Defining the Balance Between N_2 Fixation and Denitrification in Falls Lake

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

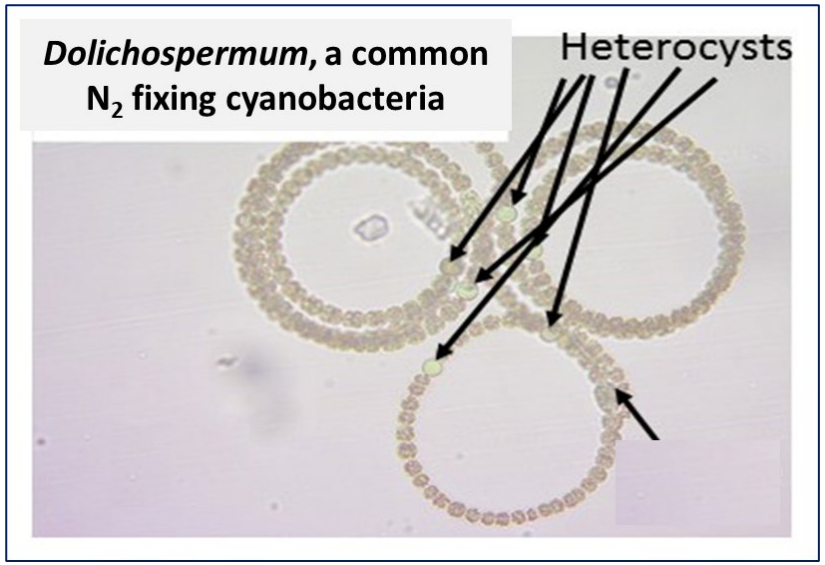
Falls Lake Nutrient Study Research Symposium
7 April 2022

Understanding N_2 fixation & Denitrification in Falls Lake is important

Balance of N_2 fixation and denitrification can determine nutrient limitation-can inform more effective nutrient control strategies

N_2 fixing cyanobacteria are surface bloom and/ or toxin producers

Measuring either helps constrains other parts of the N budget that are difficult to measure

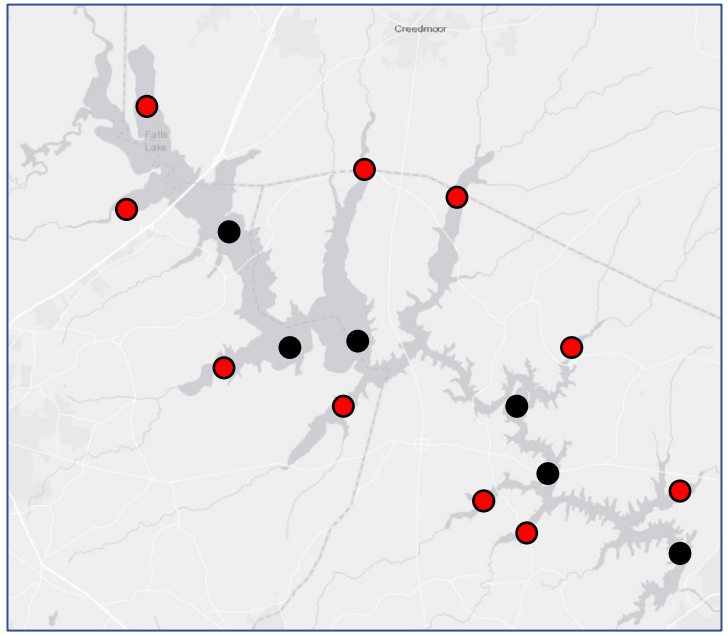


Research Questions

1) Do microbial processes cause a net production (N_2 fixation) or removal (Denitrification) of N from Falls Lake?

2) Is N_2 fixation quantitatively important relative to stream loads and atmospheric deposition? Worth including in models?

3) What factors stimulate N_2 fixation?



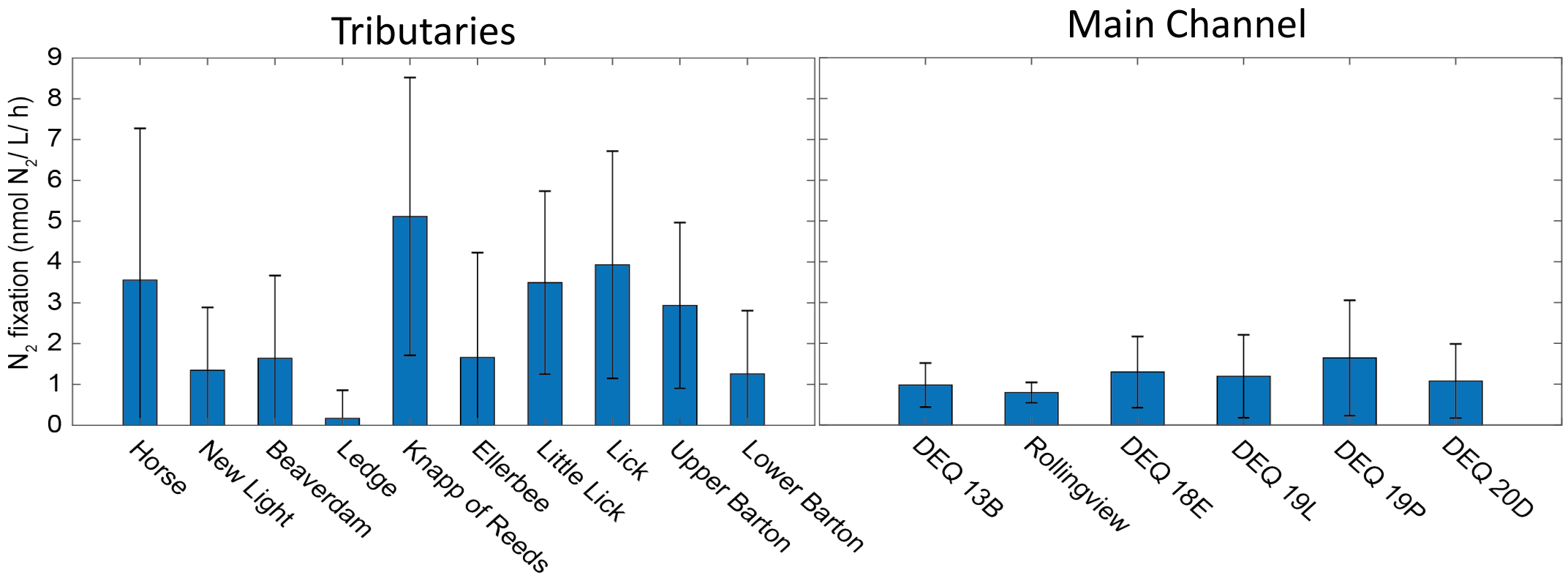
Nitrogen Fixation Measurement Methods

1) Collected surface samples
   - 5 sampling events at 6 main channel (2019-2020)
   - 5 sampling events at 10 creeks (2021)

2) N_2 fixation measured by acetylene reduction under simulated in situ conditions

3) Ancillary measurements of nutrients, phytoplankton biomass/ composition, hydrographic profiles, and light

N_2 fixation measurements and scaled-up annual estimates

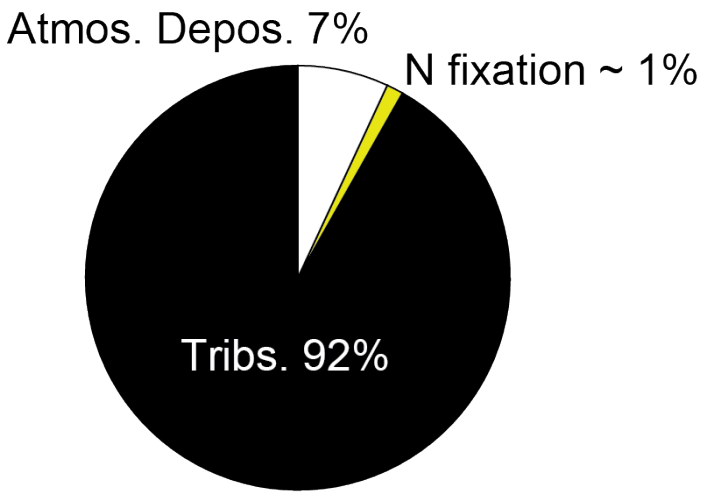


Assumptions: 1-1.5 m photic depth, 12 h photic period, 180 d season

N_2 fixation = 2.4 ×10^3 kg N/y

Nutrient Budget for 2006-2019

N Sources



6.1×10^5 kg N/y
7.5×10^4 kg P/y

N_2 fix. = 2.4×10^3 kg N/y
Atmos. dep. = 4.6×10^4 kg N/y

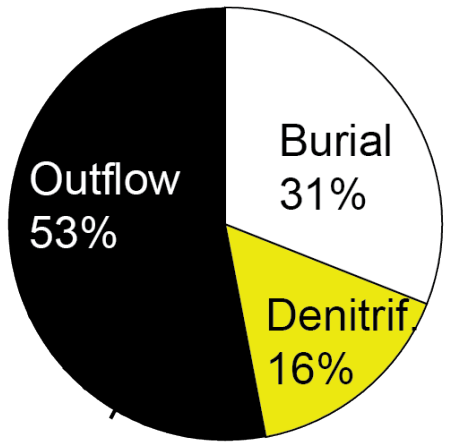
3.4×10^5 kg N/y
1.7×10^4 kg P/y
(53% of N inputs)
(14% of P inputs)

Sedimentation
2.1×10^5 kg N/y
5.7×10^4 kg P/y

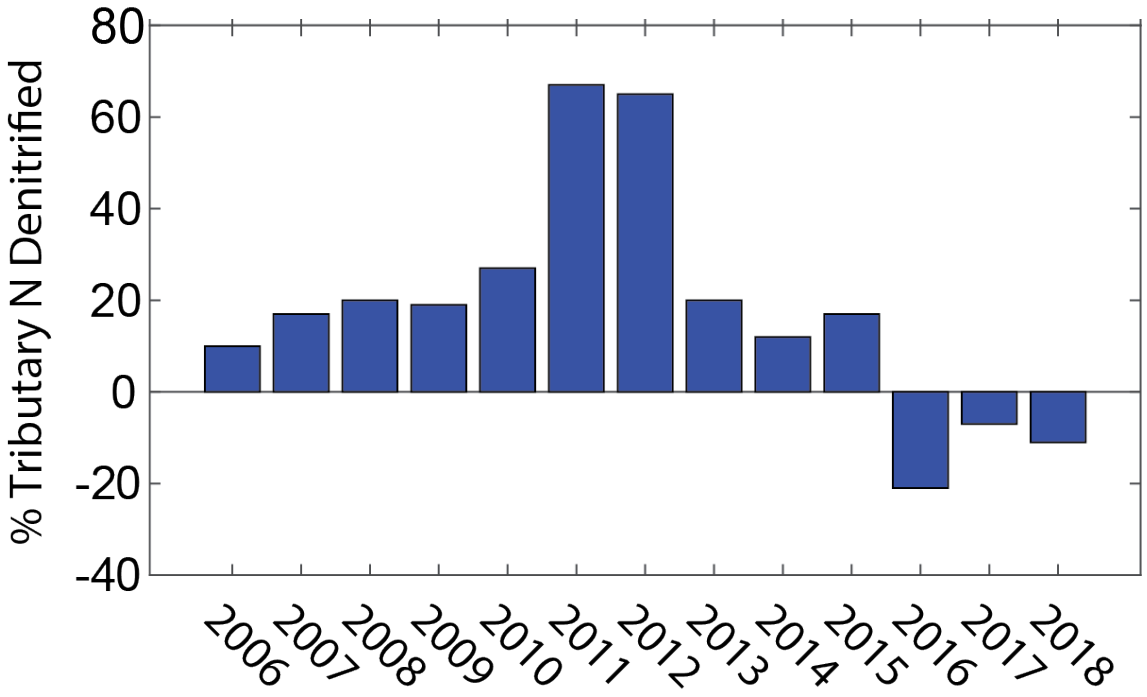
Denitrification
7.4×10^4 kg N/y

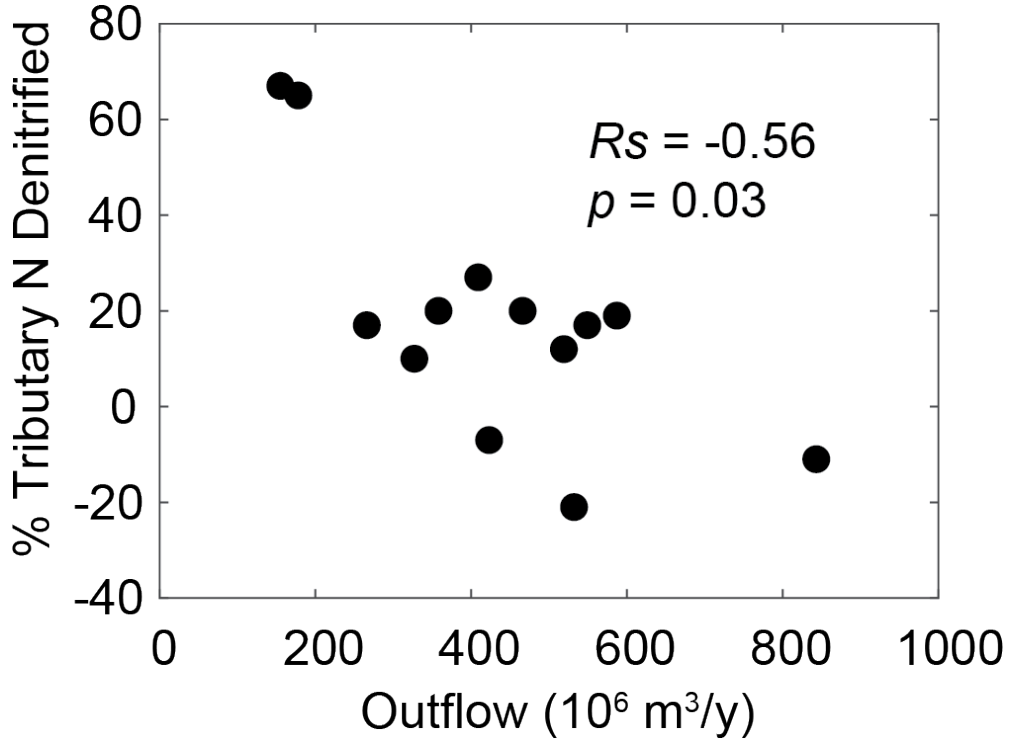
Sediment N:P = 3.67

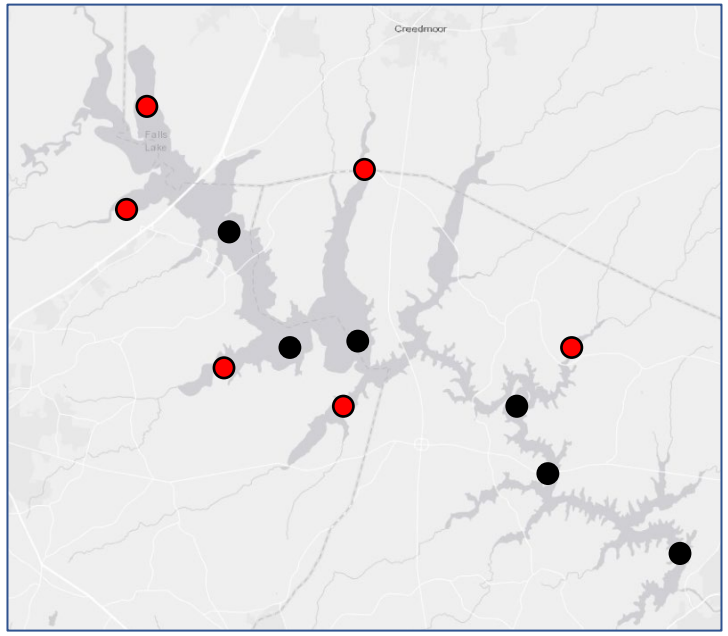
N Sinks



Annual Denitrification Rates by Mass Balance





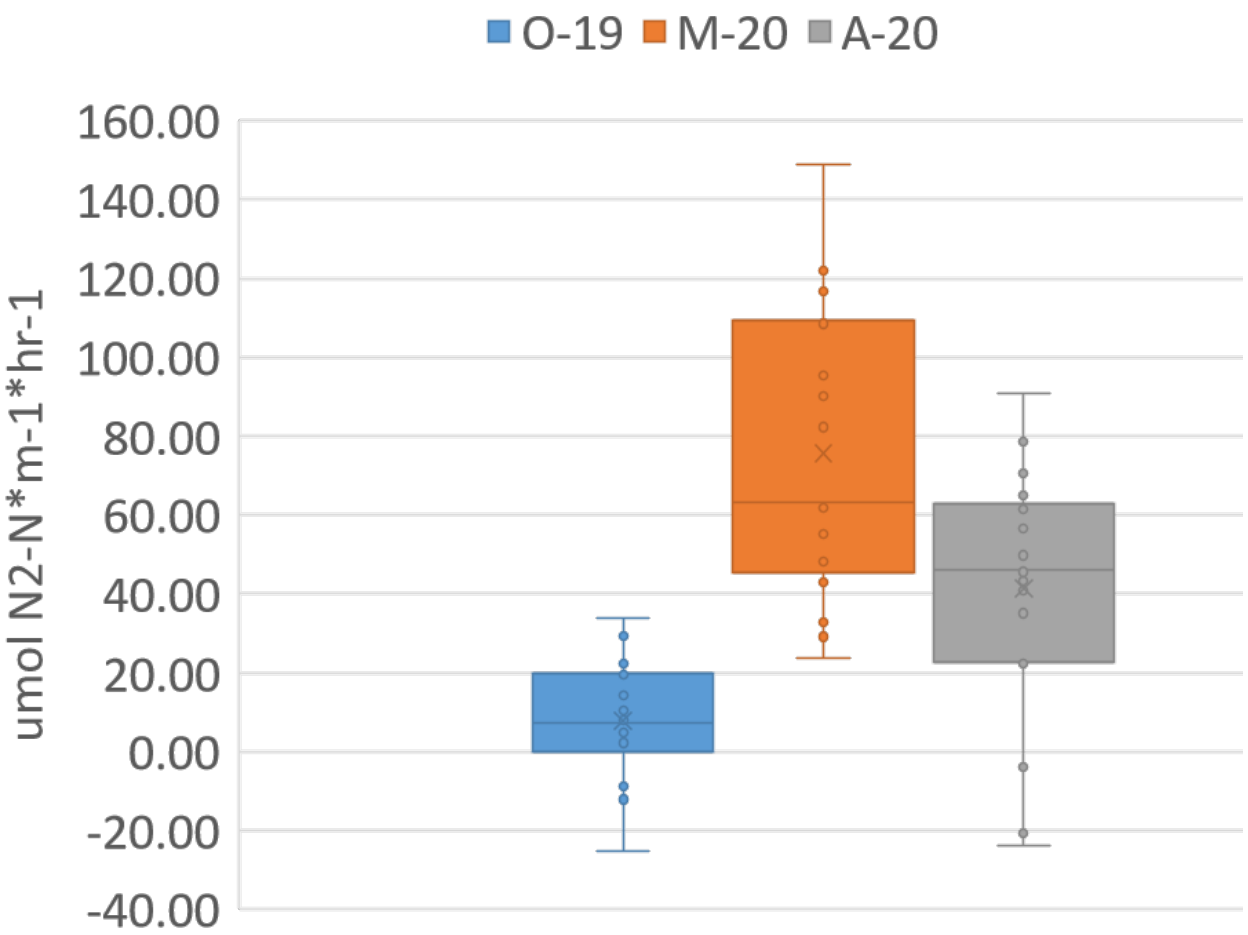


Direct Denitrification Measurement Methods

1) Collected sediment cores
   - 3 samplings at 6 main channel (Oct 2019, May, Aug 2020)
   - 1 sampling at 6 creeks (Jul 2021)

2) Steady-state, continuous flow incubation- N_2 production measured by membrane inlet mass spectrometry

Average Denitrification Rates Scaled to Lake Sediment Surface

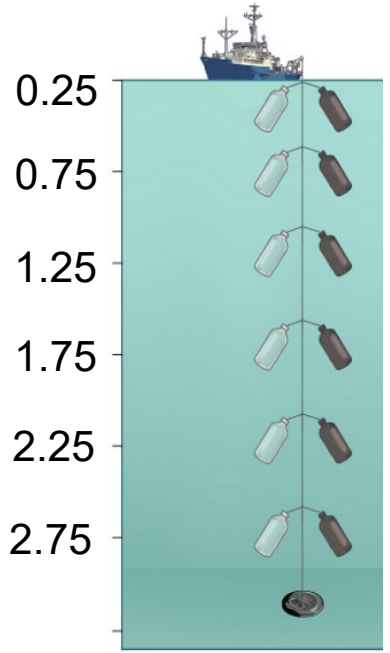


Denitrification as (% Stream Load)	
Oct 2019:	8%
May 2020:	75%
Aug 2020:	41%
Average	42%

Balance of microbial N processes tilts toward N loss by denitrification

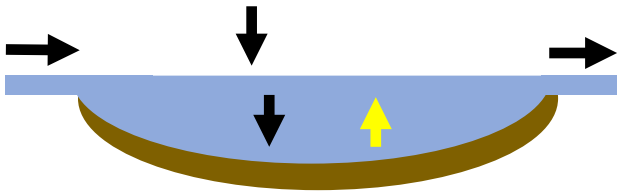
(Rates expressed as % of stream load)

N_2 fixation
Direct measurements
0.5 %



VS

Denitrification
Nutrient budget
16 %



Denitrification
Direct measurements
42 %

Policy Implications

1) Net loss of N by microbial processes may produce N limited conditions for algal growth- supports management of N loads in addition to P

2) Current water quality models appear justified in omitting N_2 fixation