Nutrient uptake stoichiometry of harmful algal blooms on Lake Erie(ID:1586): Exploring the data

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*Data analysis is preliminary and subject to change with additional data

Goals for the research

- Conduct nutrient uptake assays in the Great Lakes: Erie, Michigan, Superior & Huron in areas where CyanoHAB are probable.
- Methodology for understanding nutrient dynamics in large lakes.
- Understanding of nutrient stoichiometry necessary to support cyanoHABs.
- Understand how to better target nutrient reduction practices.
- Forecast cyanoHABs based on Stoichiometric models pared with real-time buoy data.

July 23- 30, 2019

Figure 1: Samples sites for Lake Erie Lower Food Web/primary production surveys. Selected sites will be sampled for nutrient uptake assays.

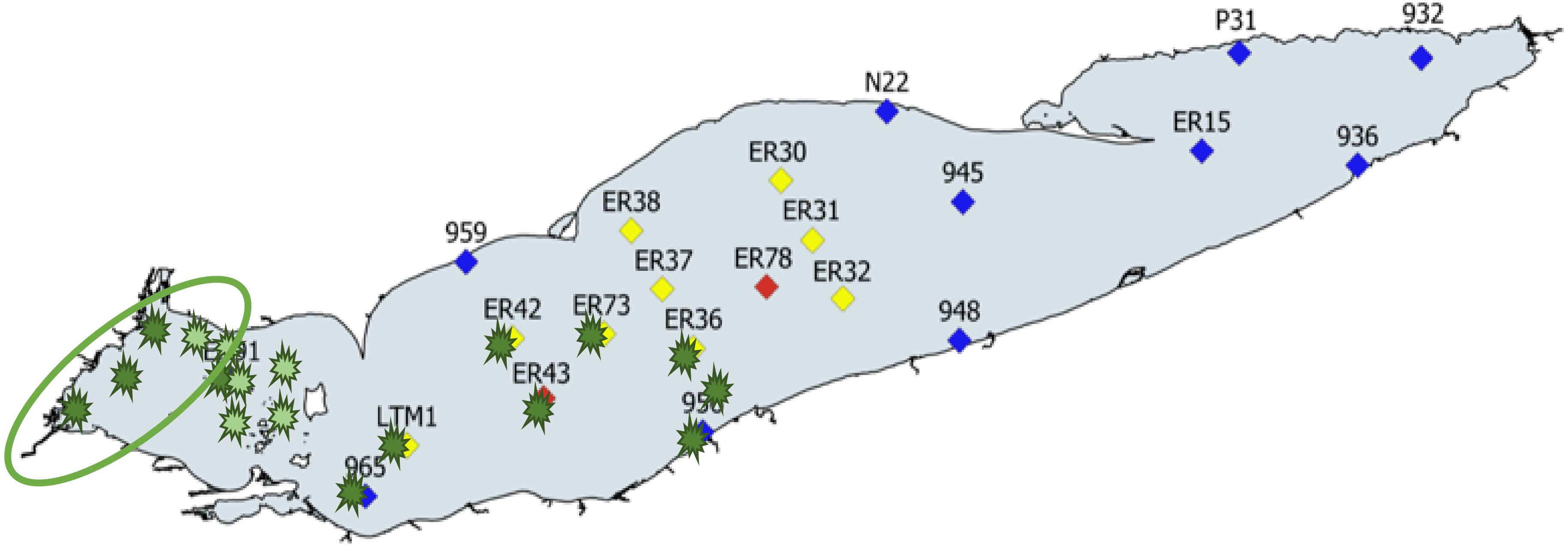
Nutrient uptake assay (NUA) sites

NUA-HABs/ Hypoxia transects (OSU)

Primary Production + ORD Nutrients + Cornell Zooplankton (Rosette + 2 Nets)

NOAA Hypoxia + Primary Production + ORD Nutrients + Cornell Zooplankton (Rosette + 2 Nets + 1 Ponar)

NOAA Hypoxia + Cornell Zooplankton (Rosette + 2 Nets + 1 Ponar)



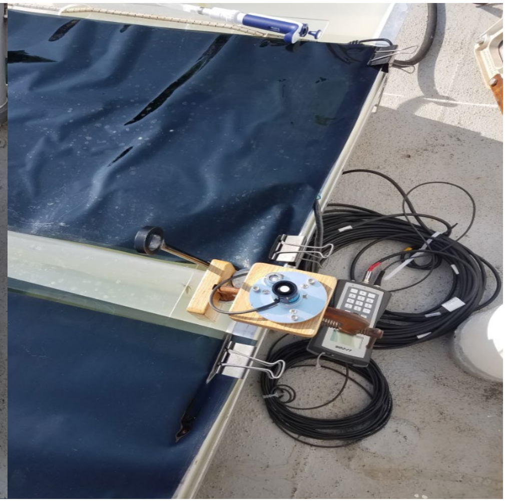
17 total stations
10 composited
7 composite and bottom

Methods

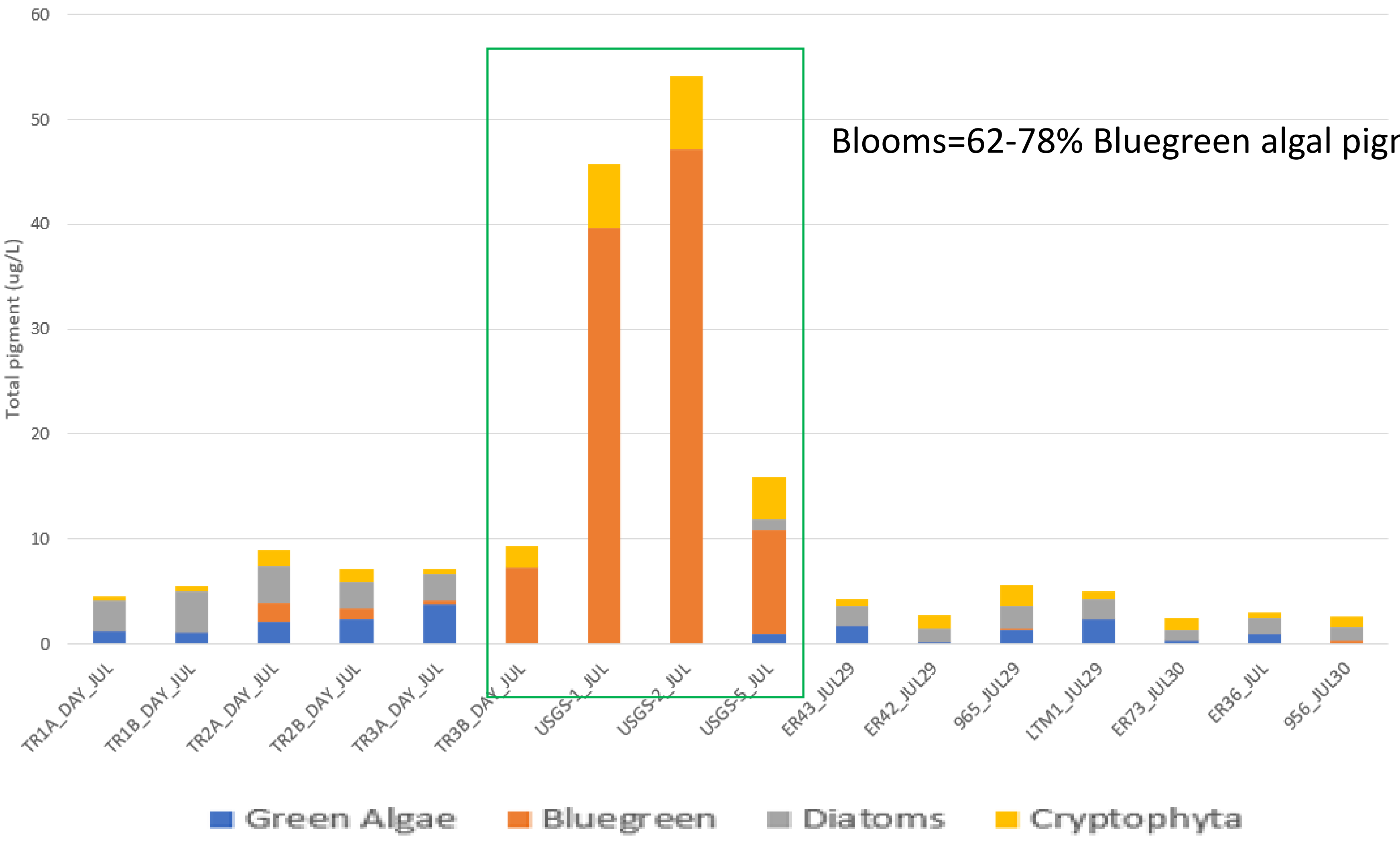
Collection:
- Samples were collected via the Rosette at 3 depths: 1M, Fmax, 2M from bottom
- Composited by stratification

Ambient sample analyses include:
- WQ: Total and Dissolved P and N, DOC, Fe, Si, Na, K, Mg, Ca, SO4, Cl,
- Phytoplankton taxonomy
- Chlorophyll a
- Microcystin

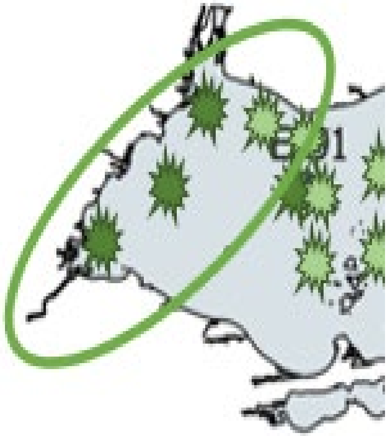
Bioassays:
- Filter through the 153 um to remove grazers immediately upon subsampling
- Conducted the following day between 10 am and 2pm
- 5L biotainers
- Added nutrients: NH_4, NO_3, PO_4 to 100ppb above background
- Under natural density film to mimic in situ light conditions.
- Tank flow through lake water to incubate at lake temperature
- Sampled hourly over 4 hours
- NH_4, NO_3, PO_4, Si, Fe, DOC, cations and anions

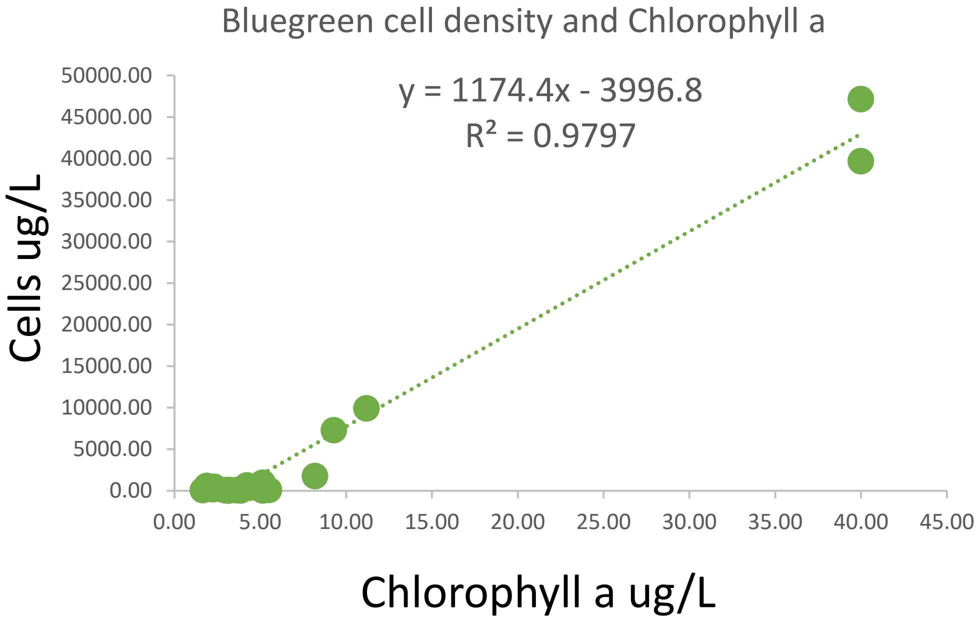


Proportion of pigments
Green algae, Bluegreen algae, Diatoms, and Cryptophyta

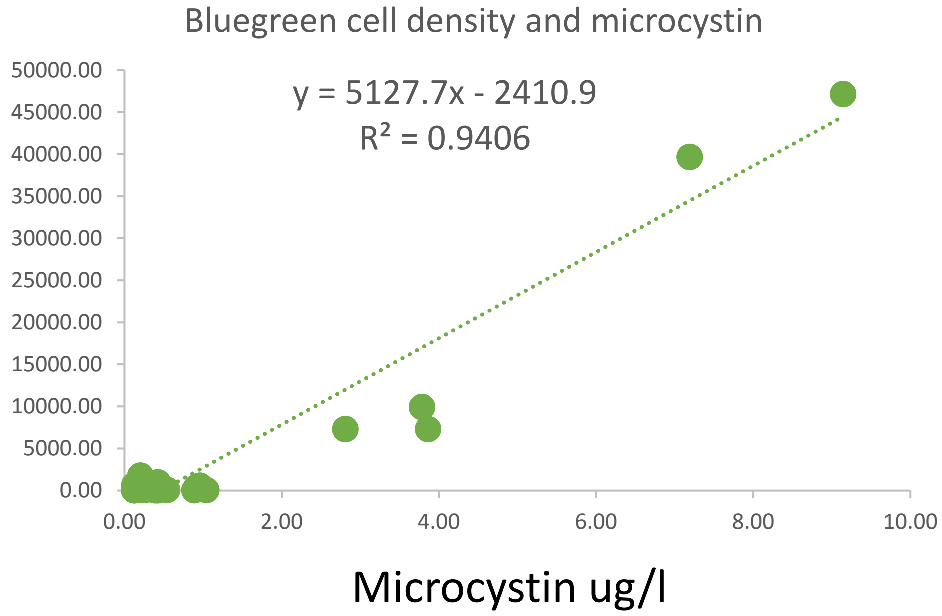


Blooms=62-78% Bluegreen algal pigments

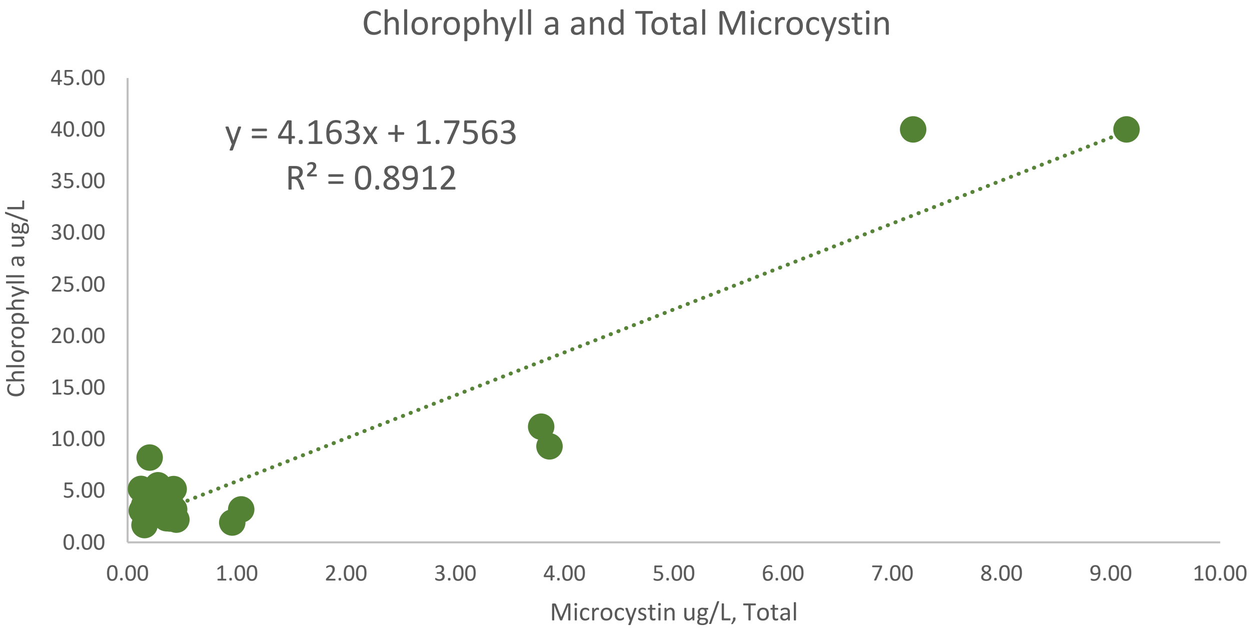




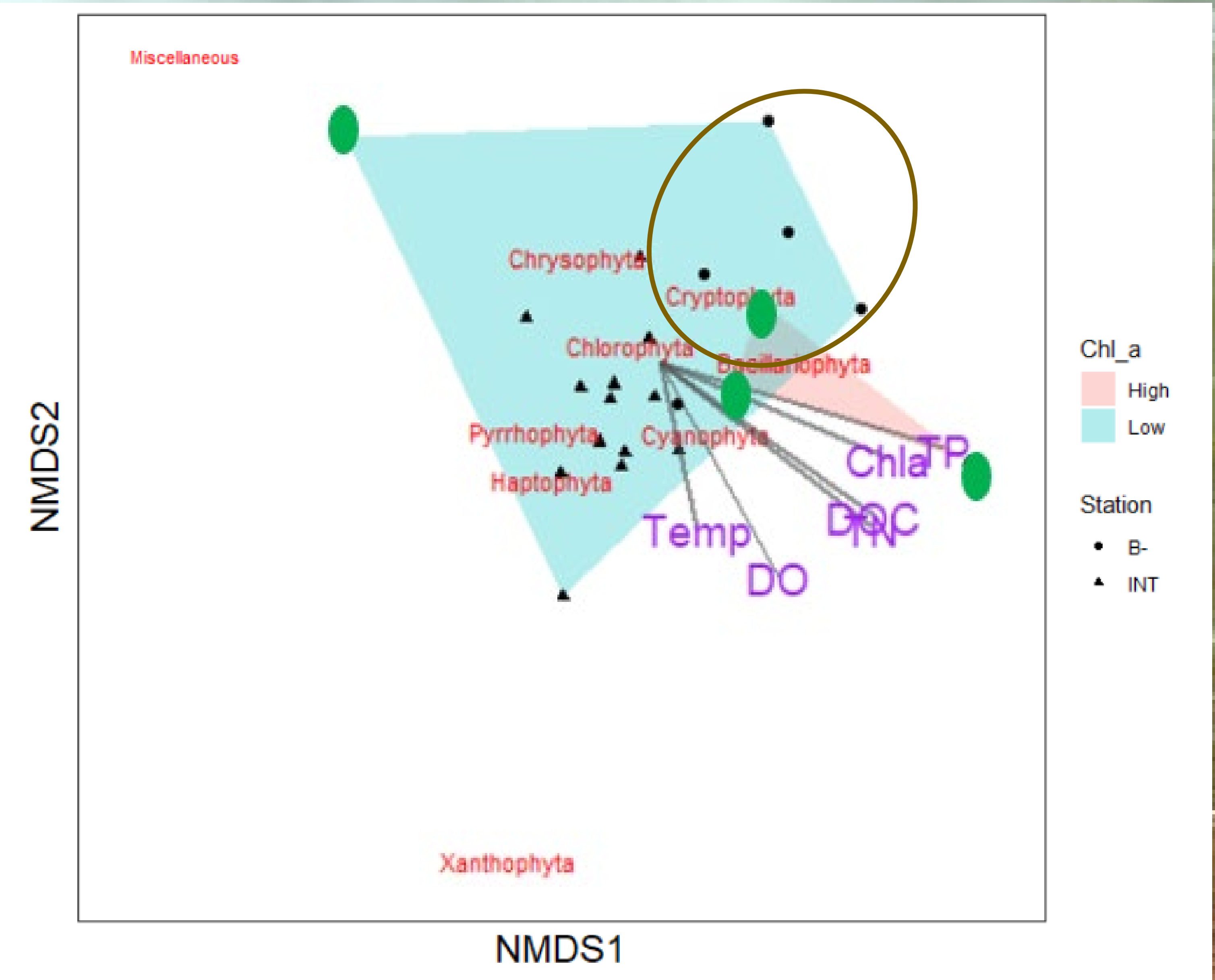
Bluegreen cell density and Chlorophyll a
y = 1174.4x - 3996.8
R² = 0.9797
Cells ug/L
50000.00
45000.00
40000.00
35000.00
30000.00
25000.00
20000.00
15000.00
10000.00
5000.00
0.00
0.00 5.00 10.00 15.00 20.00 25.00 30.00 35.00 40.00 45.00
Chlorophyll a ug/L



Bluegreen cell density and microcystin
y = 5127.7x - 2410.9
R² = 0.9406
50000.00
45000.00
40000.00
35000.00
30000.00
25000.00
20000.00
15000.00
10000.00
5000.00
0.00
0.00 2.00 4.00 6.00 8.00 10.00
Microcystin ug/l

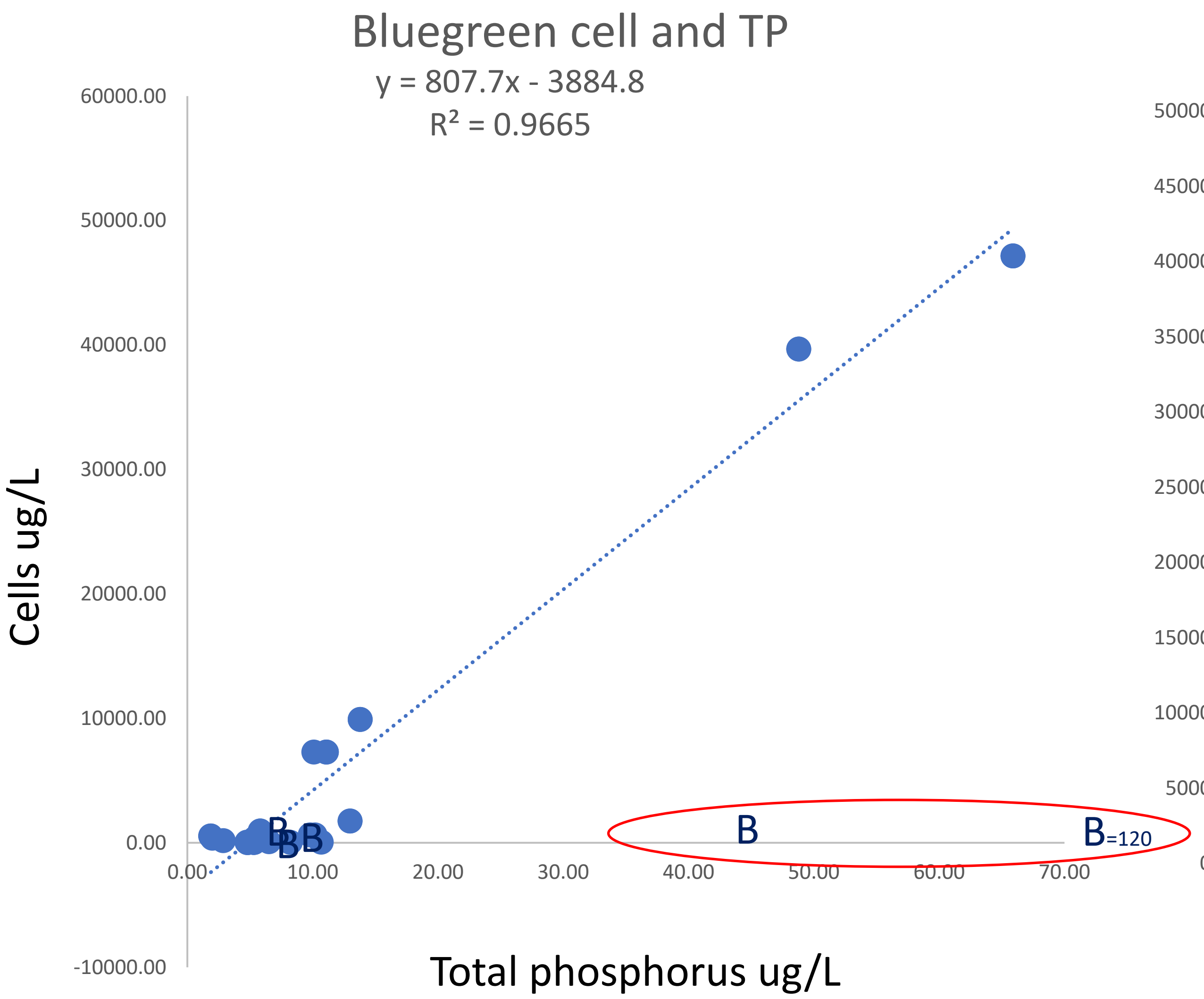


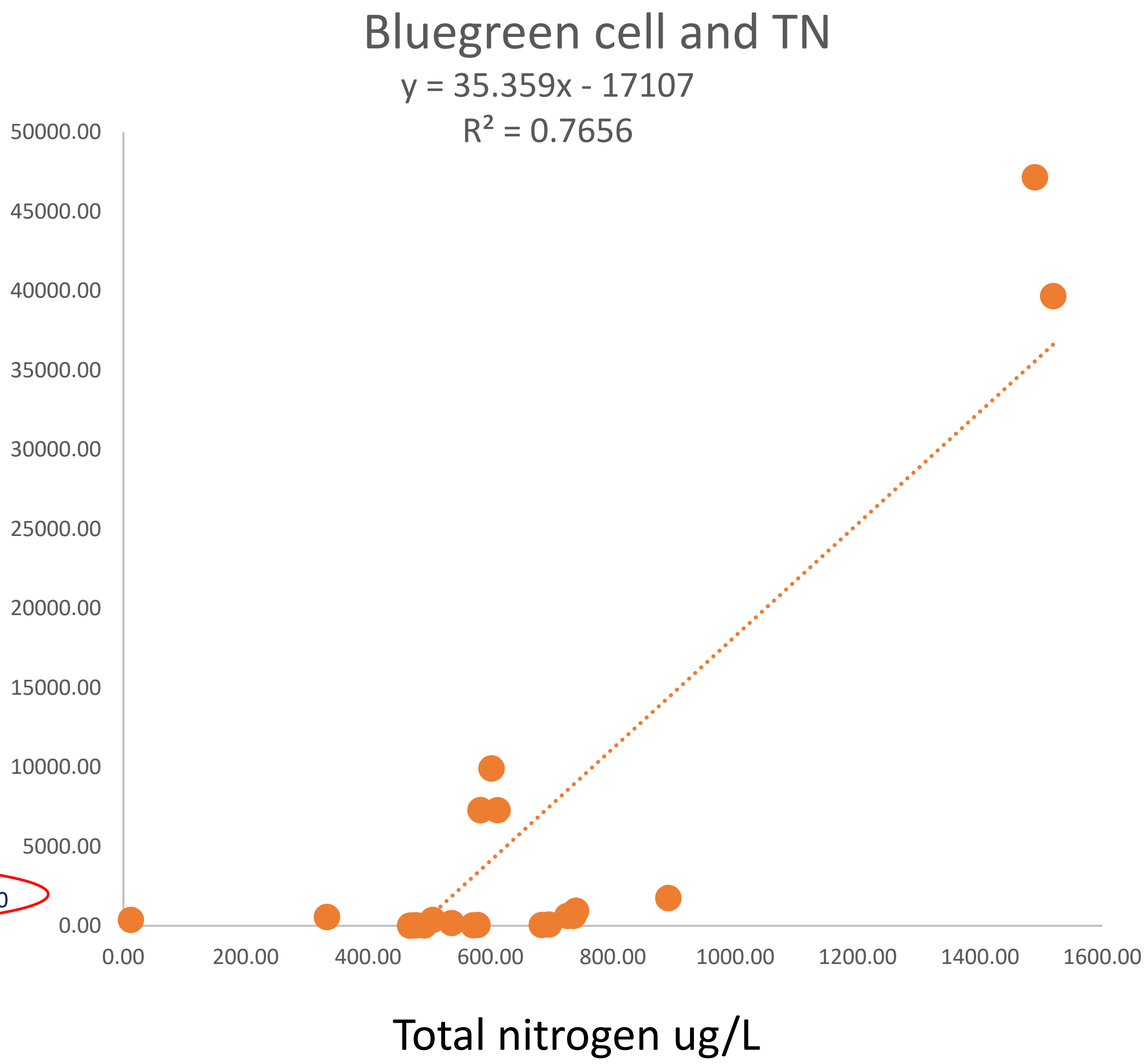
Chlorophyll a and Total Microcystin
y = 4.163x + 1.7563
R² = 0.8912
Chlorophyll a ug/L
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00
Microcystin ug/L, Total



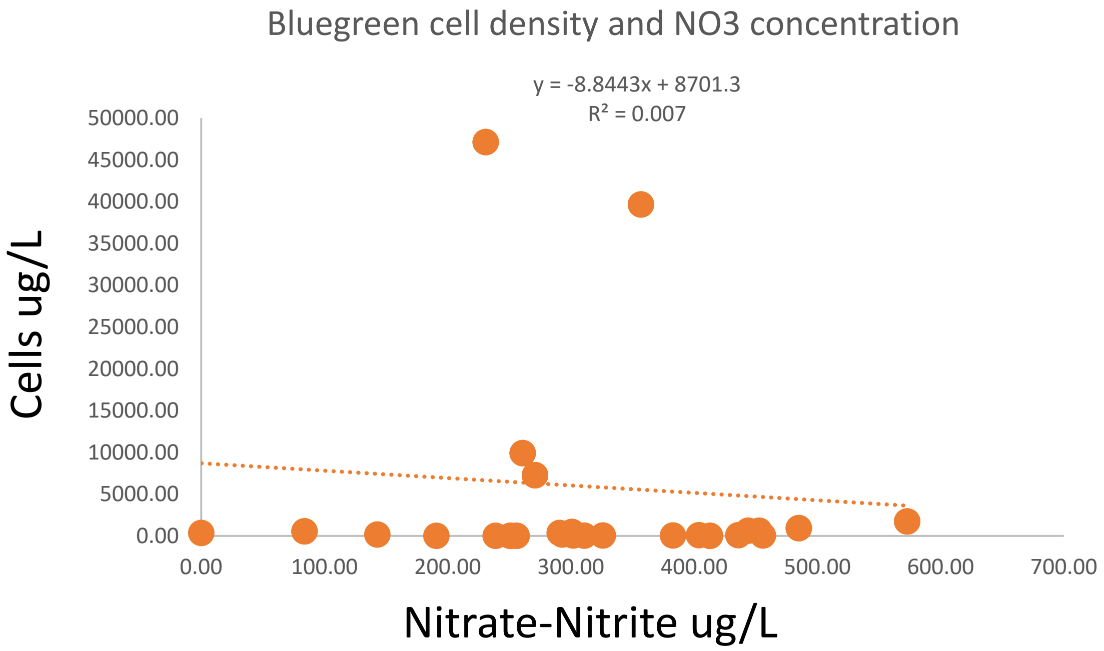
- Sites in the brown circle are samples taken at the bottom 2m where stratified temperatures- excluded from the remaining analysis.
- USGS sites 1,2,5: similar environmental and phytoplankton community to bottom samples- USGS sites were all <5m depth.
- TP looks to be a driver for high chlorophylla, but it may also be particulate P from lake bottom.
- Temperature seems to be the driver behind Cyanophyta, but has low correlation = r=0.36

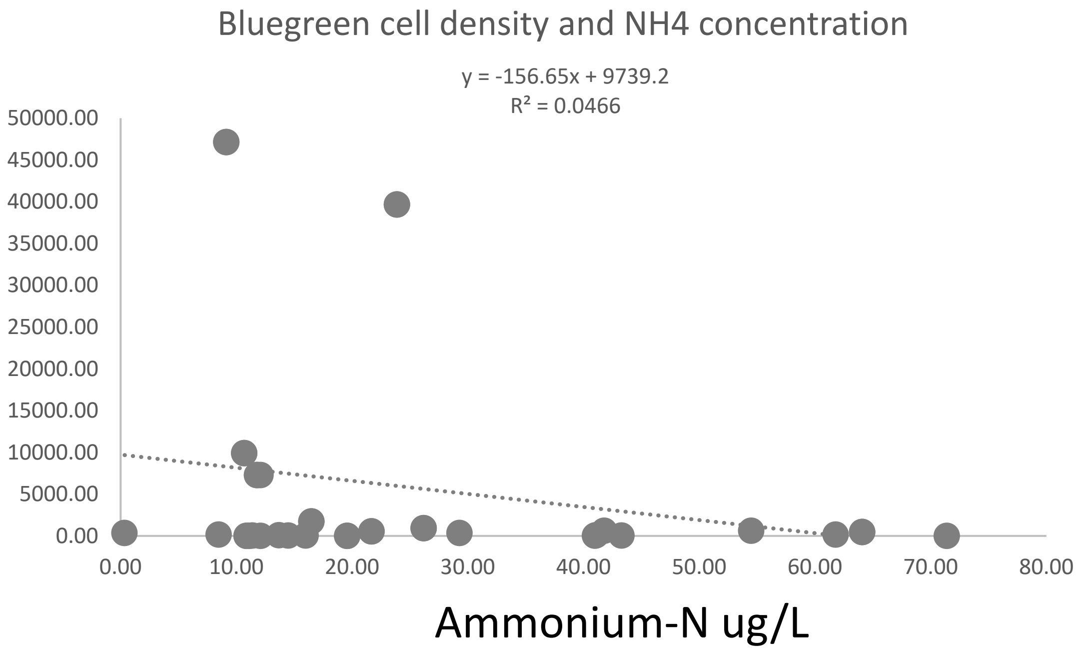
Photo credit: Brenda Lafrancois, NPS



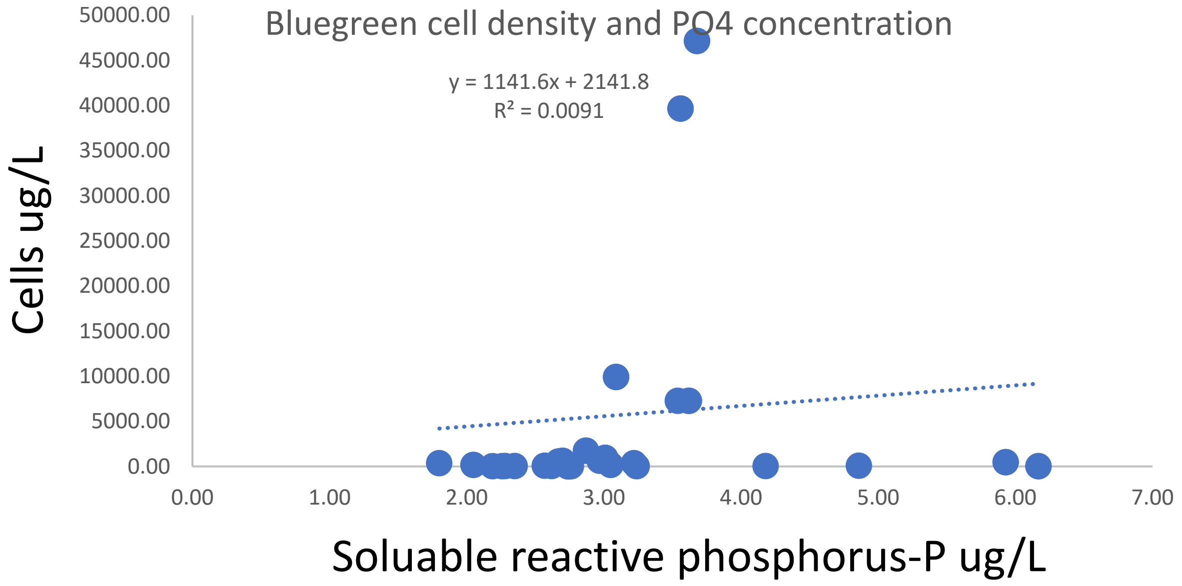


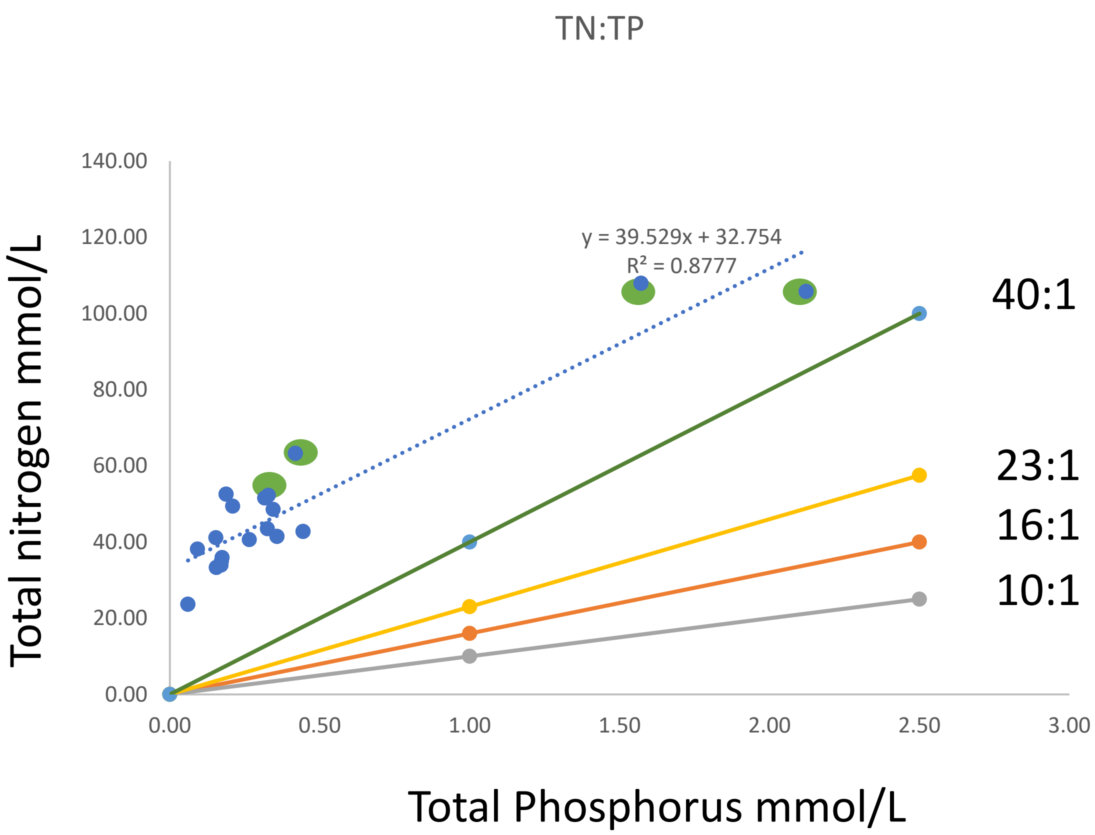
Total N and Total P, while correlated, may not be a predictor of cyanoHABs if the system is turbid from sediment particles. With bottom samples included R^2=0.20 TP, R^2=0.74 TN

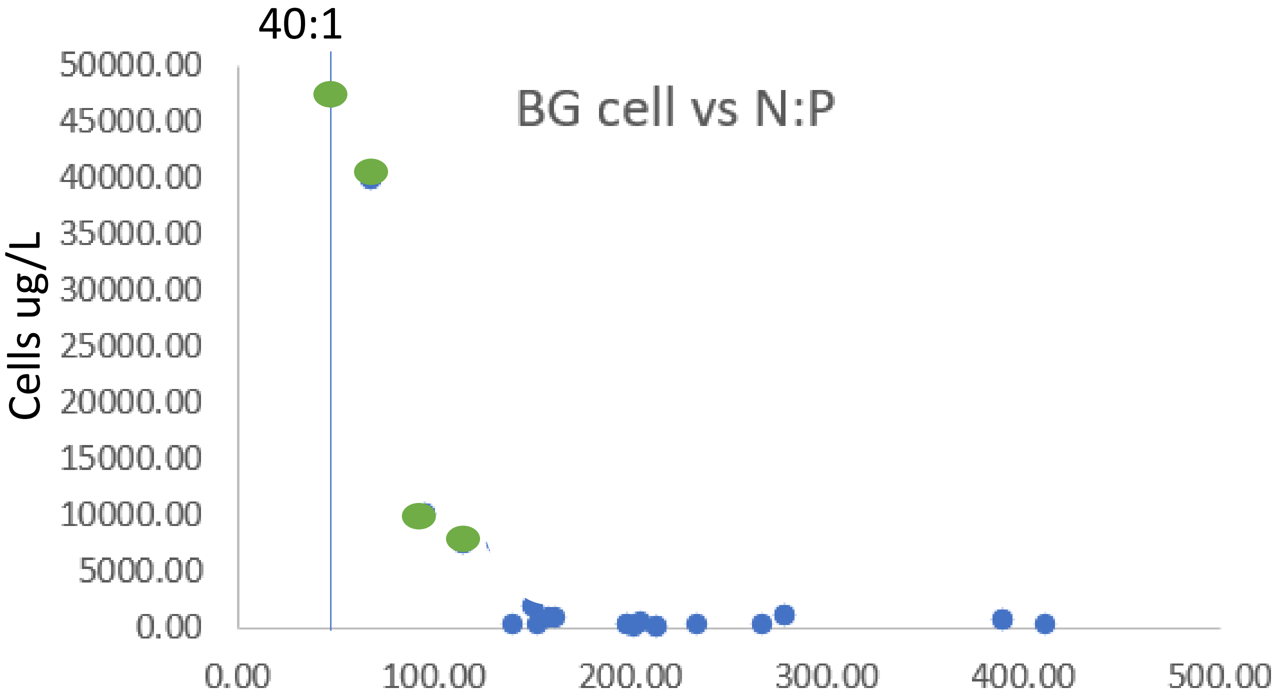




Dissolved nutrient concentrations are even less reliable indicators for blooms

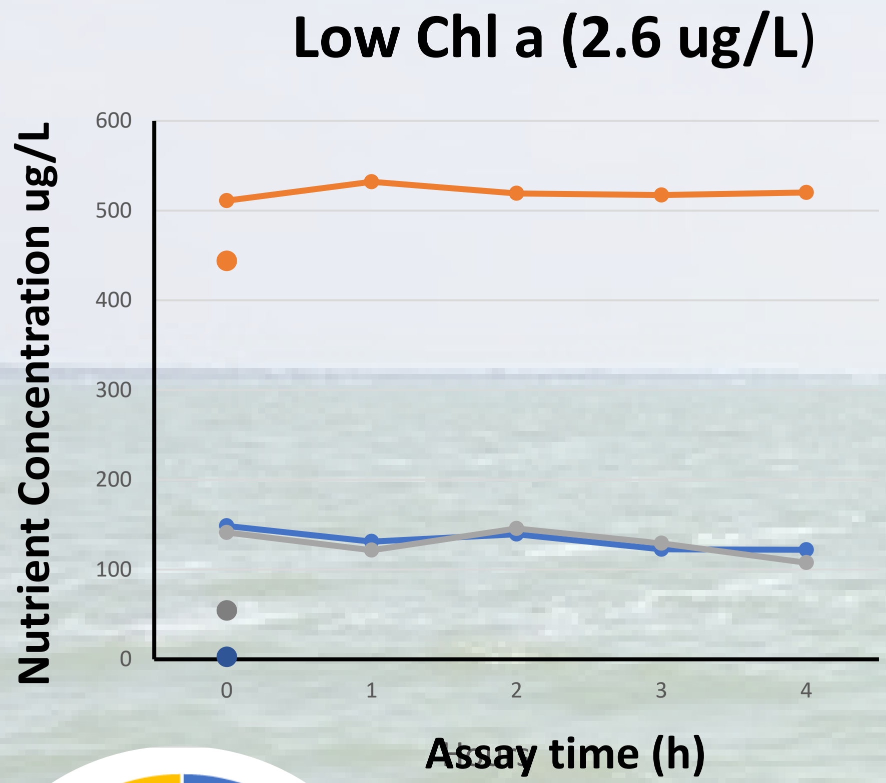


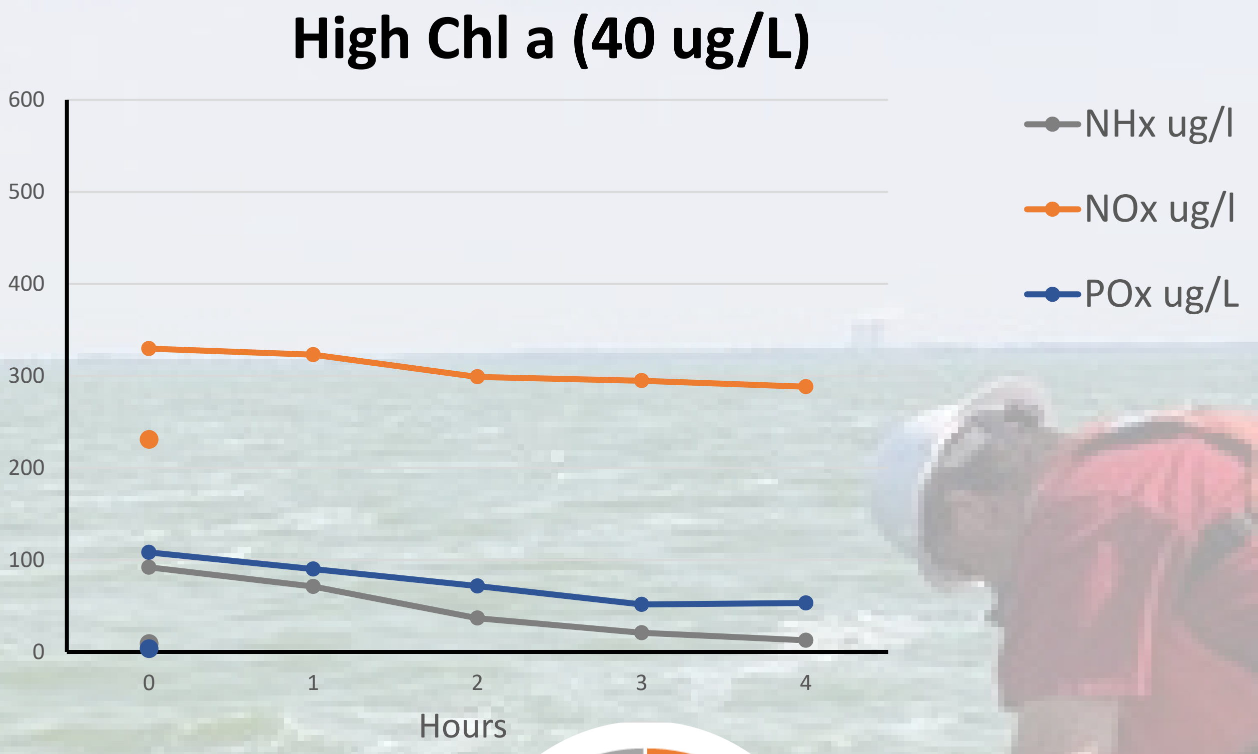


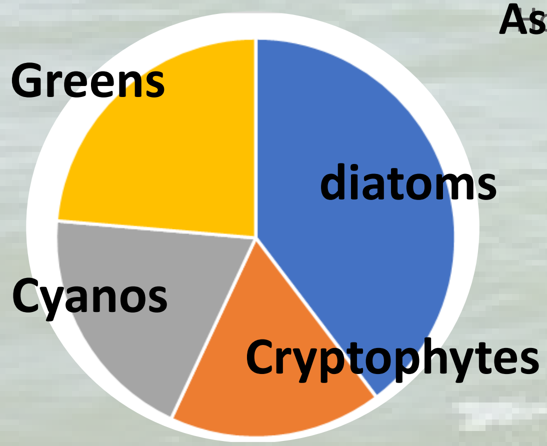


As blooms increase in biomass they become more nitrogen limited

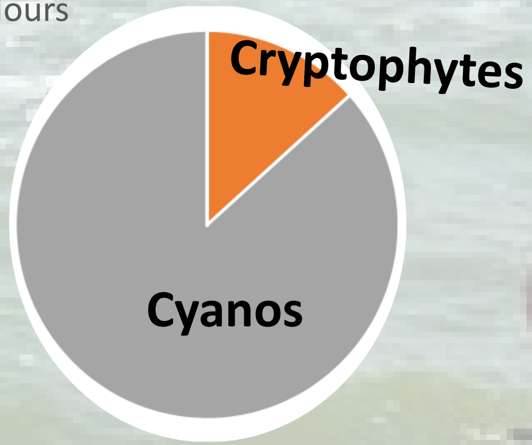
Nutrient uptake dynamics in Lake Erie (CSMI 2019)

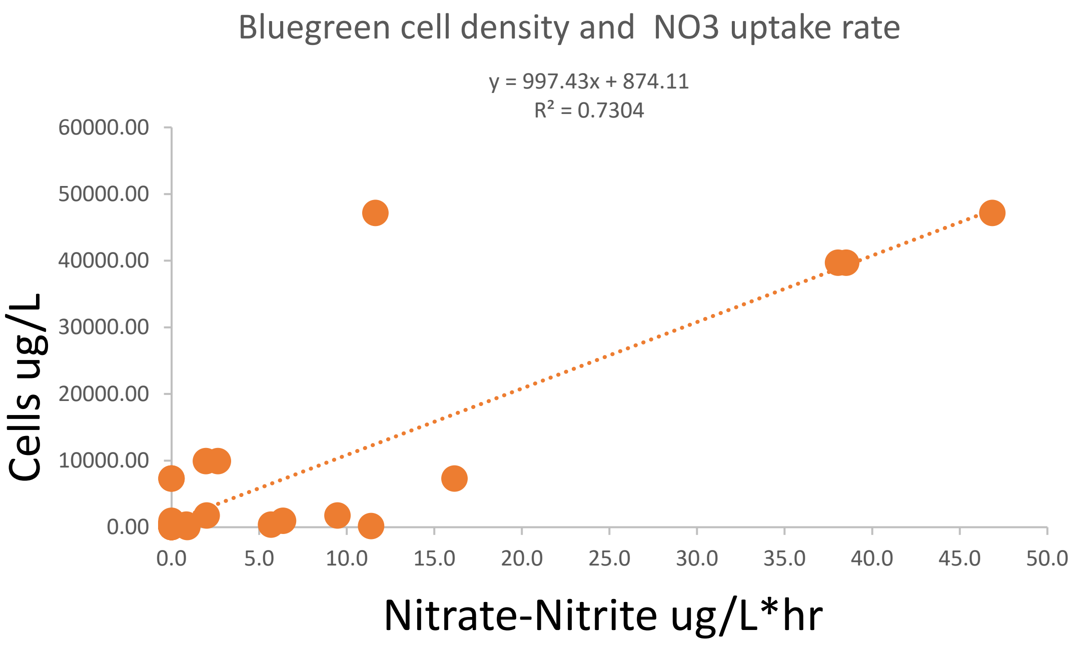


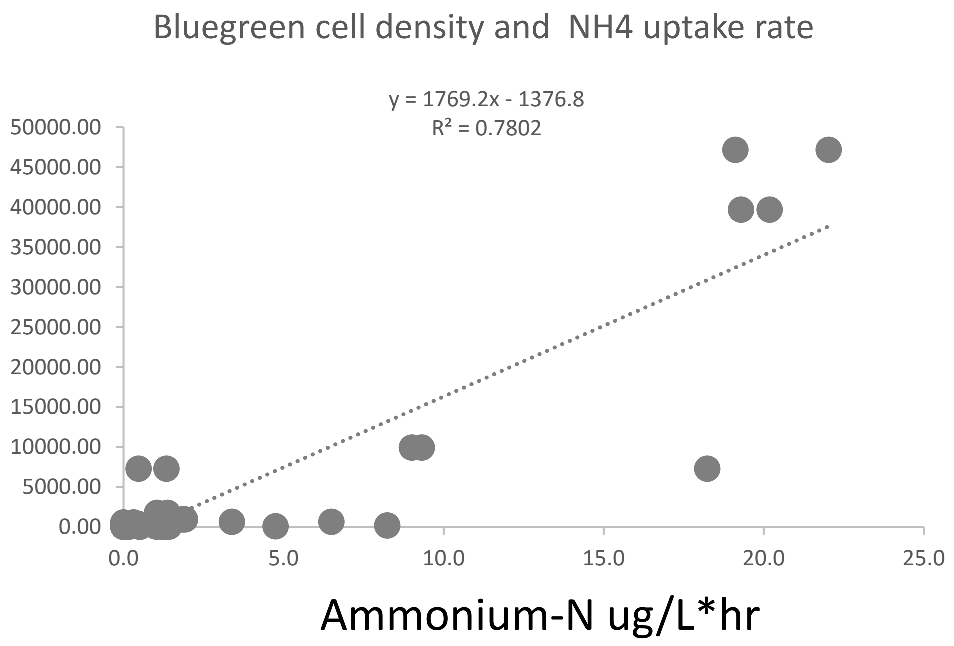


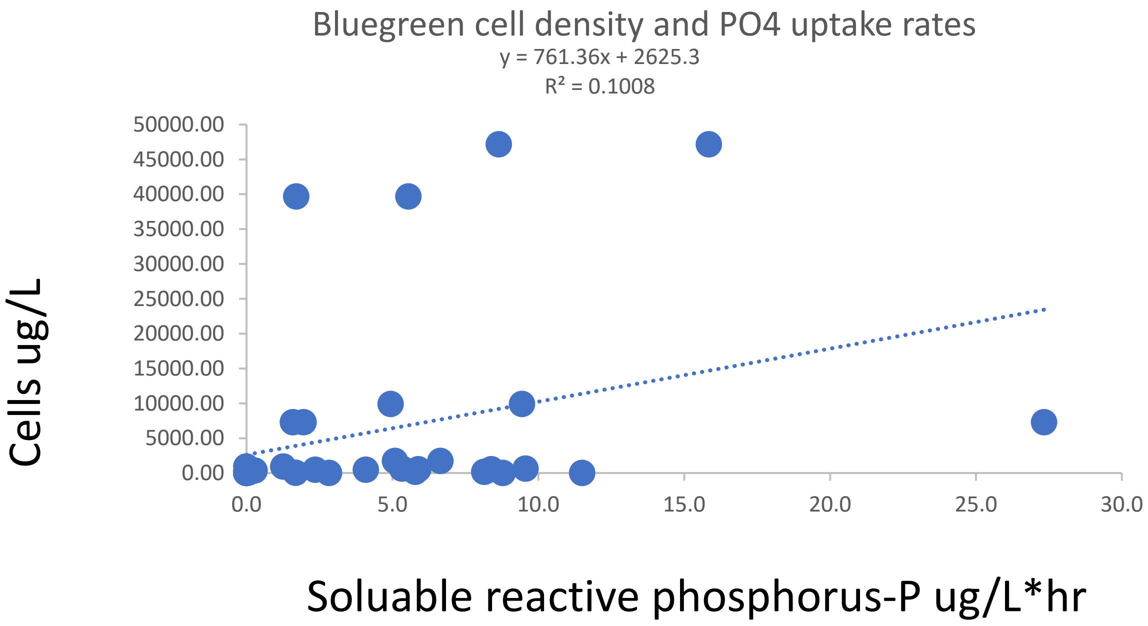


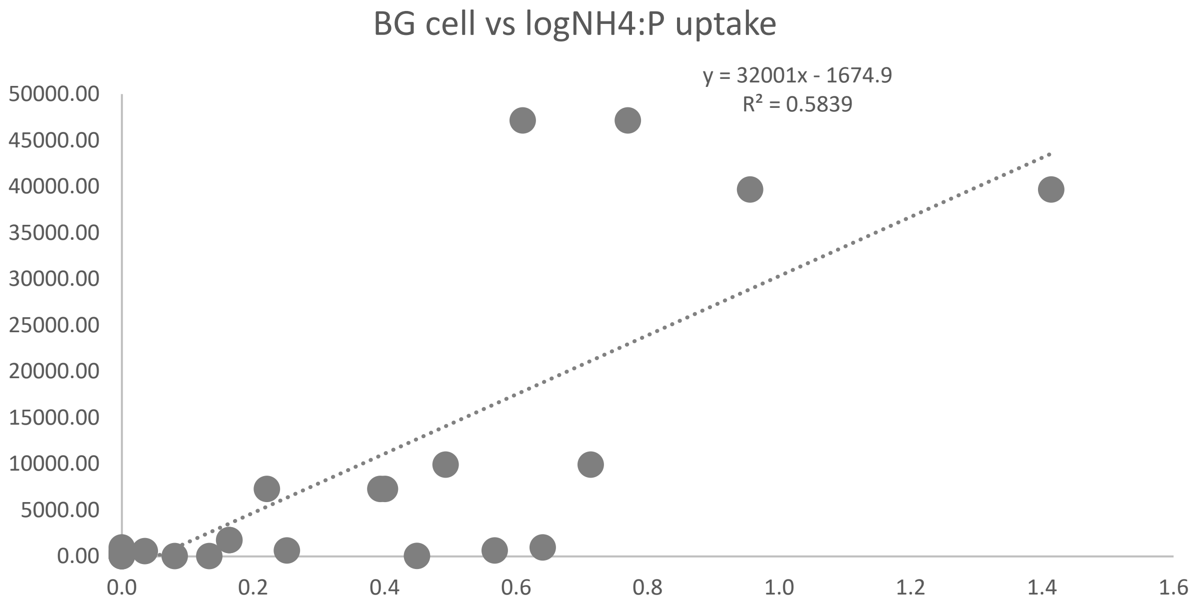
Nutrient uptake assays show minimal nutrient uptake in low Chlorophyll a sites, while high Chlorophyll a sites show Ammonium and Phosphate as the preferred nutrients, possibly co-limiting.

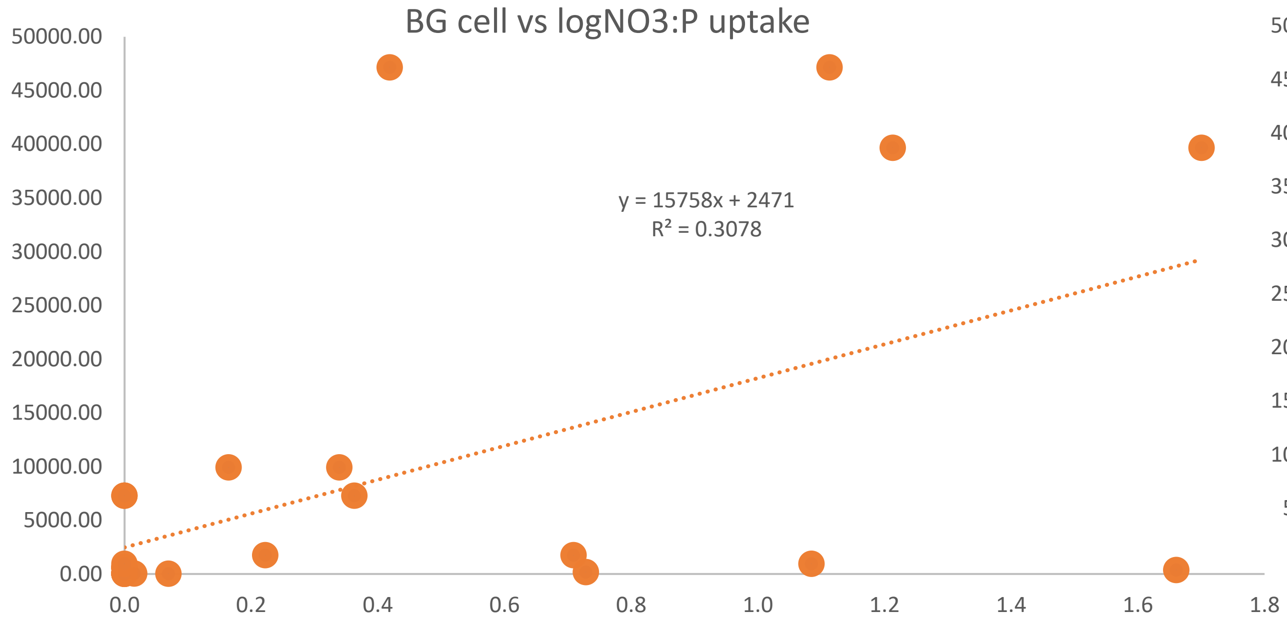


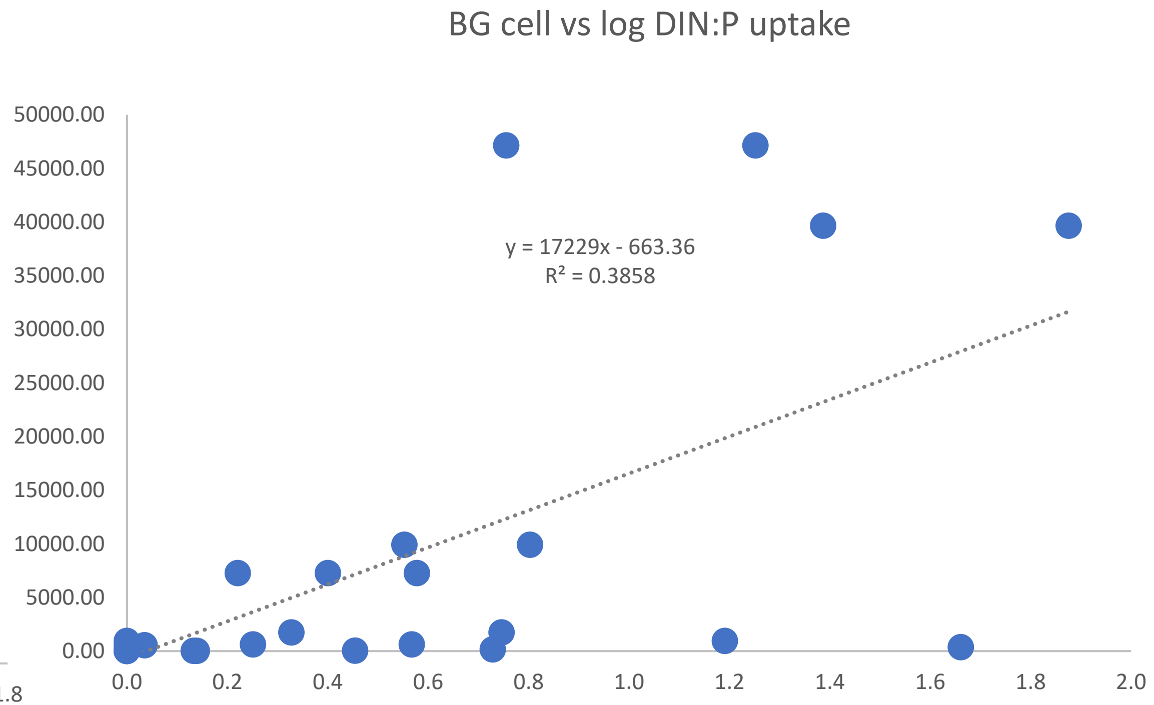

Bluegreen cell density and NO3 uptake rate
y = 997.43x + 874.11
R² = 0.7304
60000.00
50000.00
40000.00
30000.00
20000.00
10000.00
0.00
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
Cells ug/L
Nitrate-Nitrite ug/L*hr


Bluegreen cell density and NH4 uptake rate
y = 1769.2x - 1376.8
R² = 0.7802
50000.00
45000.00
40000.00
35000.00
30000.00
25000.00
20000.00
15000.00
10000.00
5000.00
0.00
0.0
5.0
10.0
15.0
20.0
25.0
Ammonium-N ug/L*hr


Bluegreen cell density and PO4 uptake rates
y = 761.36x + 2625.3
R² = 0.1008
50000.00
45000.00
40000.00
35000.00
30000.00
25000.00
20000.00
15000.00
10000.00
5000.00
0.00
0.0
5.0
10.0
15.0
20.0
25.0
30.0
Cells ug/L
Soluable reactive phosphorus-P ug/L*hr


BG cell vs logNH4:P uptake
y = 32001x - 1674.9
R² = 0.5839
50000.00
45000.00
40000.00
35000.00
30000.00
25000.00
20000.00
15000.00
10000.00
5000.00
0.00
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6


BG cell vs logNO3:P uptake
y = 15758x + 2471
R² = 0.3078
50000.00
45000.00
40000.00
35000.00
30000.00
25000.00
20000.00
15000.00
10000.00
5000.00
0.00
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8


BG cell vs log DIN:P uptake
y = 17229x - 663.36
R² = 0.3858
50000.00
45000.00
40000.00
35000.00
30000.00
25000.00
20000.00
15000.00
10000.00
5000.00
0.00
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0

Summary

- L Erie Chlorophyll a can be a good predictor for cyanobacteria biomass and microcystin concentration for our study.

- As cyanoHAB blooms intensify the system seems to become more nitrogen limited- suggesting greater dissolved nitrogen uptake than phophorous uptake.

- Nutrient uptake assays suggest that cyanobacteria are nitrogen hungry

- Nitrogen reduction may be considered as another management option to control cyanoHABs

Photo credit: Brenda Lafrancois, NPS

Future

- Deeper look into nitrogen cycling and cyanoHABs.
- Can we link nutrient uptake with real-time buoy data to forecast onset of blooms?
- Do cold oligotrophic inland lake blooms behave similarly to more temperate eutrophic lakes?
- How do the other great lakes compare to Lake Erie?

Photo credit: Brenda Lafrancois, NPS