Defining the Balance Between Cyanobacterial N_2 Fixation and Denitrification in Falls Lake

Nathan Hall
Michael Piehler
Hans Paerl
UNC Chapel Institute of Marine Sciences

NC Policy Collaboratory Nutrient Study Advisory Board
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Understanding N_2 fixation of Falls Lake is a good idea

1) N_2 fixation can represent an important pathway of new N inputs-enhanced fertility and associated problems of eutrophication

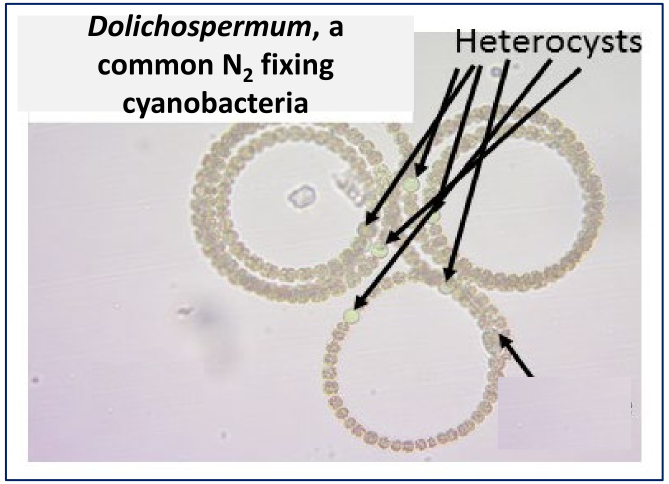
2) N_2 fixing cyanobacteria are scum and/ or toxin producers

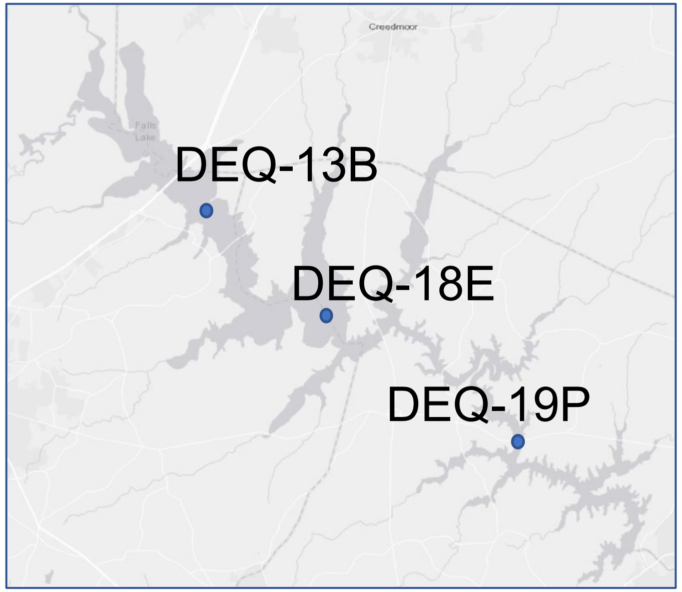
3) Balance of N_2 fixation and denitrification often determines nutrient limitation-can inform more effective nutrient control strategies

4) Can help constrain other parts of the N budget that are difficult to measure such as denitrification

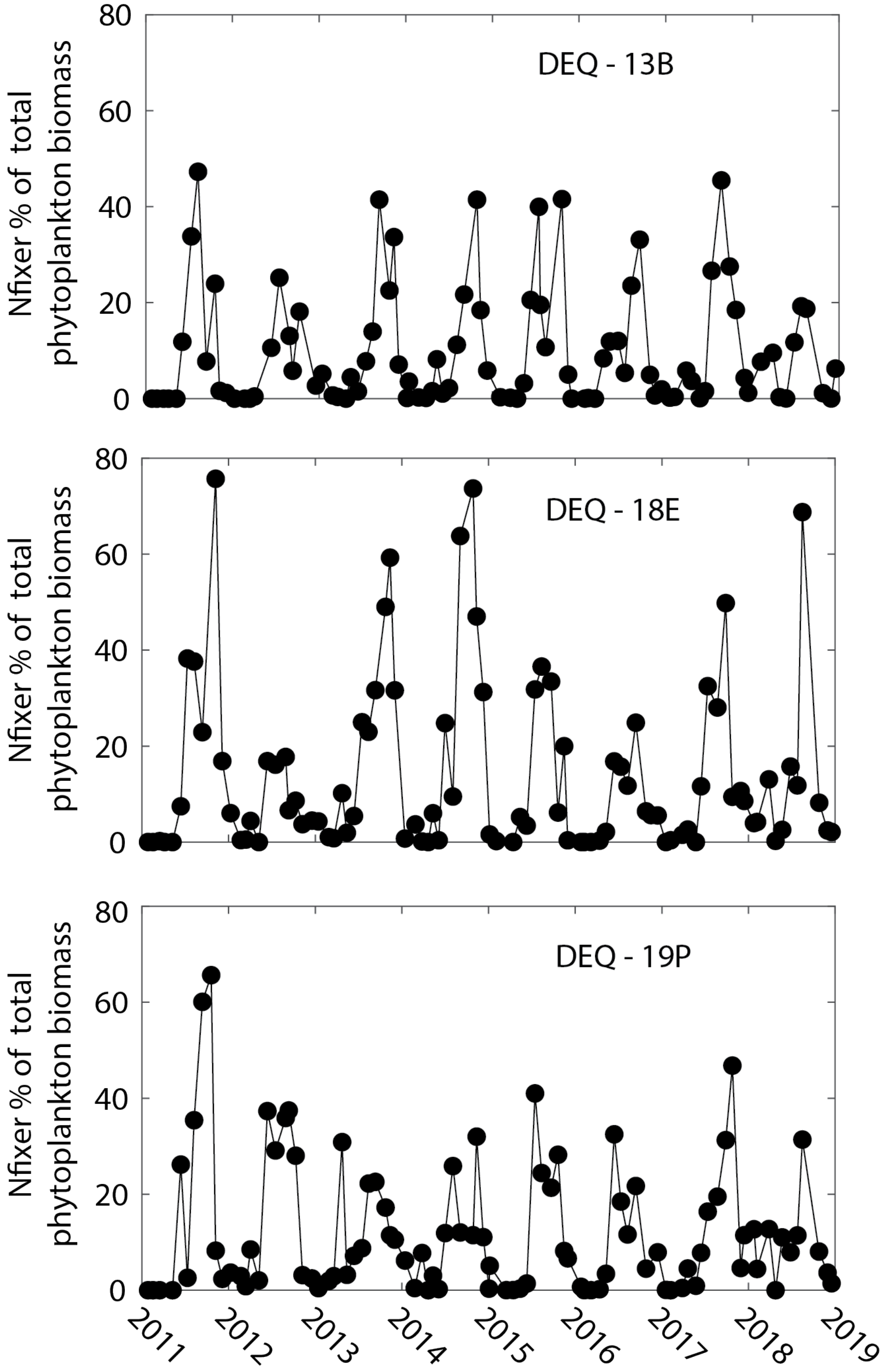
Parking under the buzzard tree at the Barton Creek boat ramp is a BAD IDEA!

N_2 fixing cyanobacteria are important components of the Falls Lake phytoplankton community





But N_2 fixing cyanobacteria are not currently represented in the latest DEQ or UNRBA models



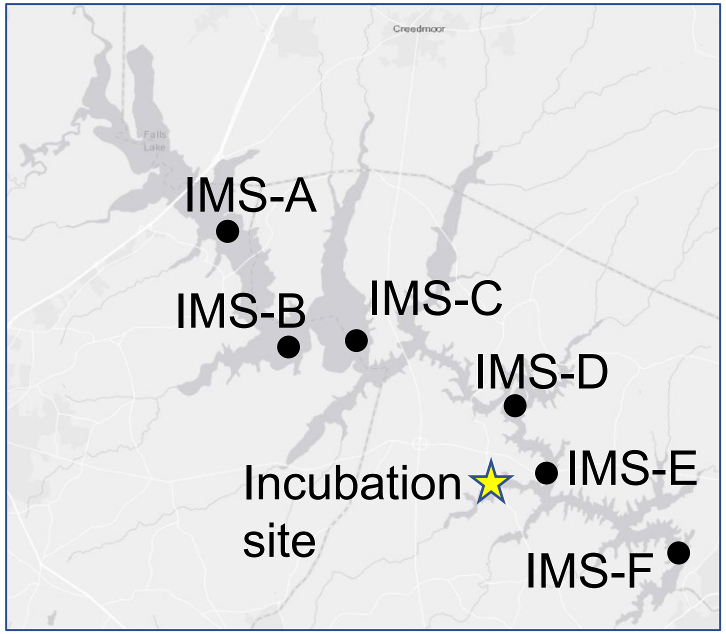
Study Objectives

1) Estimate lake-wide rates of N_2 fixation to determine its importance relative to other N sources

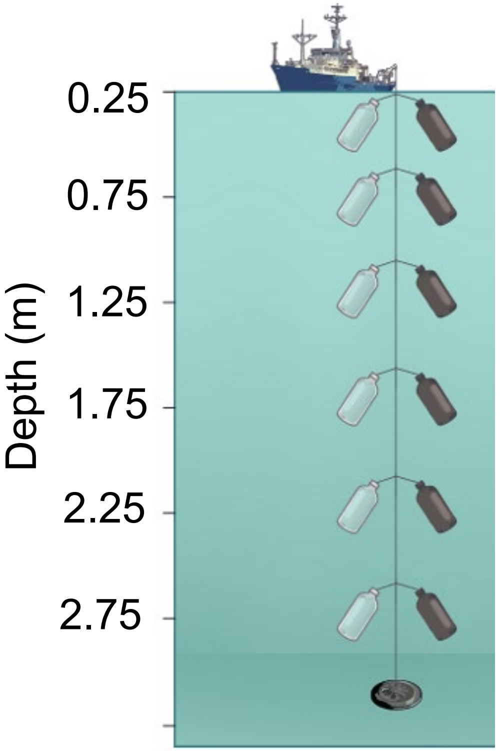
2) Explore correlates of N_2 fixation to uncover stimulatory factors

3) Construct a N mass balance for the lake that includes N2 fixation to calculate a lake-wide estimate for denitrification

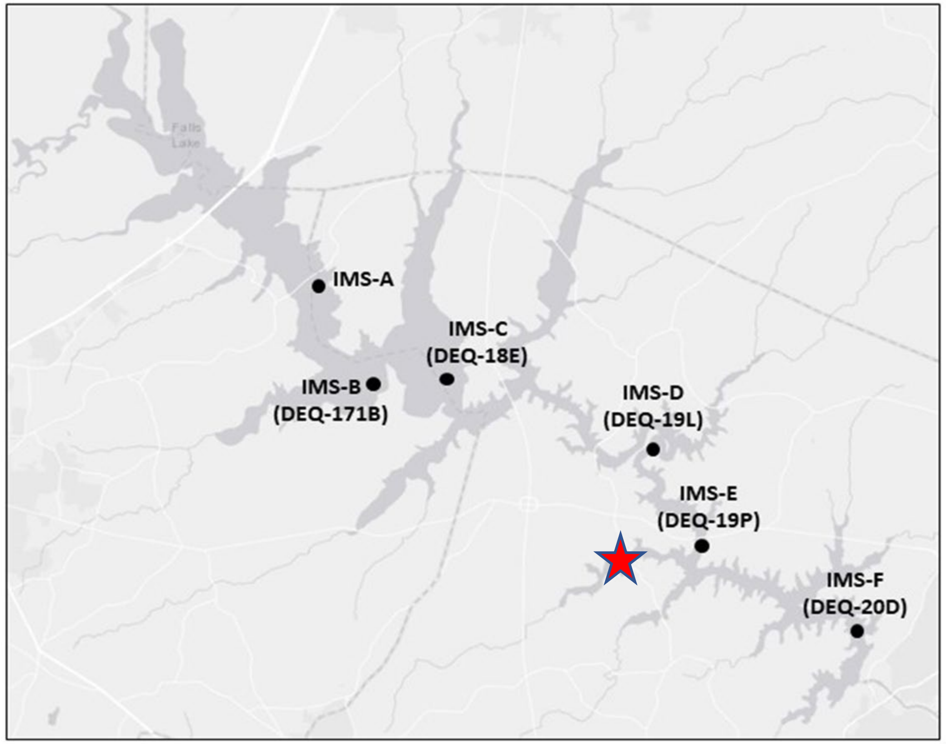
Field Measurement Methods

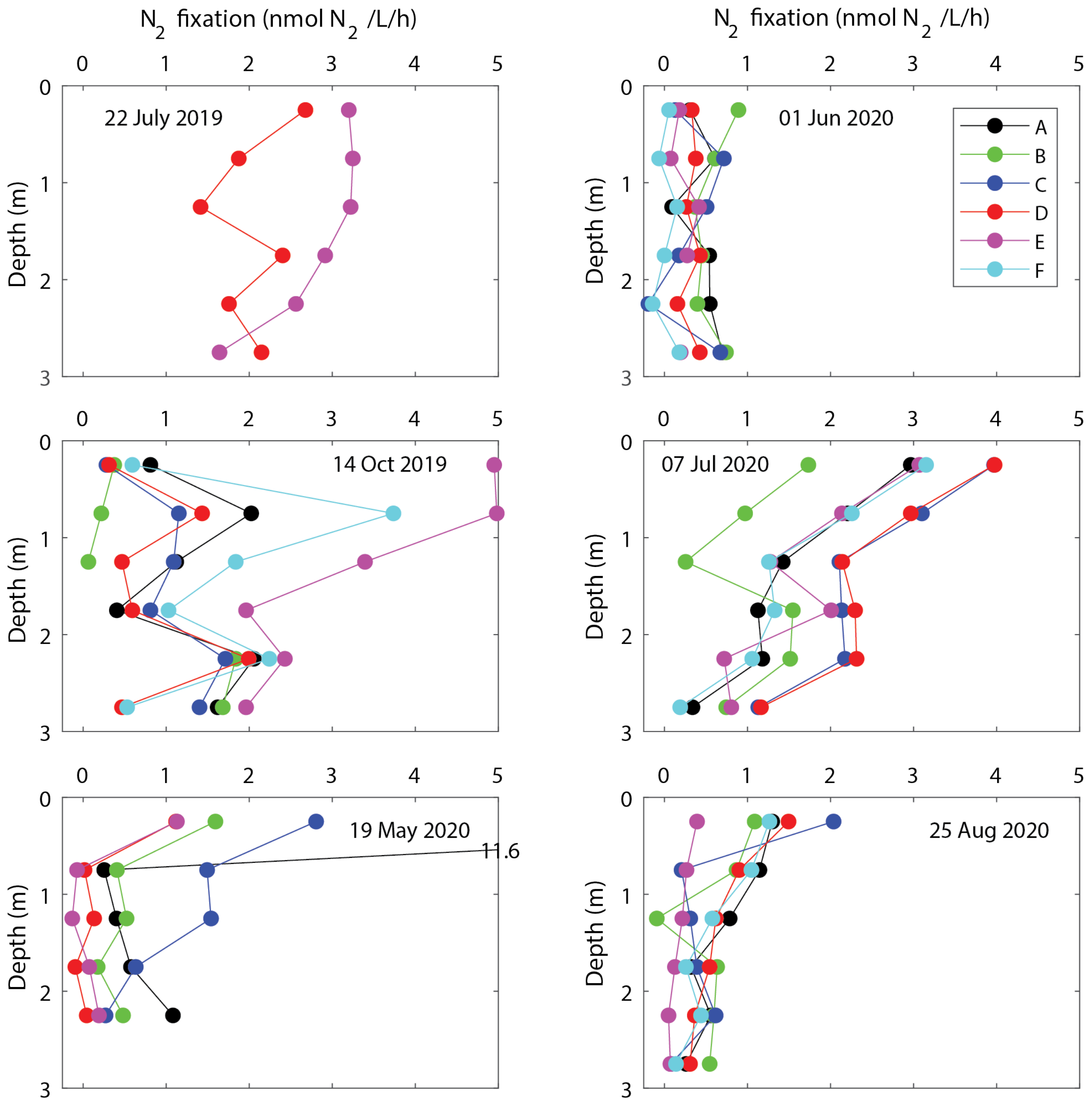


1) Collected photic zone composite sample from 6 sites
2) Light/ dark bottle, acetylene reduction assay
3) Incubated triplicated samples for 3-4 h at 6 depths (~50 to 1% PAR)
4) Deionized water blanks as a control for non-biological acetylene reduction
5) Calculated N_2 fixation based on 4:1 acetylene to N_2 fixation ratio
6) Ancillary measurements of nutrients, phytoplankton biomass/ composition, hydrographic profiles, and P.A.R.

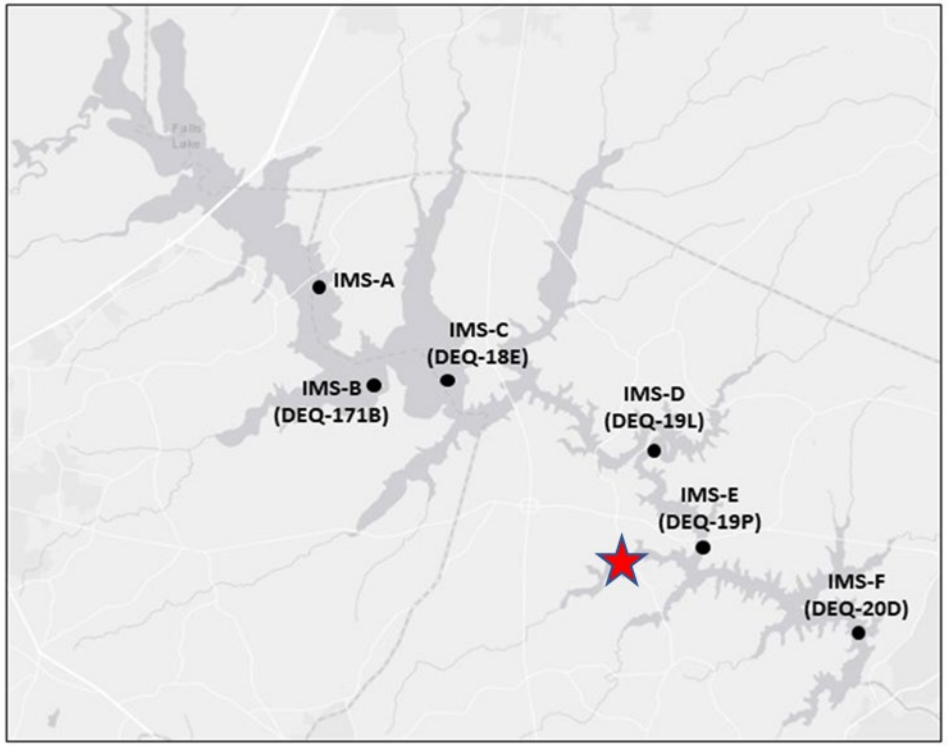


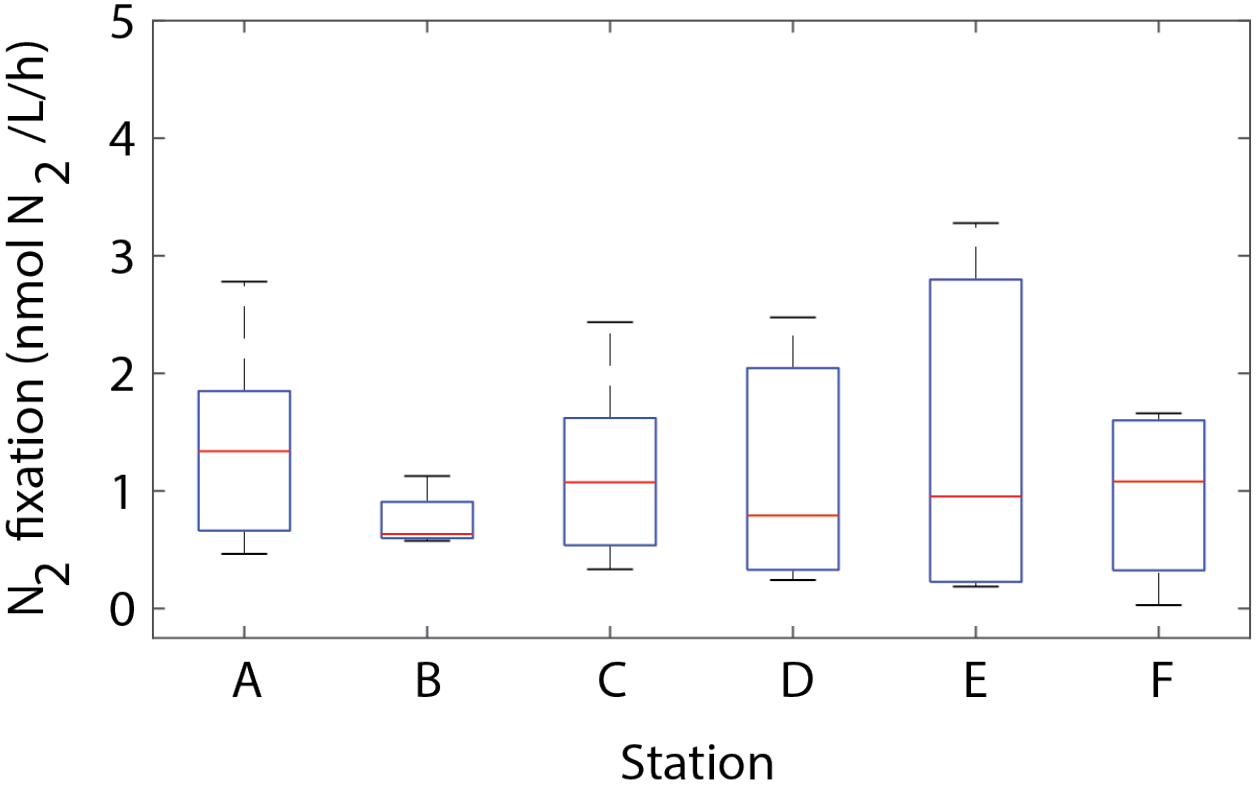
Depth profiles of N fixation at 6 stations on 6 dates



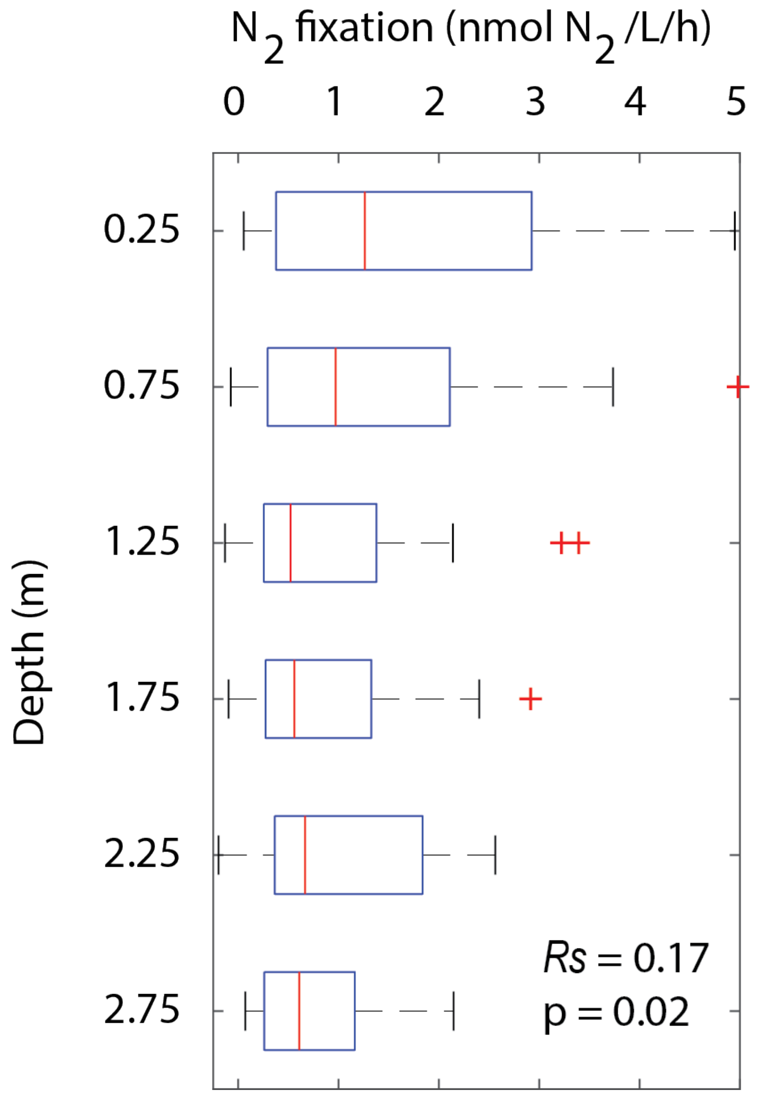


No strong downstream patterns were evident

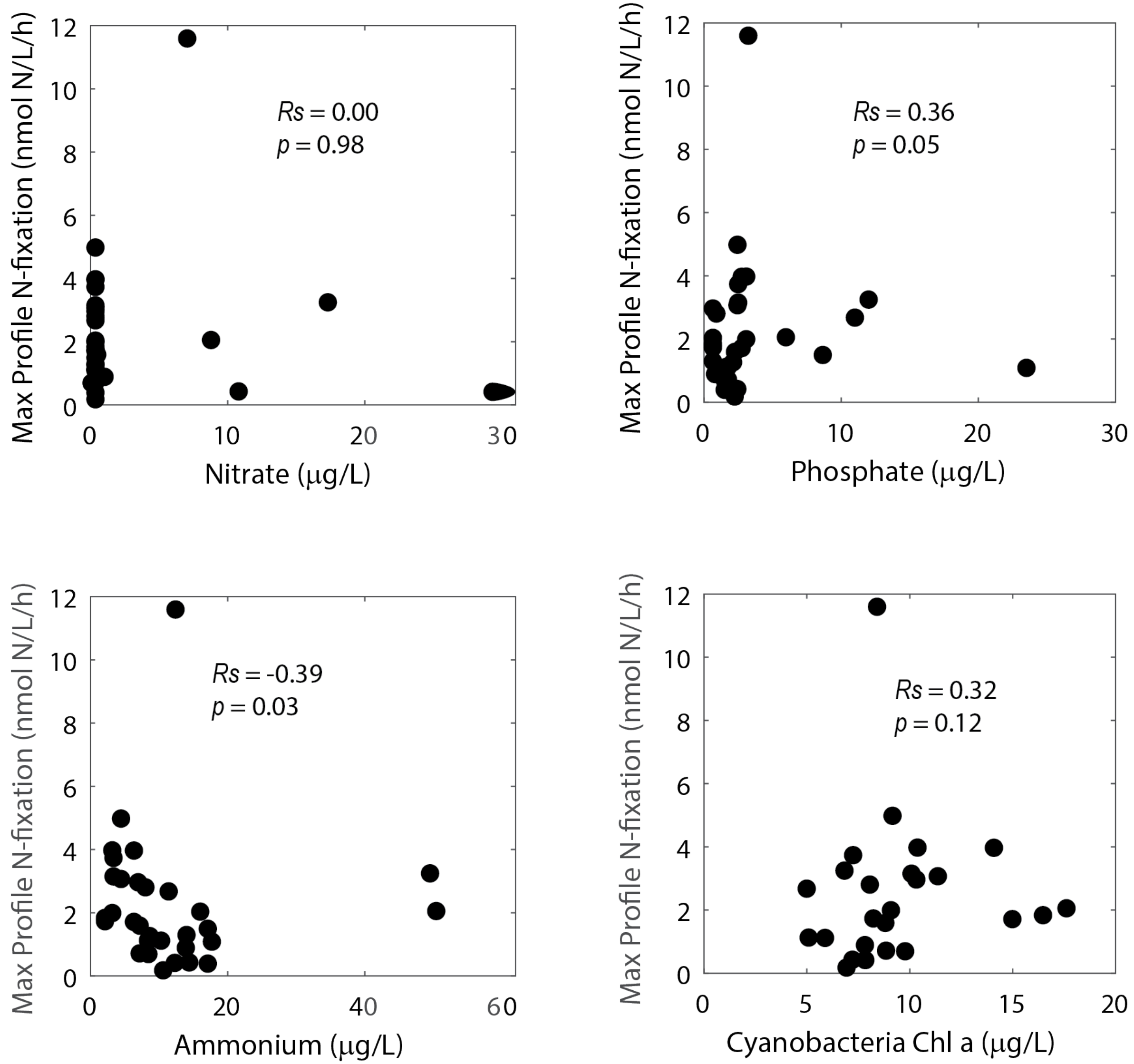




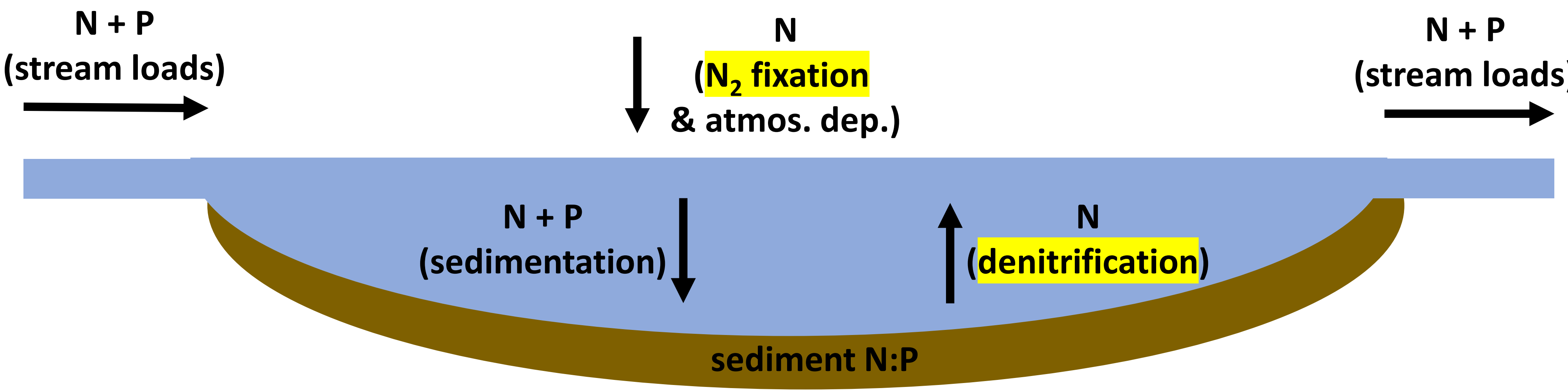
Response to the light gradient was weak but statistically significant



Negative relation to ammonium and positive relation to phosphate



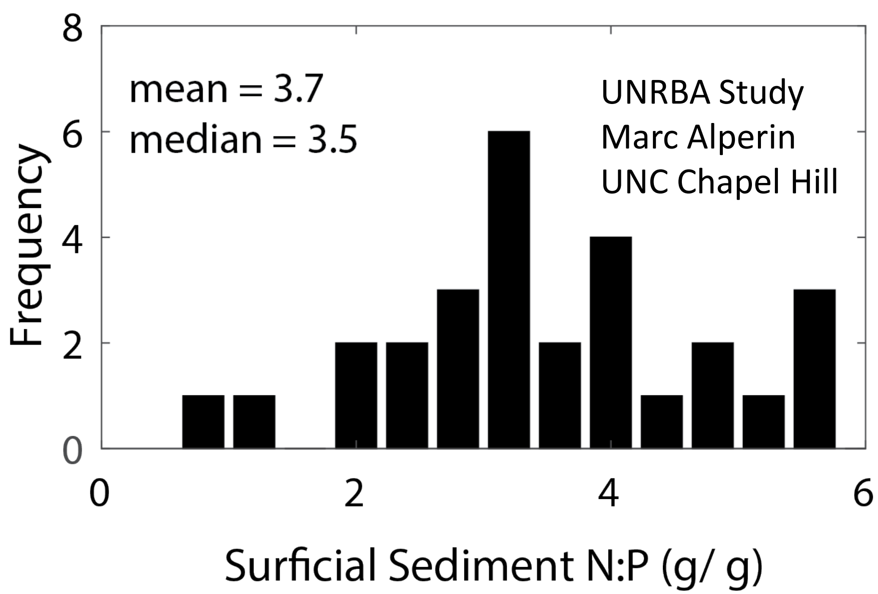
Estimating denitrification from a lake-wide mass balance of N and P



$$N_{ret} = N_{in} - N_{out}$$

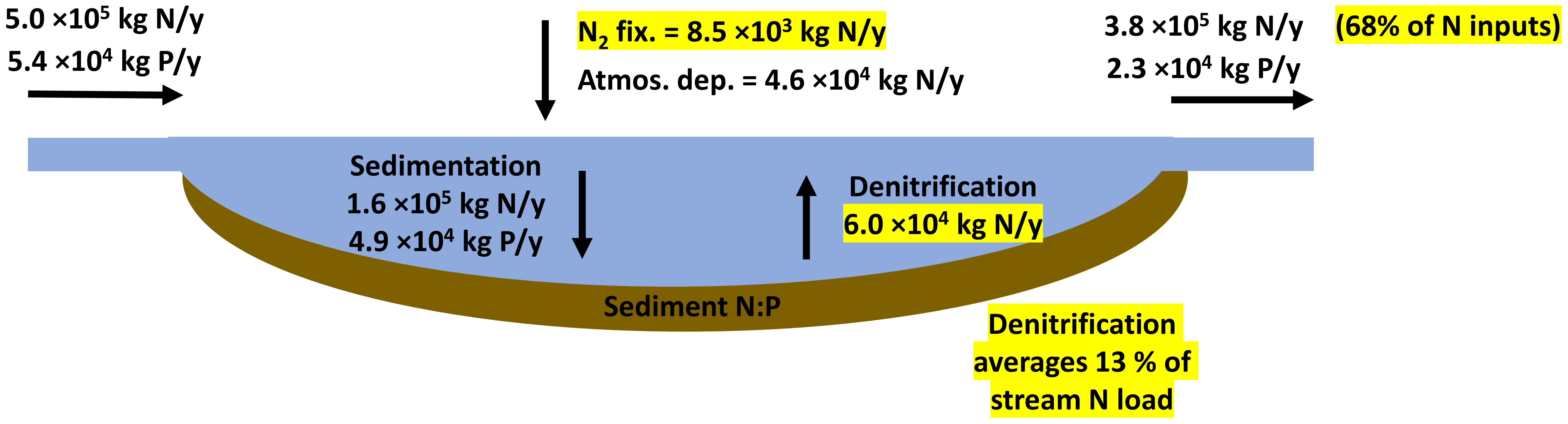
$$P_{ret} = P_{in} - P_{out}$$

$$DNF = N_{ret}(N{:}P_{ret} - N{:}P_{sed})/(N{:}P_{ret})$$

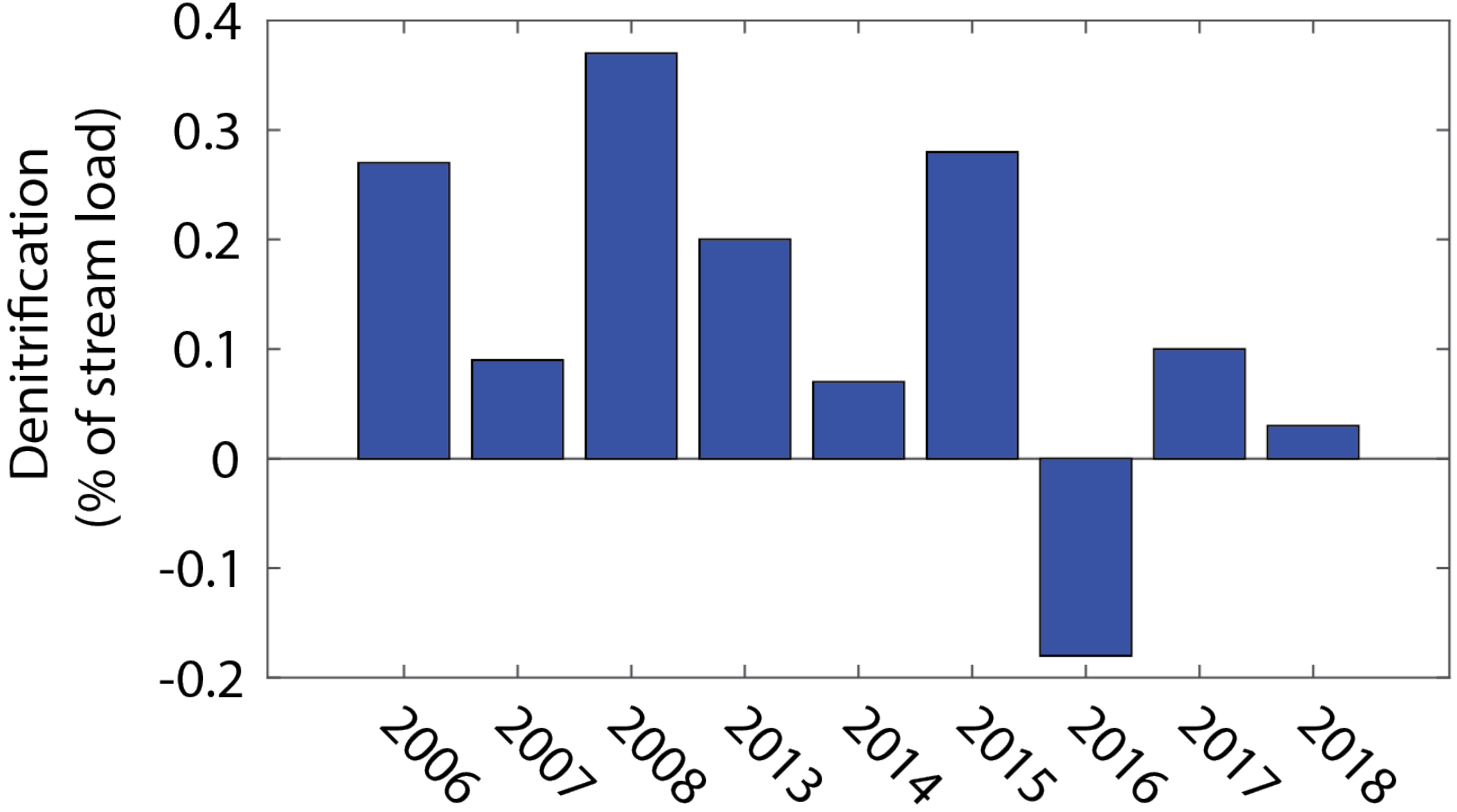


Budget for 2006-2018

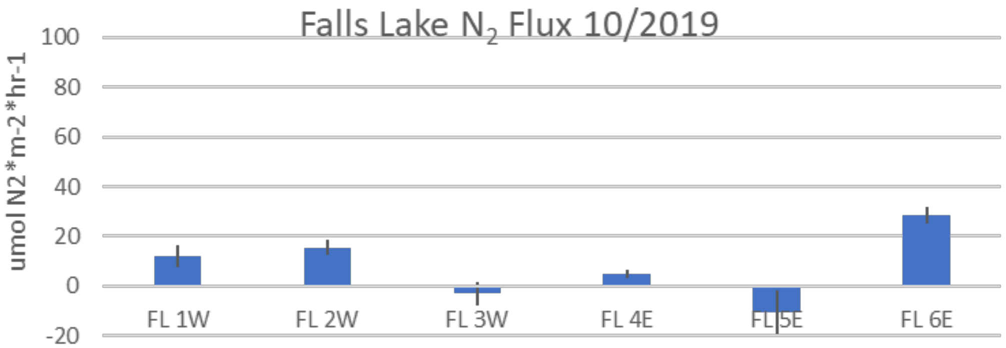
(excluding 2009-2012)

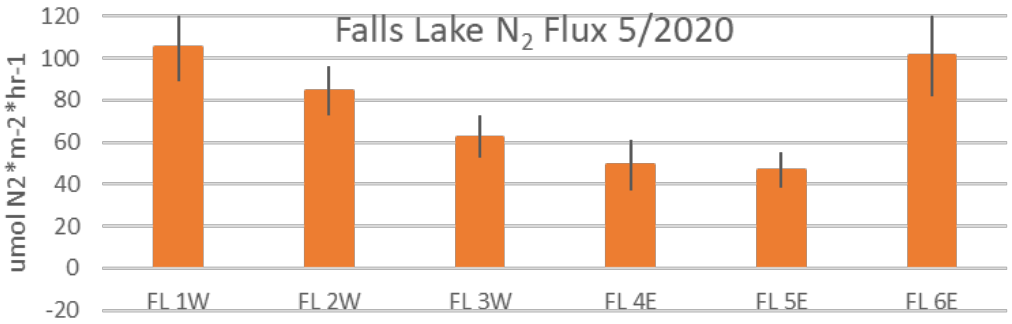


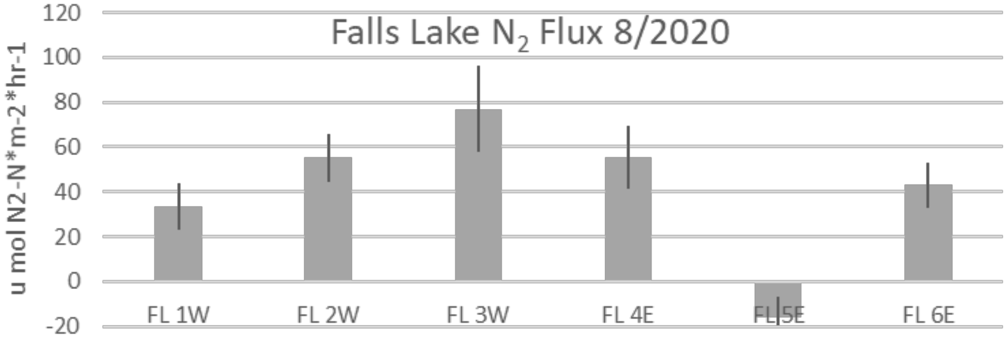
Annual Denitrification Rates by Mass Balance



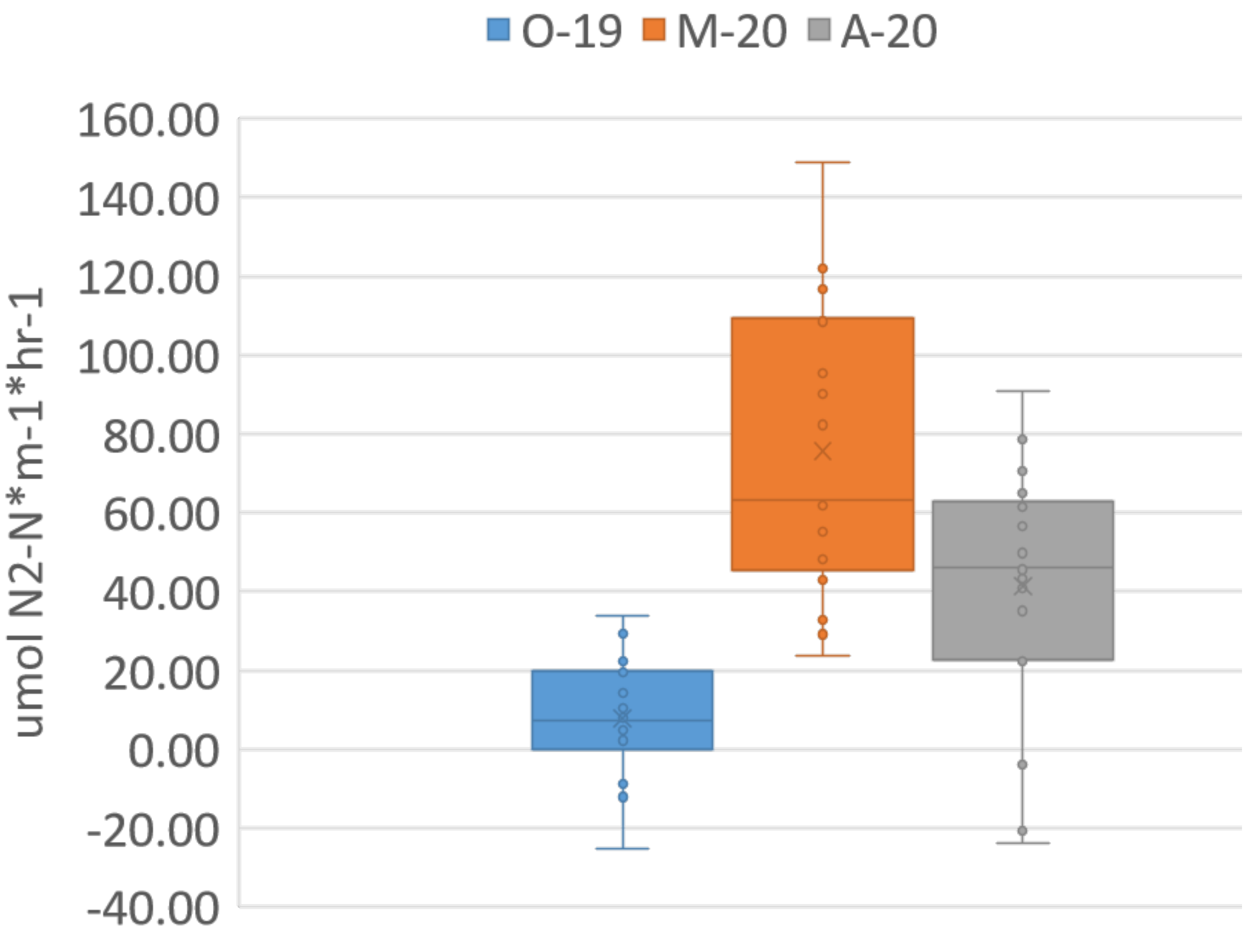
Direct Measurements of Denitrification by Sediment Core Incubations (Mike Piehler's Lab)







Average Denitrification Rates Scaled to Lake Sediment Surface



Denitrification as (% Stream Load)	
Oct 2019:	8%
May 2020:	41%
Aug 2020:	75%
Average	42%

Conclusions

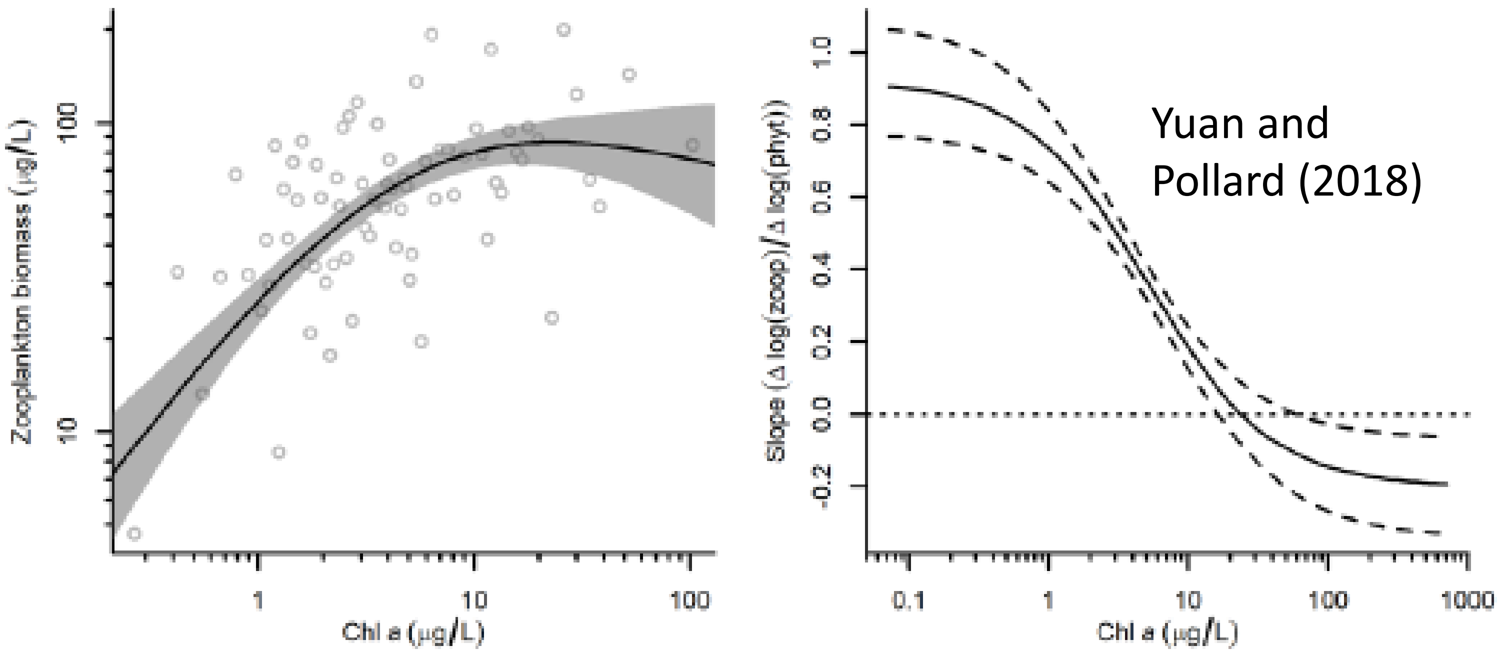
1) N_2 fixation appears to be a small N source, ~2% of stream loads
2) Denitrification estimates are variable, but denitrification is significant, 10-40% of stream loads

Continuing Work

1) Increase sampling stations to capture longitudinal patchiness
2) Use nutrient addition experiments to test nutrient limitation status and ability to “turn on” N_2 fixation
3) Continue comparisons of denitrification estimates vs direct measurements

Work on a site-specific chlorophyll *a* standard for Falls Lake

EPA Document Number: 820P20001



1) What does this relationship look like for southeastern reservoirs?

2) What about specifically for Falls Lake?

3) Can this approach be used to produce a defendable Chl *a* criteria protective of aquatic life for Falls Lake?