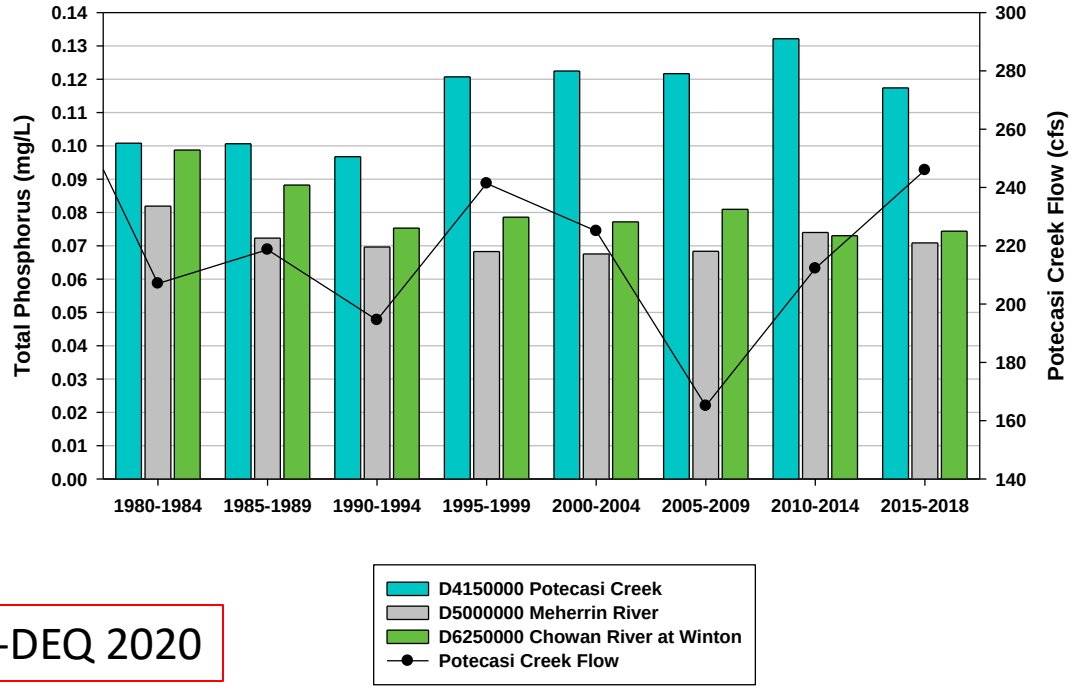


Source: NC-DEQ 2020

Trends in Total P concentrations

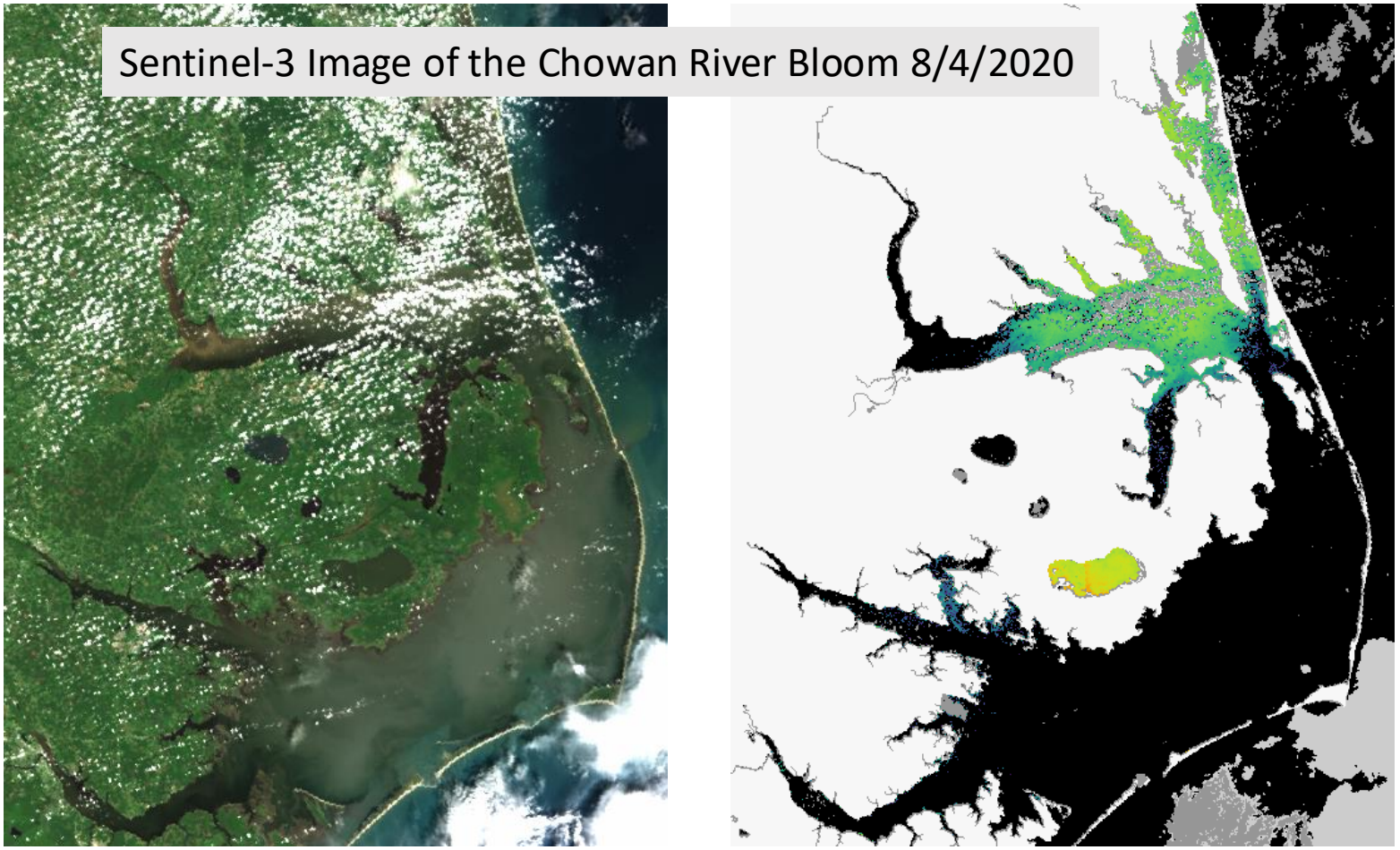
No long term trend, despite reductions in inputs. This points to legacy P in system, able to support eutrophication with increases in N loading





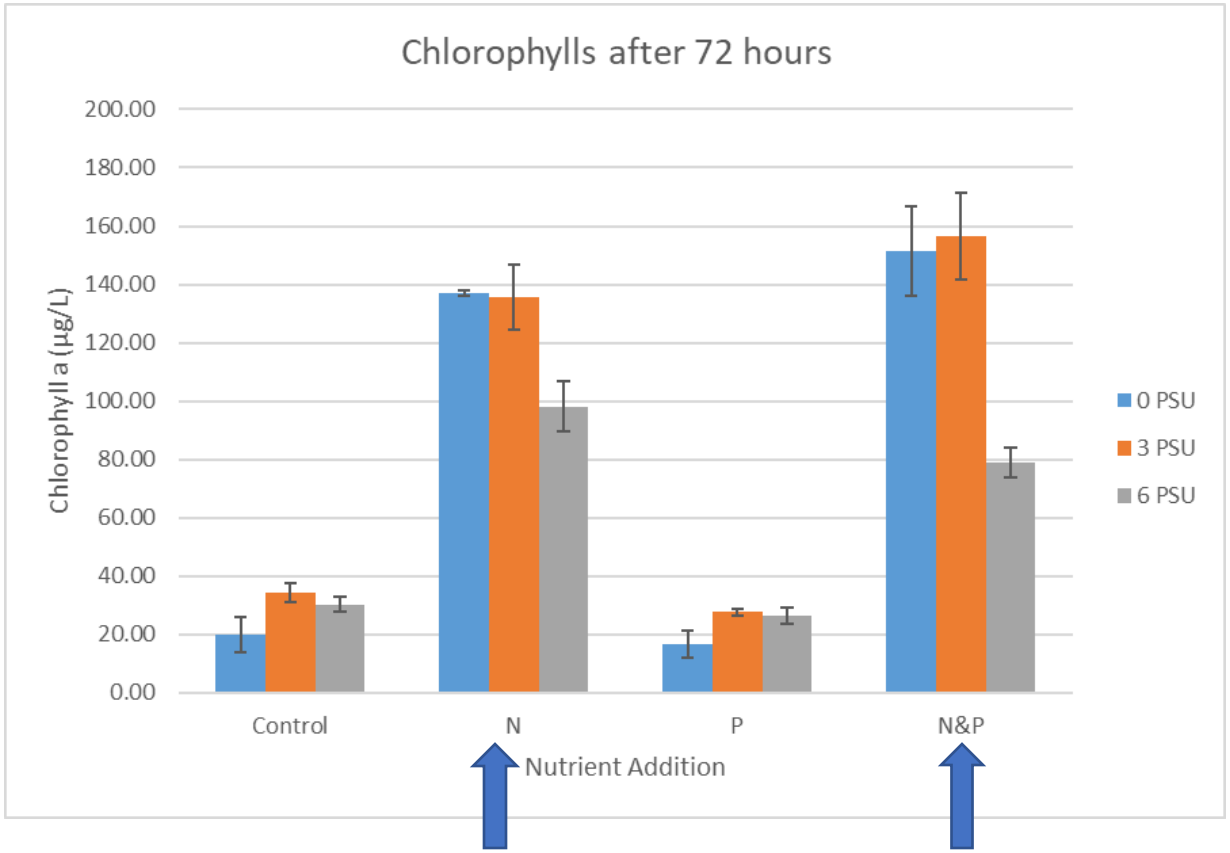
Source: NC-DEQ 2020

Salinity effects on CyanoHABs?



https://coastalscience.noaa.gov/research/stressor-impacts-mitigation/hab-monitoring-system/cyanobacteria-algal-bloom-from-satellite-in-albemarle-and-pamlico-sounds-nc/

Salinity effects on the Chowan River/Albemarle Sound blooms?
Conclusion: Blooms can expand



Puentes et al. (UNC-IE Class) 2020

Conclusions and Recommendations

- >40 years of bioassays has shown N, N+P and even P limitation can occur, depending on hydrology, 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.
- Increases in TN parallel increases in chlorophyll (algal production) 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).
- Need: determine reductions needed to get below bloom thresholds (estimates range from 30-40% for N and P)
- Climatic changes (more episodic rainfall and extreme drought events, warming) are stimulating and intensifying blooms. In the short term can't change the weather. May need to reduce nutrient inputs even more, and 30-40% is a starting target.