Beneficial Use Impairments (BUIs) in the Grand Calumet River Area of Concern (AOC)

Phytoplankton and Zooplankton

Ann St. Amand, Ph.D., CLP
PhycoTech, Inc.

PhycoTech, Inc.

Background

- In 1987, the Great Lakes Water Quality Agreement between the United States and Canada was revised.
- 42 (later 43) Areas of Concern (AOC) were identified.
- AOC could have up to 14 Beneficial Use Impairments
  - Grand Calumet River, Indiana Harbor and Ship Canal (IHSC), nearshore Lake Michigan was the only AOC to have all 14.
  - **BUI 8: Eutrophication or undesirable algae.**
  - **BUI 13: Degradation of phytoplankton and zooplankton populations.**

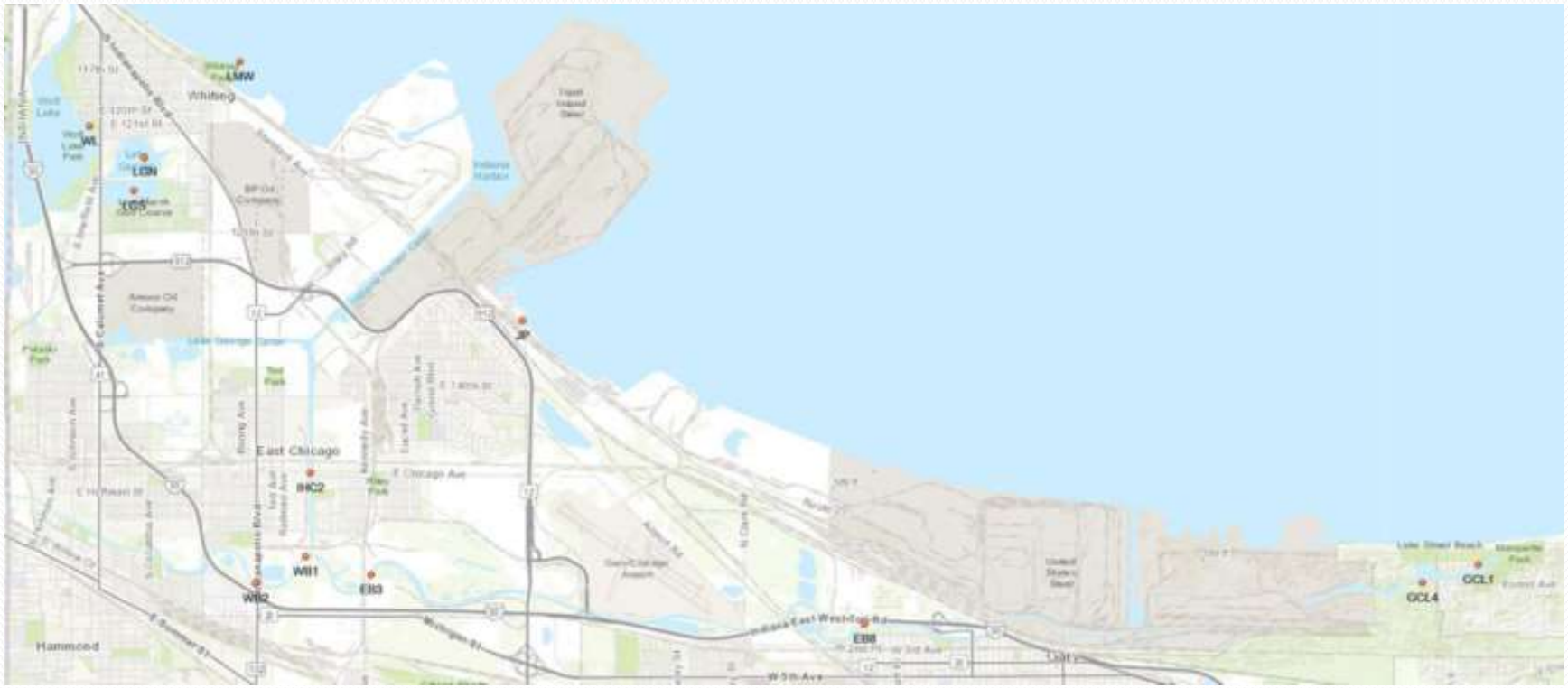
Background

- **Sampling**
  - Phytoplankton
    - Grab Samples
      - 0.25% Glutaraldehyde Final Concentration
      - Analyzed to lowest taxonomic level
  - Zooplankton
    - Schindler Traps – 30L
      - 30 Trap Pulls (900 L)
        - Ethanol
        - Analyzed to lowest taxonomic level

Previous Data

- **This study adhered to the same sampling stations as the 2012 study.**

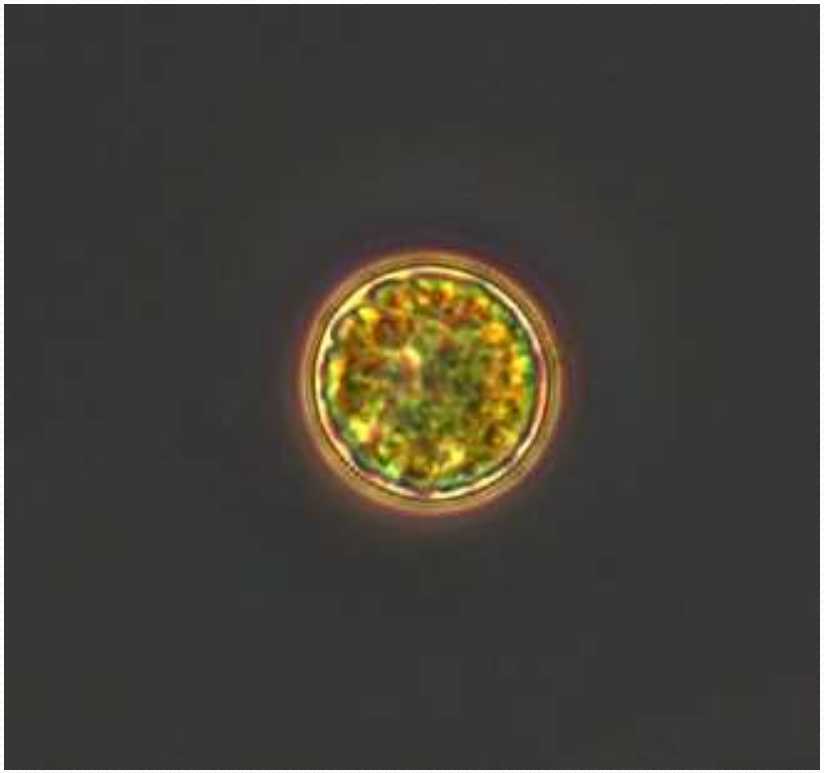
Grand Calmuet River AOC Sites/Lakes



Grand Calmuet River AOC Sites/Lakes

Phytoplankton Results

- We analyzed both algae in terms of the total assemblage, functional groups and indicator taxa.



Phytoplankton Results-Functional Groups

- **Other**
- **Non-HAB- Nontoxic Bluegreen Algae (Cyanophyta)**
- **HAB1-Non-heterocystic Bluegreen Algae that can produce toxins or taste/odor compounds (Cyanophyta)**
- **HAB-Heterocystic Bluegreen Algae that can produce toxins or taste/odor compounds (Cyanophyta)**
- **Green Algae (Chlorophyta)**
- **Euglenoid Algae (Euglenophyta)**
- **Diatoms/Chrysophytes (Bacillariophyceae/Chrysophyta)**
- **Cryptomonads/Non-Ceratium Dinoflagellates (Cryptophyta/Pyrrhophyta)**
- **Ceratium (Pyrrhophyta)**

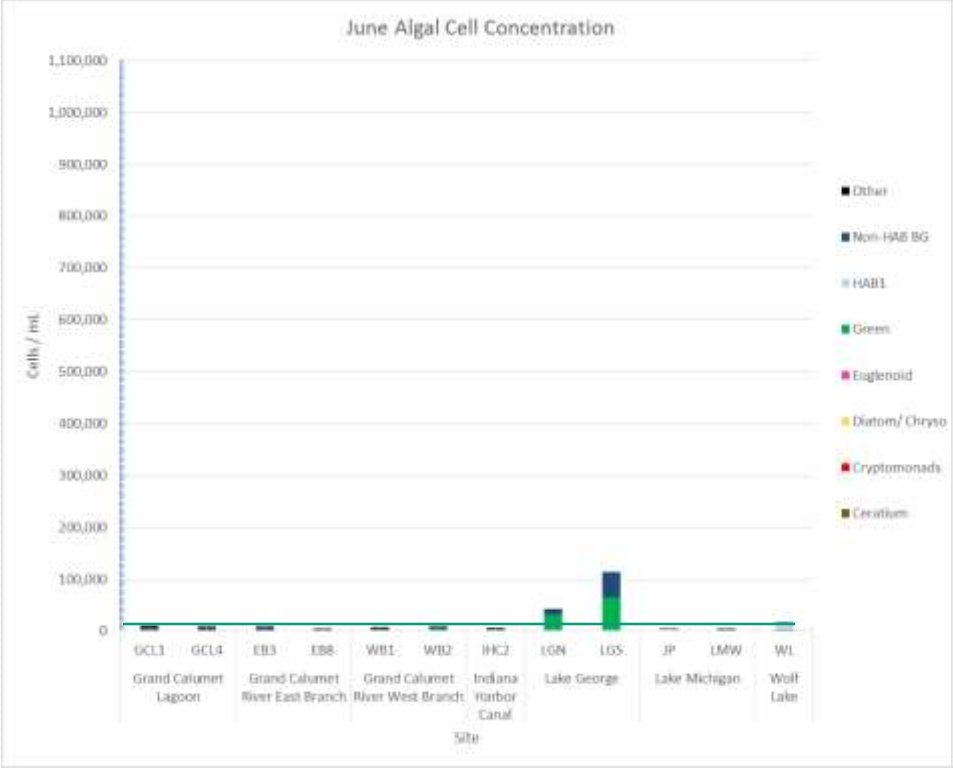
Phytoplankton Results-Functional Groups

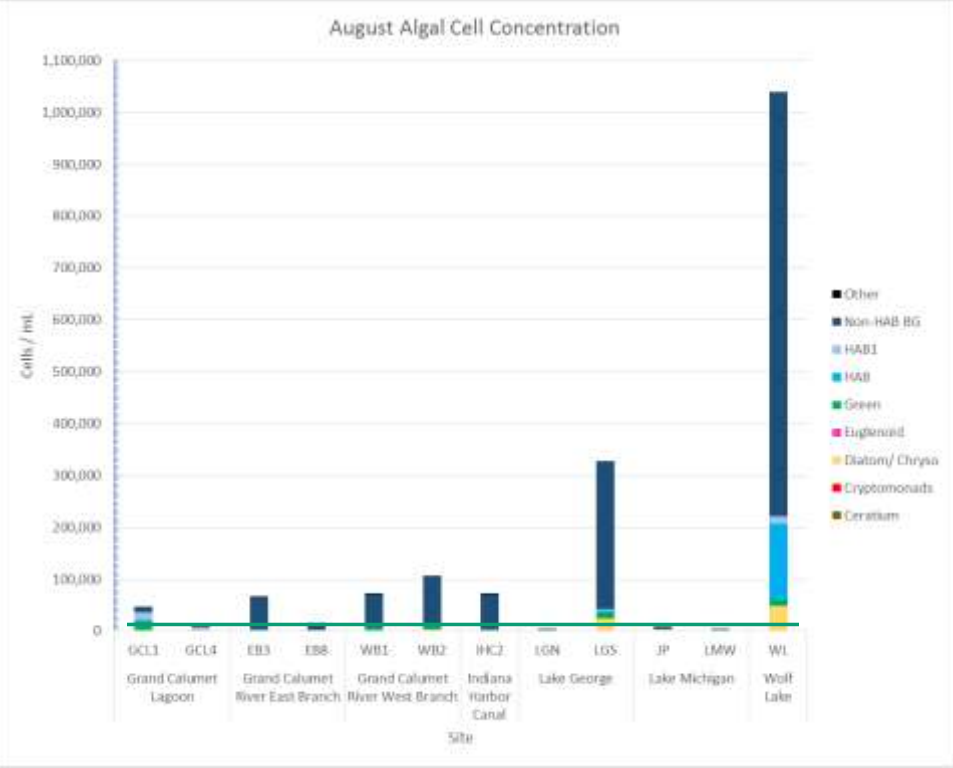
- **HAB1-Non-heterocystic Bluegreen Algae that can produce toxins or taste/odor compounds (Cyanophyta)**
  - ***Microcystis***
  - ***Planktothrix***
  - ***Pseudanabaena***
  - ***Woronichinia***

  Can't fix their own nitrogen
- **HAB-Heterocystic Bluegreen Algae that can produce toxins or taste/odor compounds (Cyanophyta)**
  - ***Dolichospermum***
  - ***Raphidiopsis (Cylindrospermopsis)***
  - ***Aphanizomenon***
  - ***Cuspidothrix***

  Fix their own nitrogen

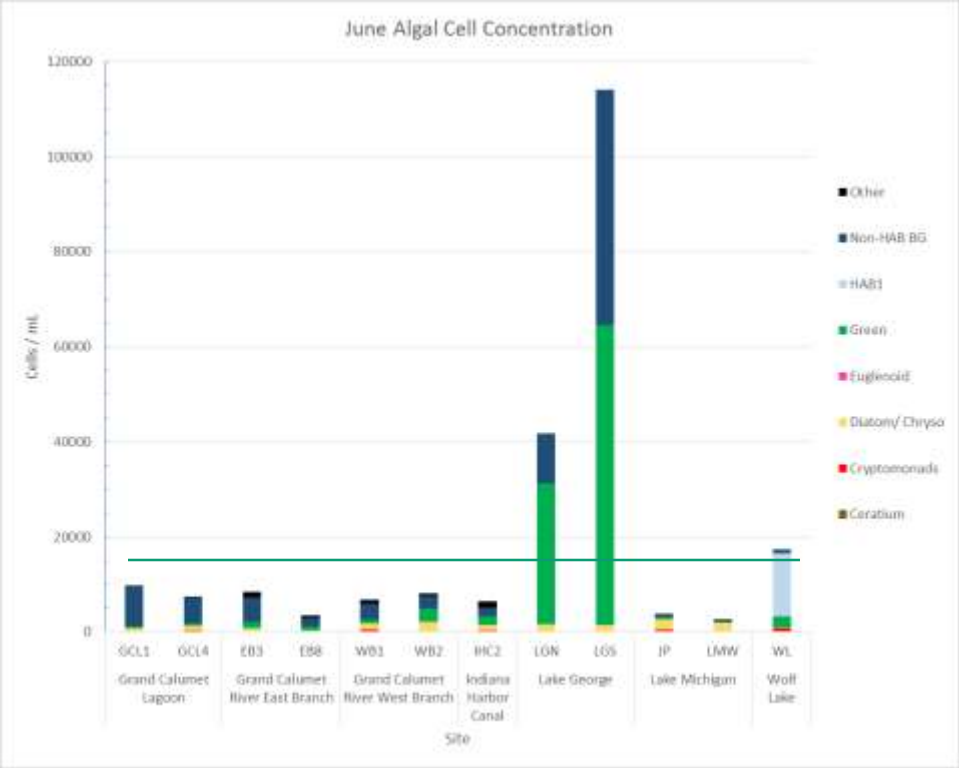
Phytoplankton Results
Algal Cell Concentration





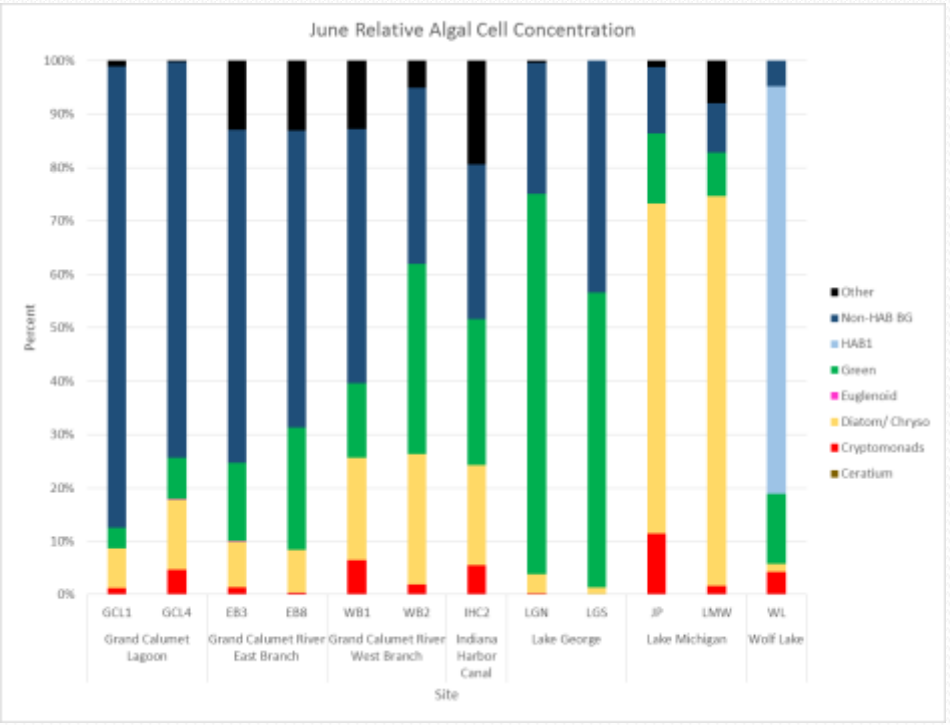
Control line at 15,000 Cells/mL indicates eutrophication

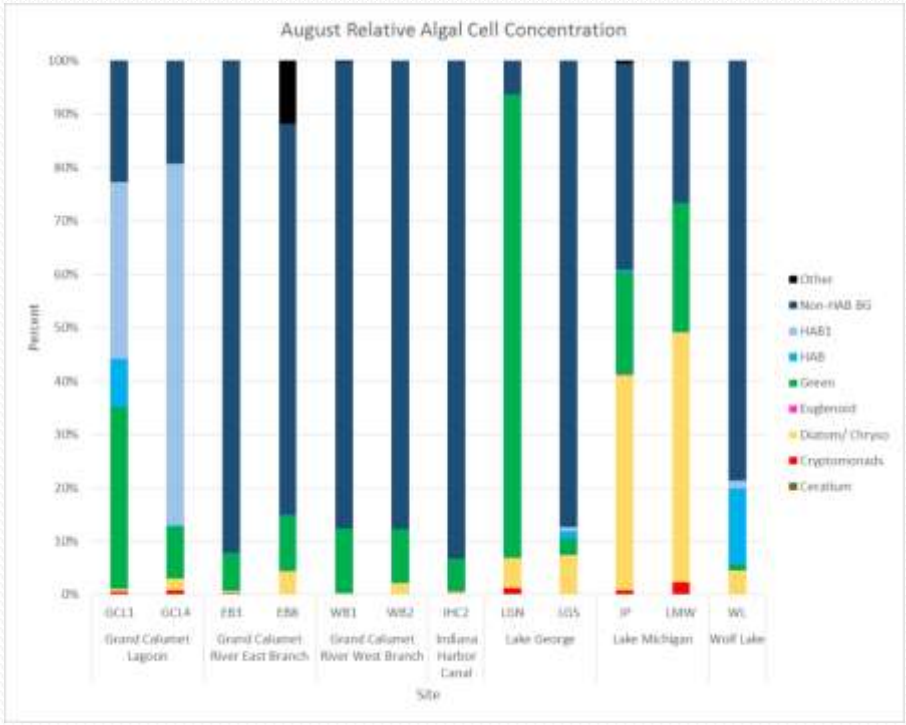
Phytoplankton Results
Algal Cell Concentration



Control line at 15,000 Cells/mL indicates eutrophication

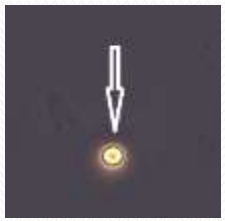
Phytoplankton Results
Relative Algal Cell Concentration





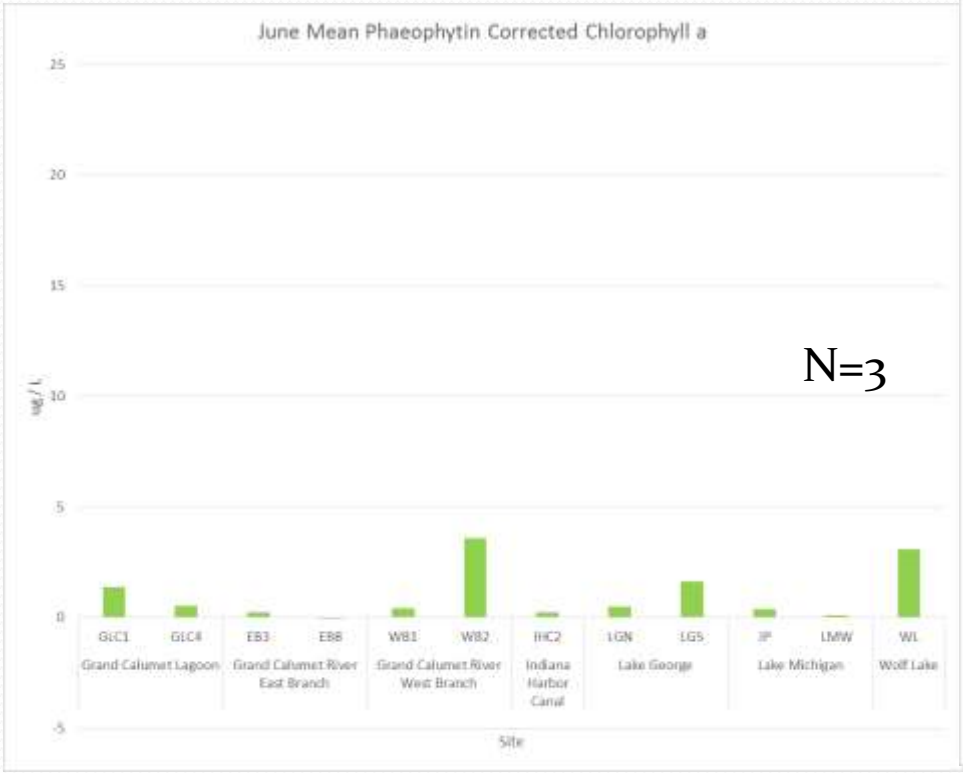
Phytoplankton Results Biovolume

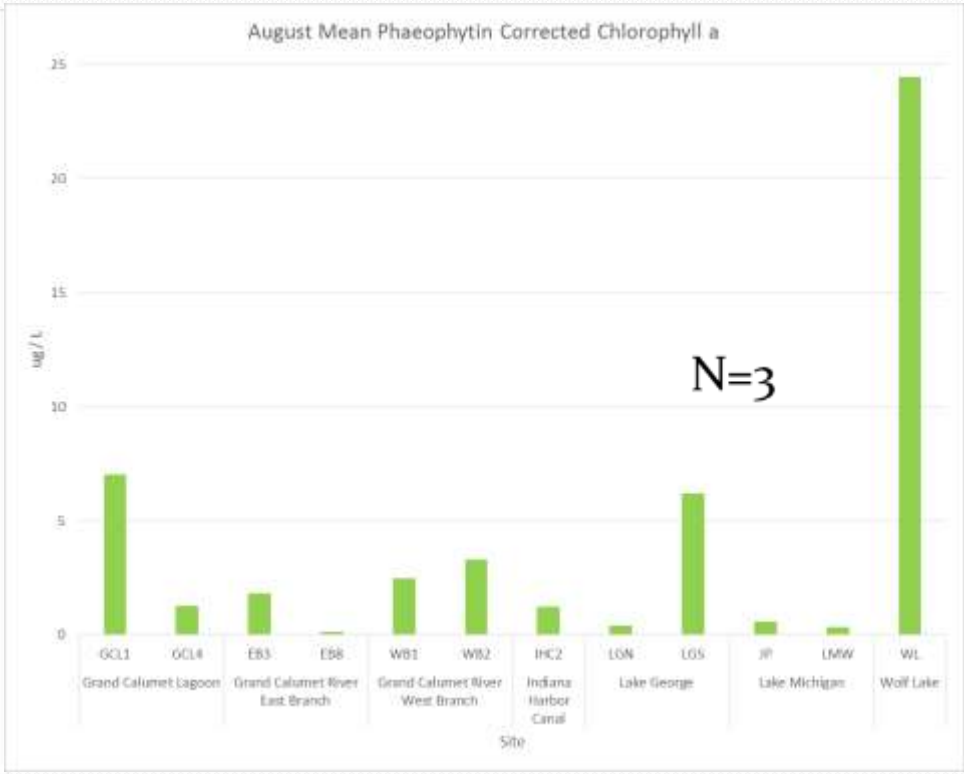
- Biovolume helps adjust for concentration *AND* size…



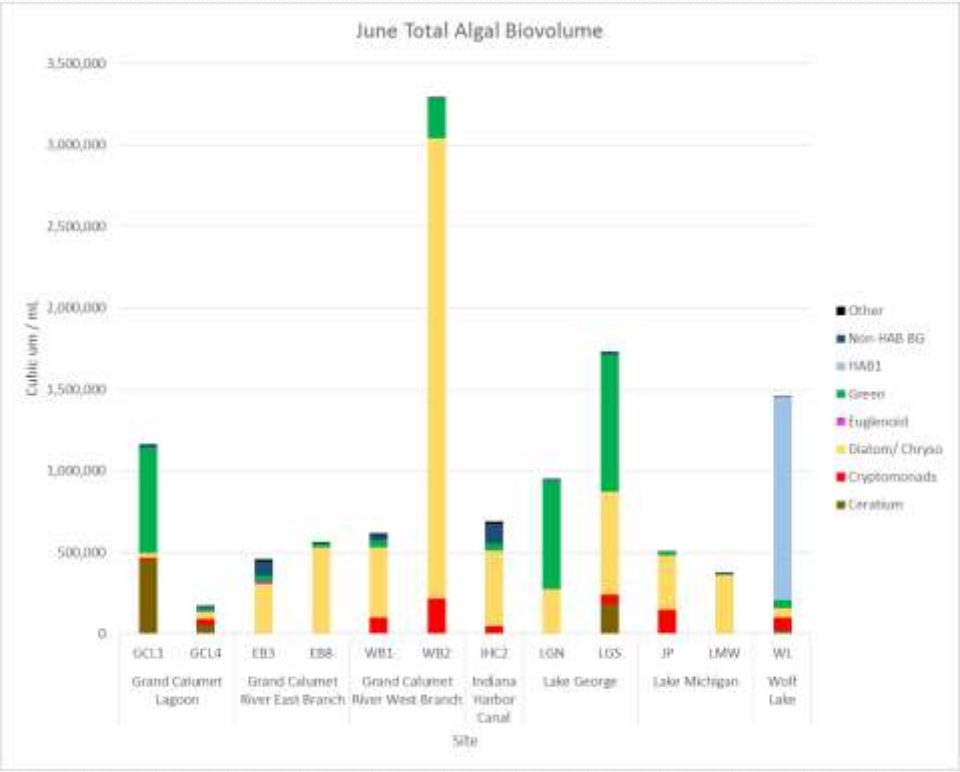
Single Chlorococcales

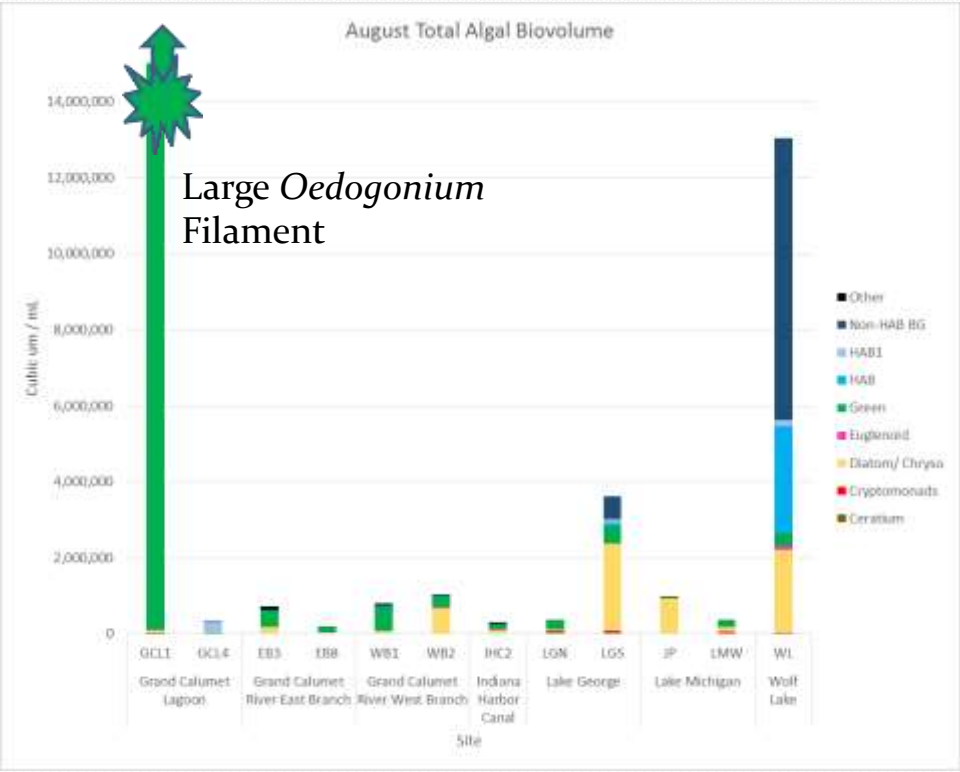
Chlorophyll *a*





Phytoplankton Results
Algal Biovolume

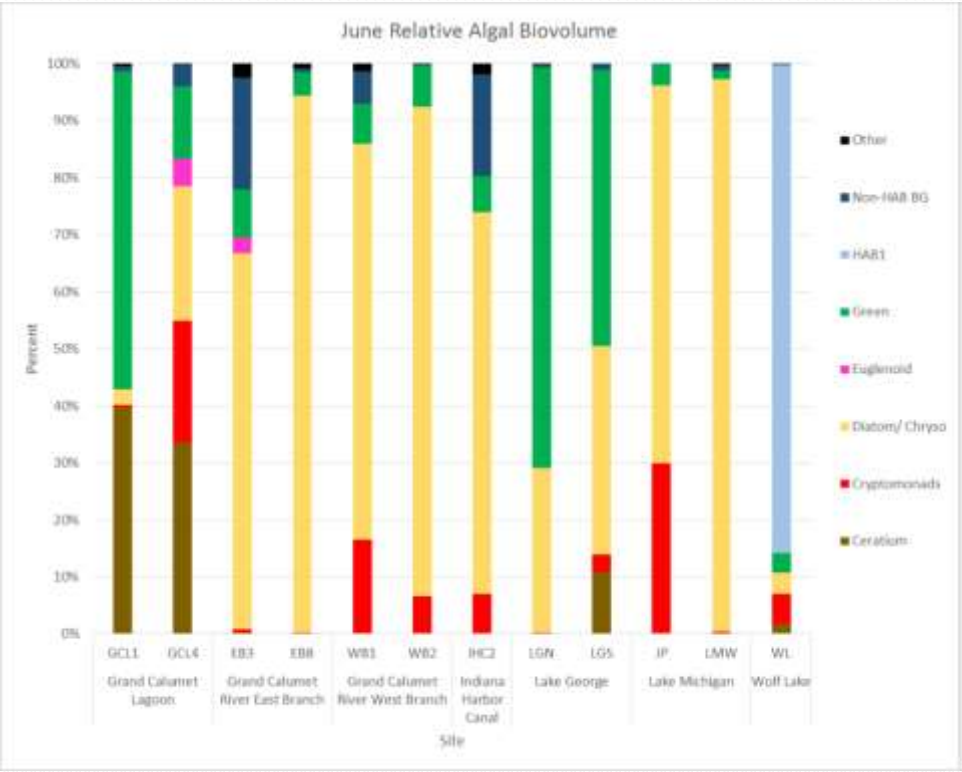


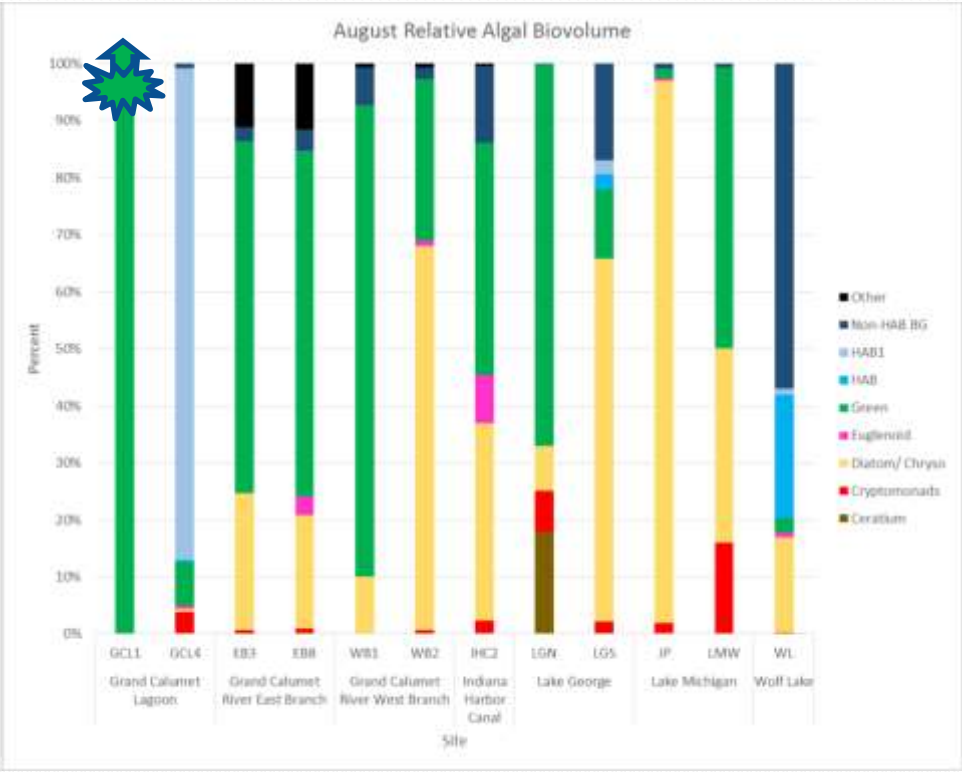


Phytoplankton Results
Algal Biovolume

GCL1

Phytoplankton Results
Relative Algal Biovolume

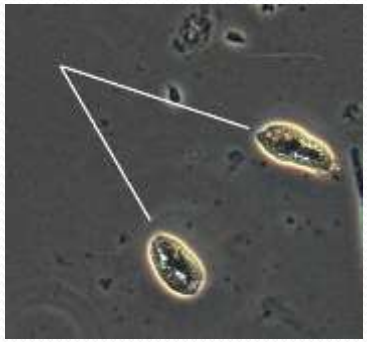


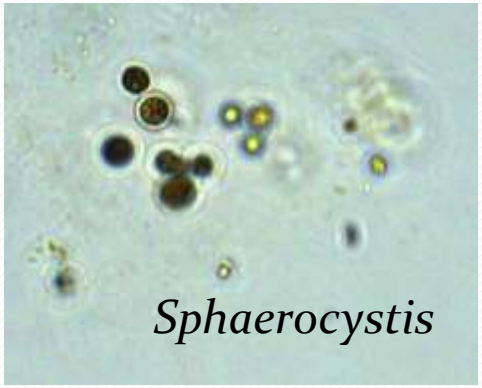


Trends

- Presence of some species indicate reasonably good water quality.

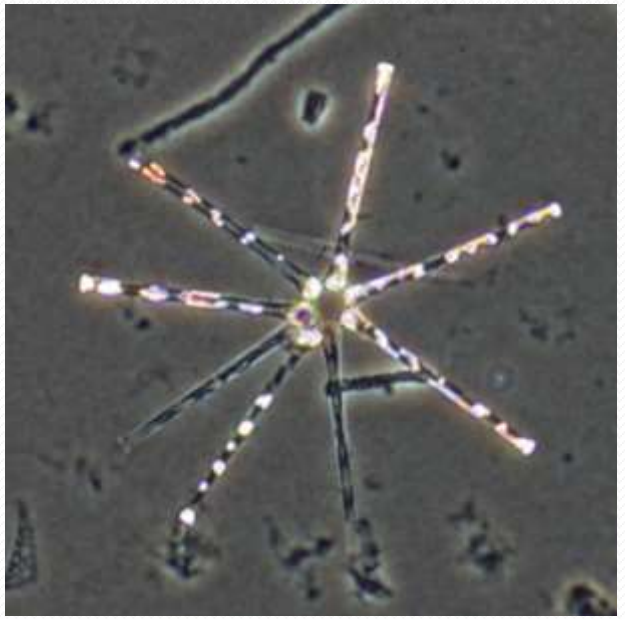
Cryptomonas

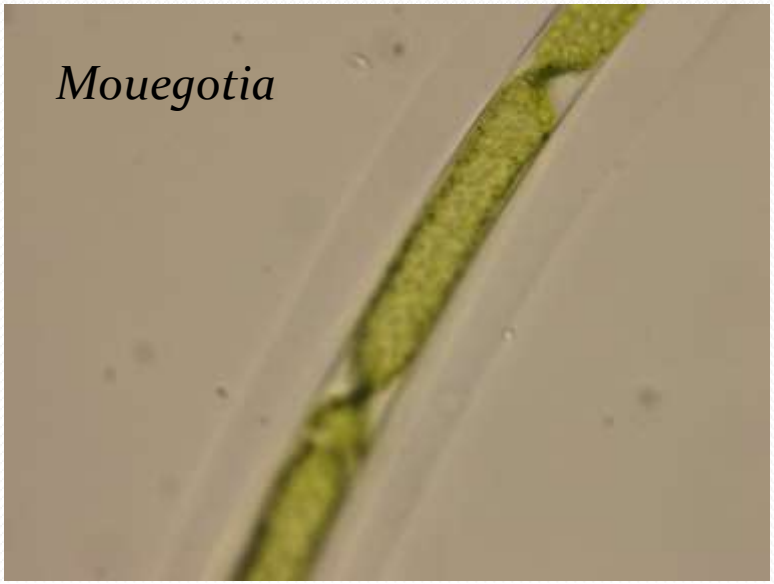




Sphaerocystis

Asterionella





Mouegotia

Trends

- Presence of high densities of Dinoflagellates and Euglenoids indicates high organic matter.

Ceratium

Euglena

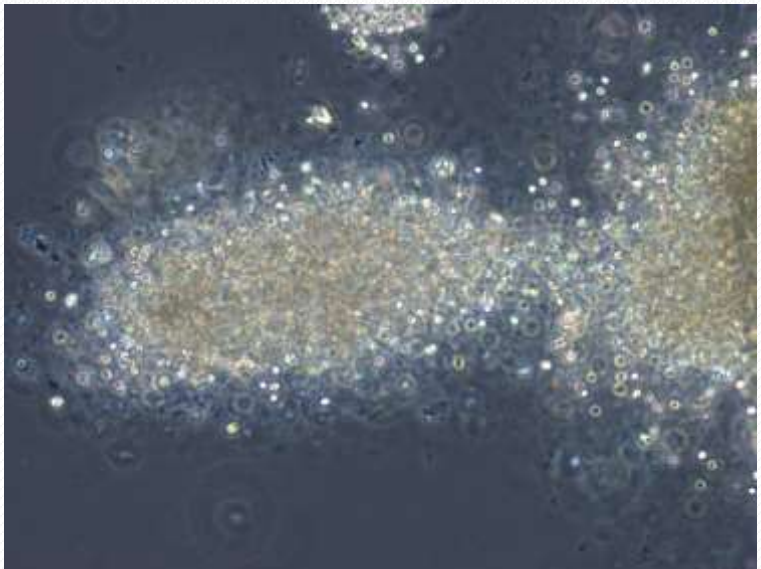
Trends

- Fair number of periphytic algal species represented in the plankton.
  - *Melosira varians*
  - *Aulacoseira italica*
  - *Oedogonium* sp.

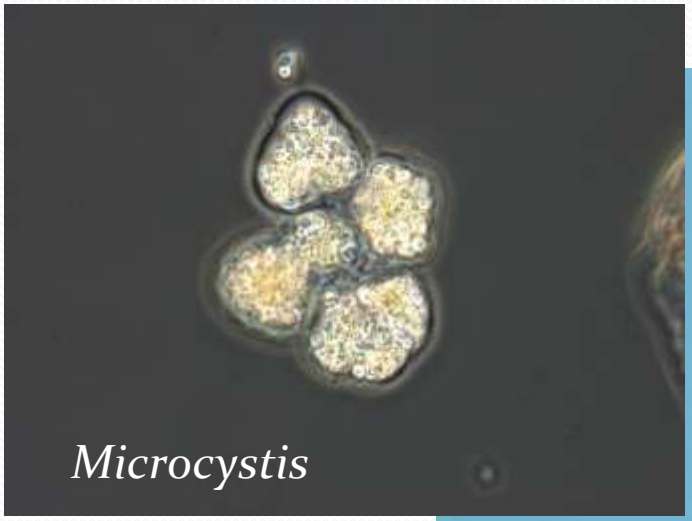
- Indication of shallow system with a lot of benthic influence typical of wetland and riverine systems.
- Also could indicate higher levels of disturbance.

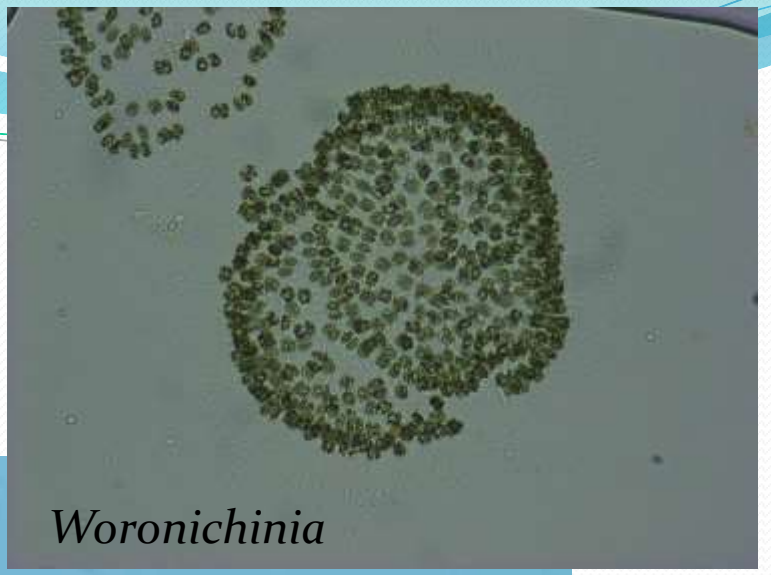
Trends

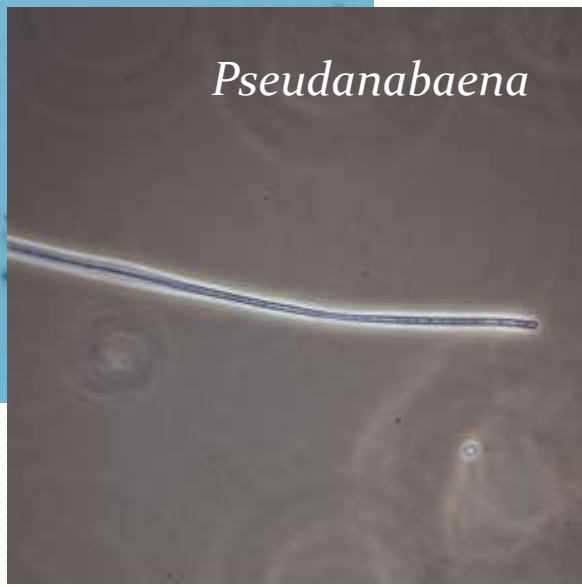
- HAB taxa present in several of the sample sites/lakes are capable of toxin production and ecological impairment
  - *Microcystis*
  - *Raphidiopsis (Cylindrospermopsis)*
  - *Cuspidothrix*
  - *Planktothrix*
  - *Dolichospermum*
  - *Woronichinia*



Trends

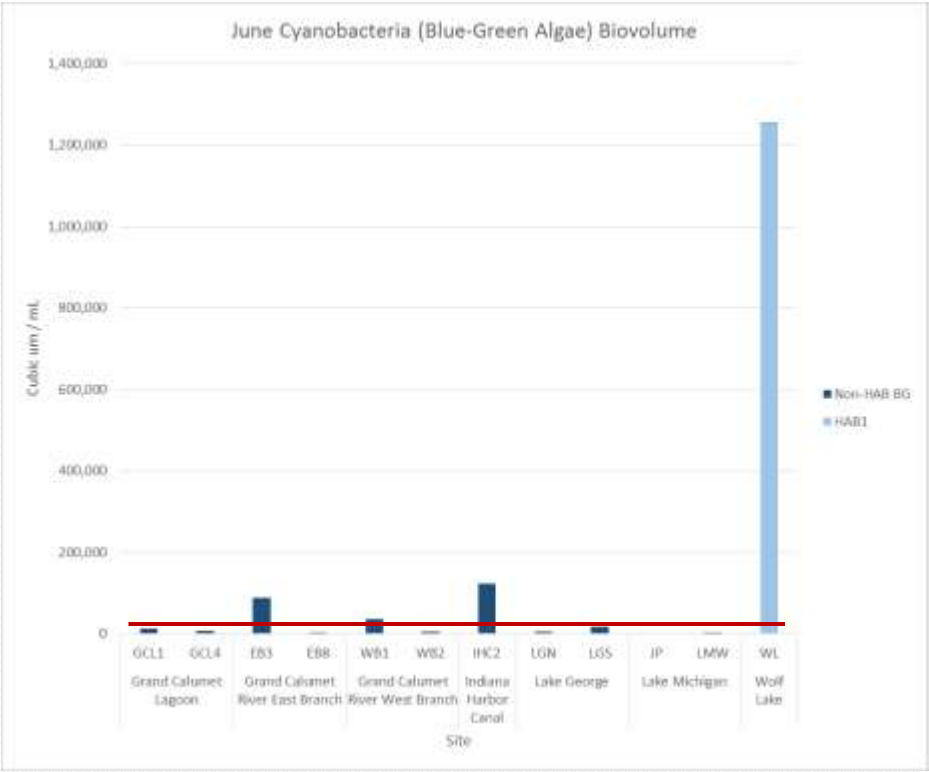


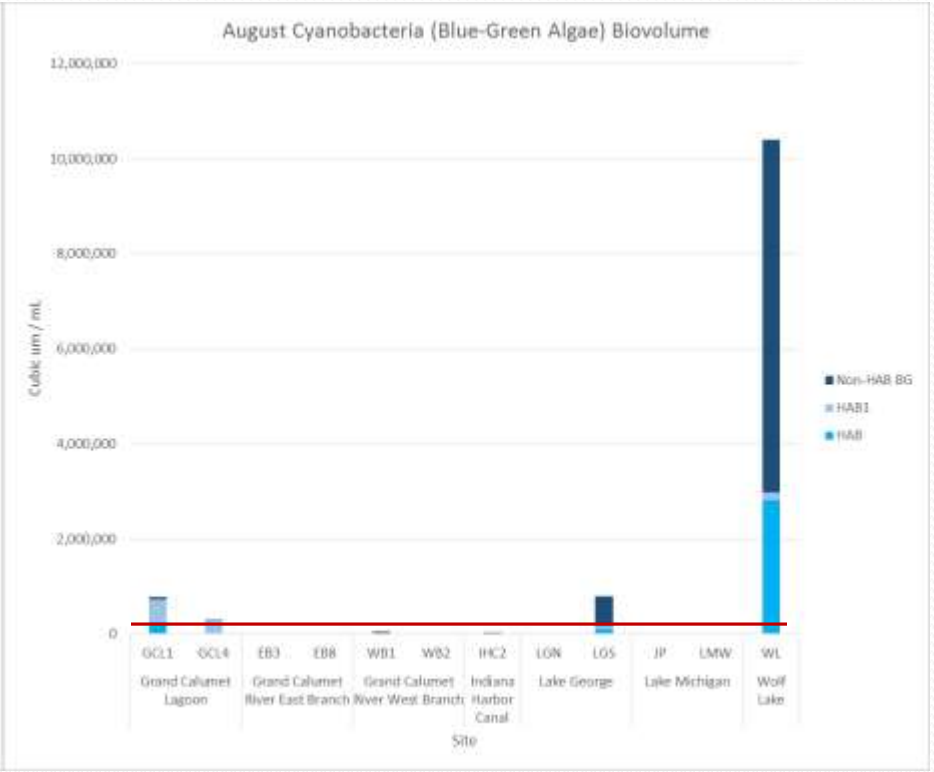




Representative HAB taxa

Trends – HAB Cell Concentration

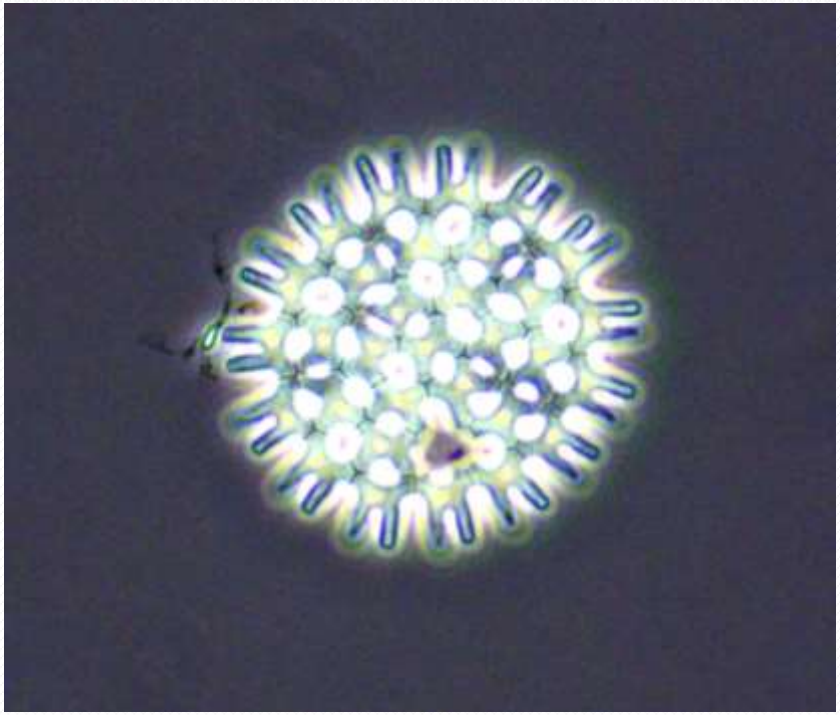




Control line indicates 20,000 Cells/mL HAB taxa, WHO lower limit for risk assessment.

Phytoplankton Assemblages

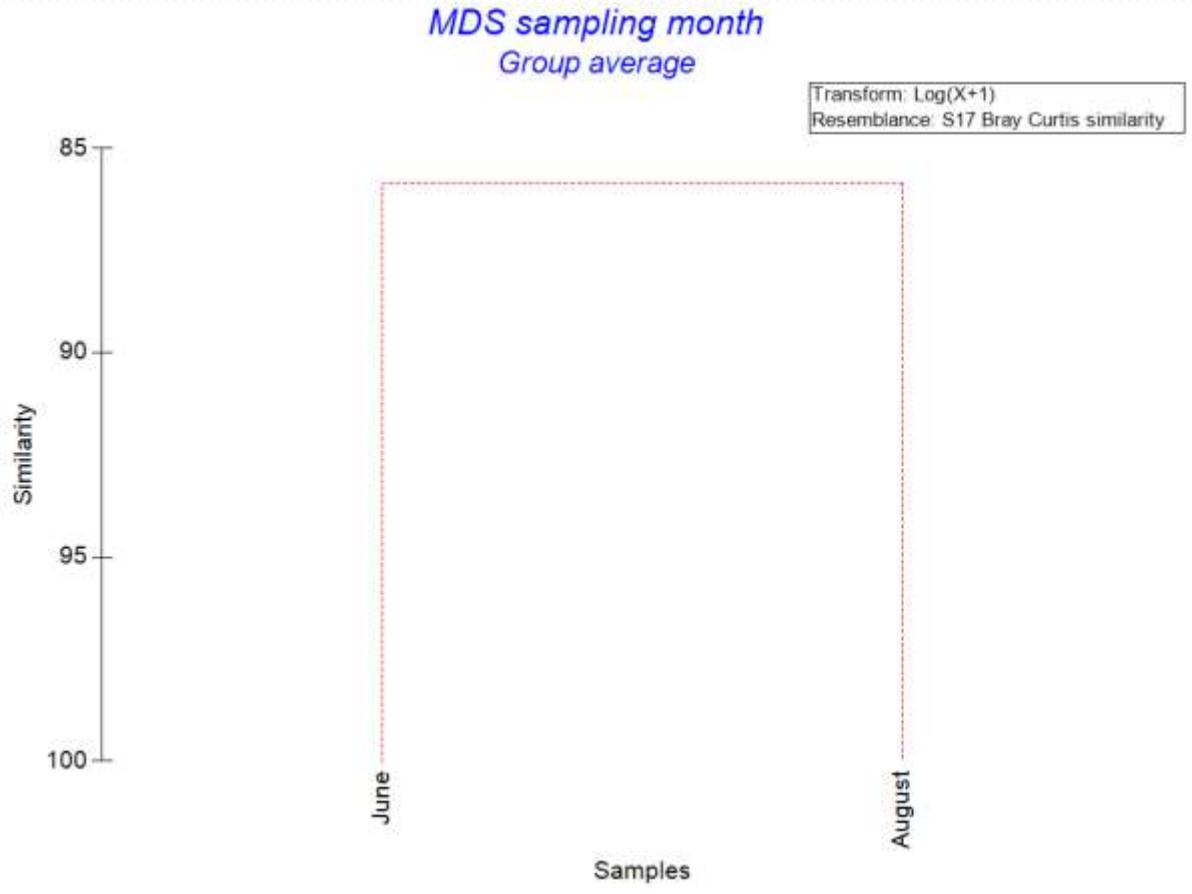
- We analyzed the algal data to determine if sites/lakes had statistically different assemblages (biovolume), and if some sites/lakes were more similar than others.



Phytoplankton Assemblages

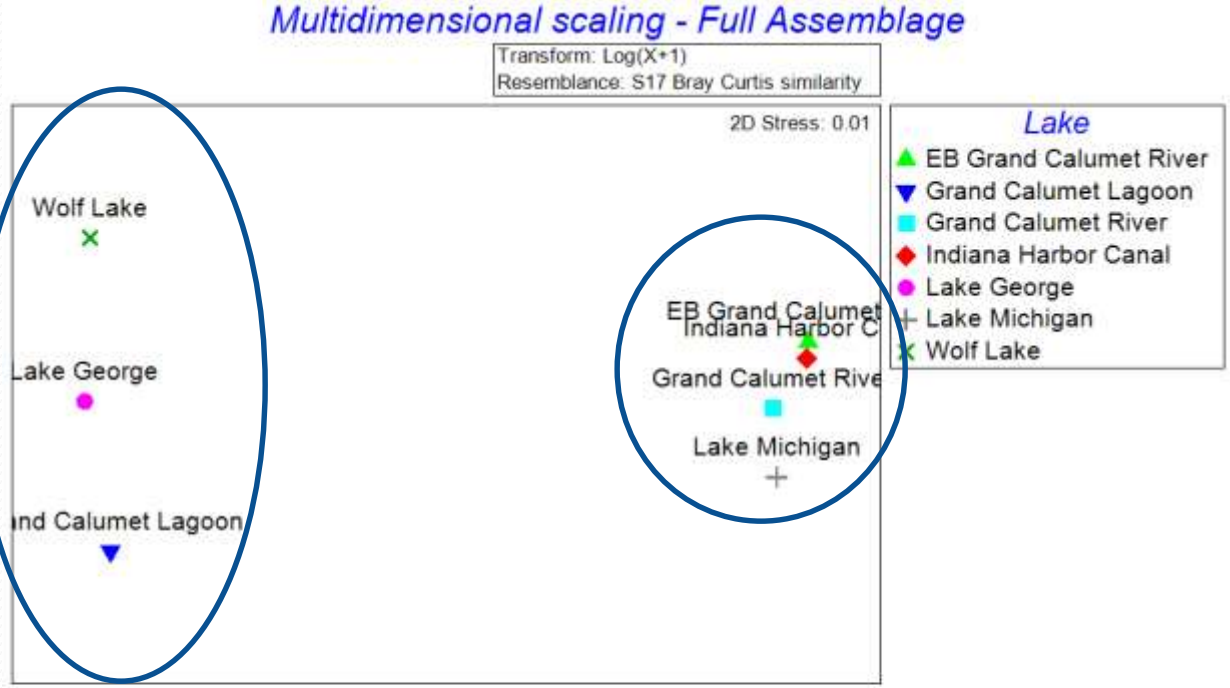
- We **Log** transformed all of our algae and zooplankton data for statistical analysis – Multidimensional Scaling using Primer e6.
- Biovolume.
- We did not delete outlier taxa.

Phytoplankton – Growth Season



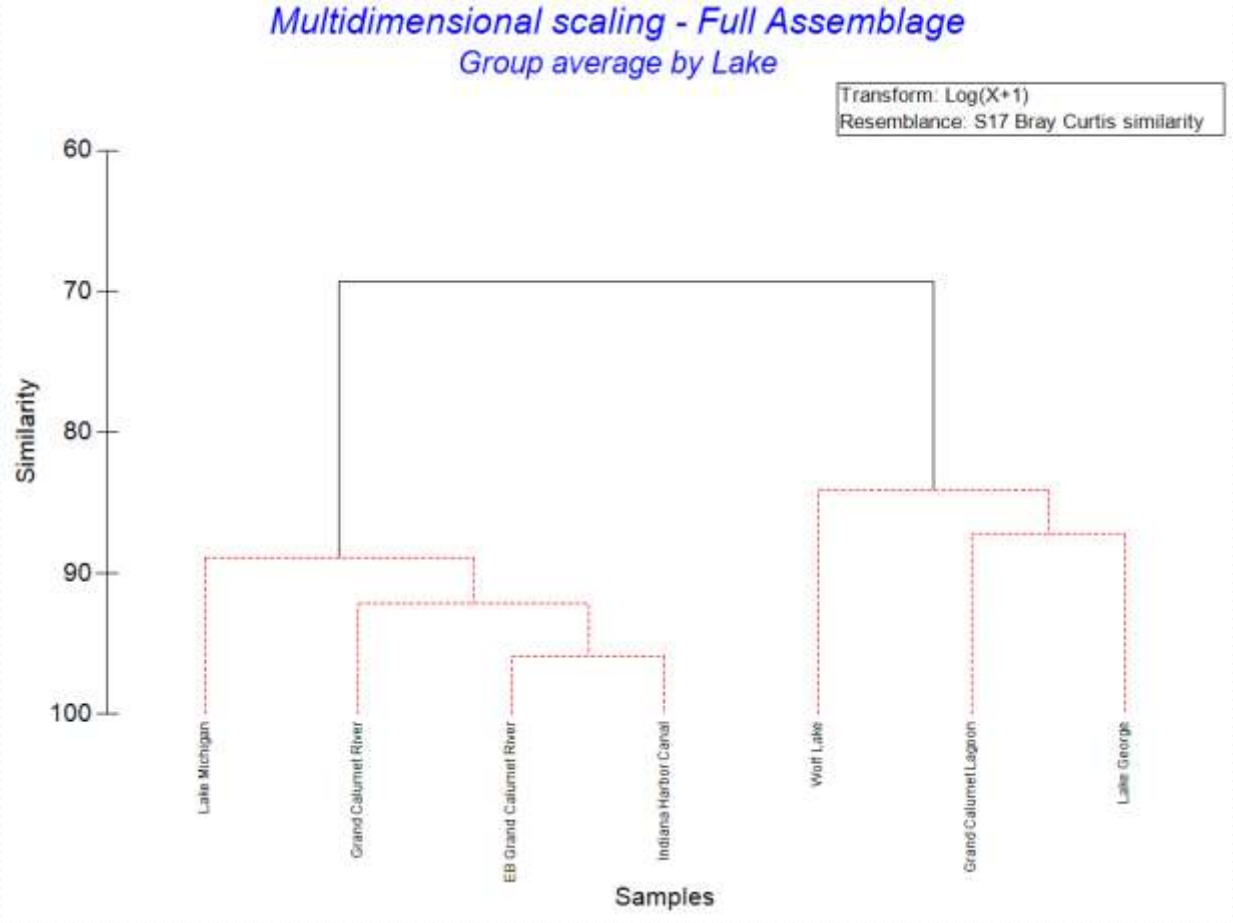
We can pool June and August samples as the Growth Season and average by Site/Lake

Phytoplankton – Full Assemblage



Including the full assemblage as individual taxa.

Phytoplankton – Full Assemblage

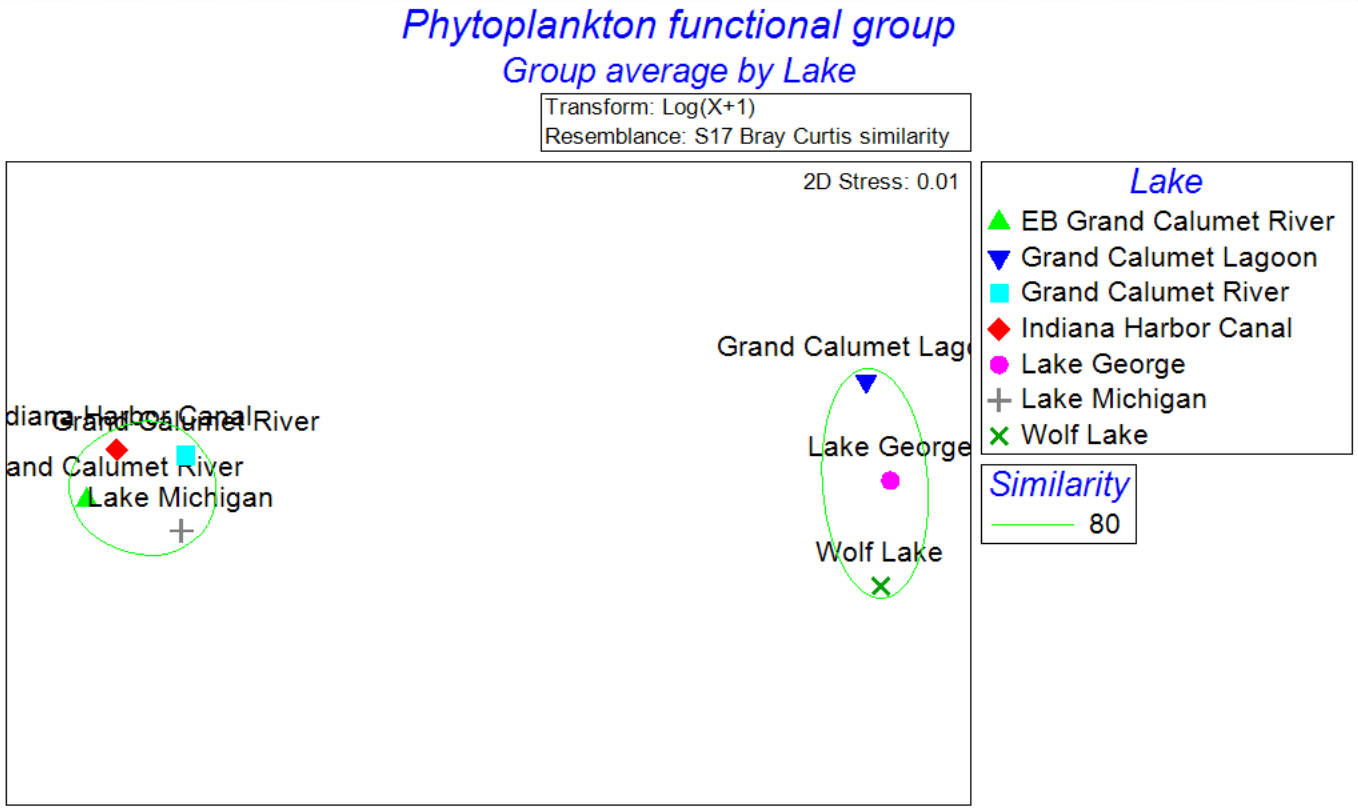


Solid lines indicate statistically significant relationships ($p<0.05$)

Phytoplankton Results-Functional Groups

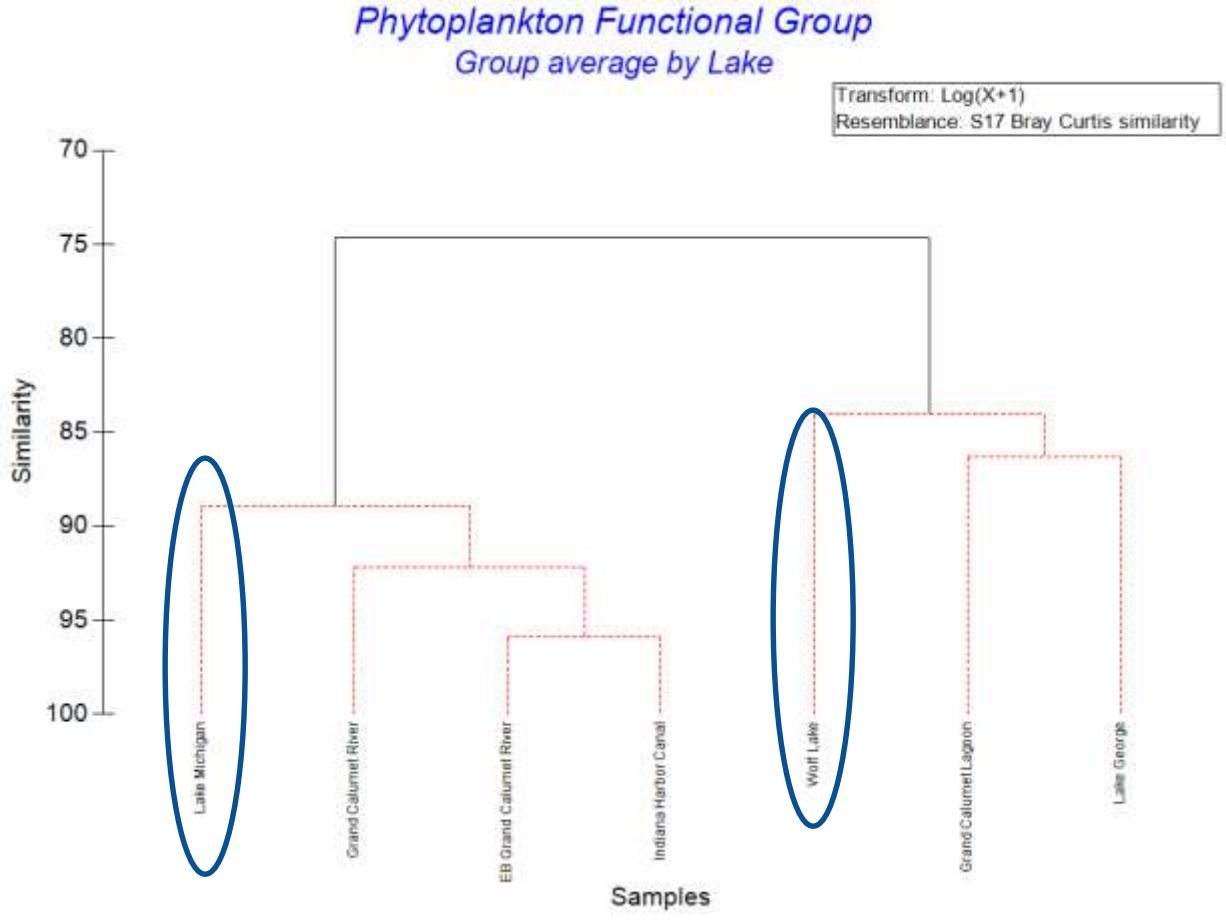
- **Other**
- **Non-HAB- Nontoxic Bluegreen Algae (Cyanophyta)**
- **HAB1-Non-heterocystic Bluegreen Algae that can produce toxins or taste/odor compounds (Cyanophyta)**
- **HAB-Heterocystic Bluegreen Algae that can produce toxins or taste/odor compounds (Cyanophyta)**
- **Green Algae (Chlorophyta)**
- **Euglenoid Algae (Euglenophyta)**
- **Diatoms/Chrysophytes (Bacillariophyceae/Chrysophyta)**
- **Cryptomonads/Non-Ceratium Dinoflagellates (Cryptophyta/Pyrrhophyta)**
- **Ceratium (Pyrrhophyta)**

Phytoplankton – Functional Groups



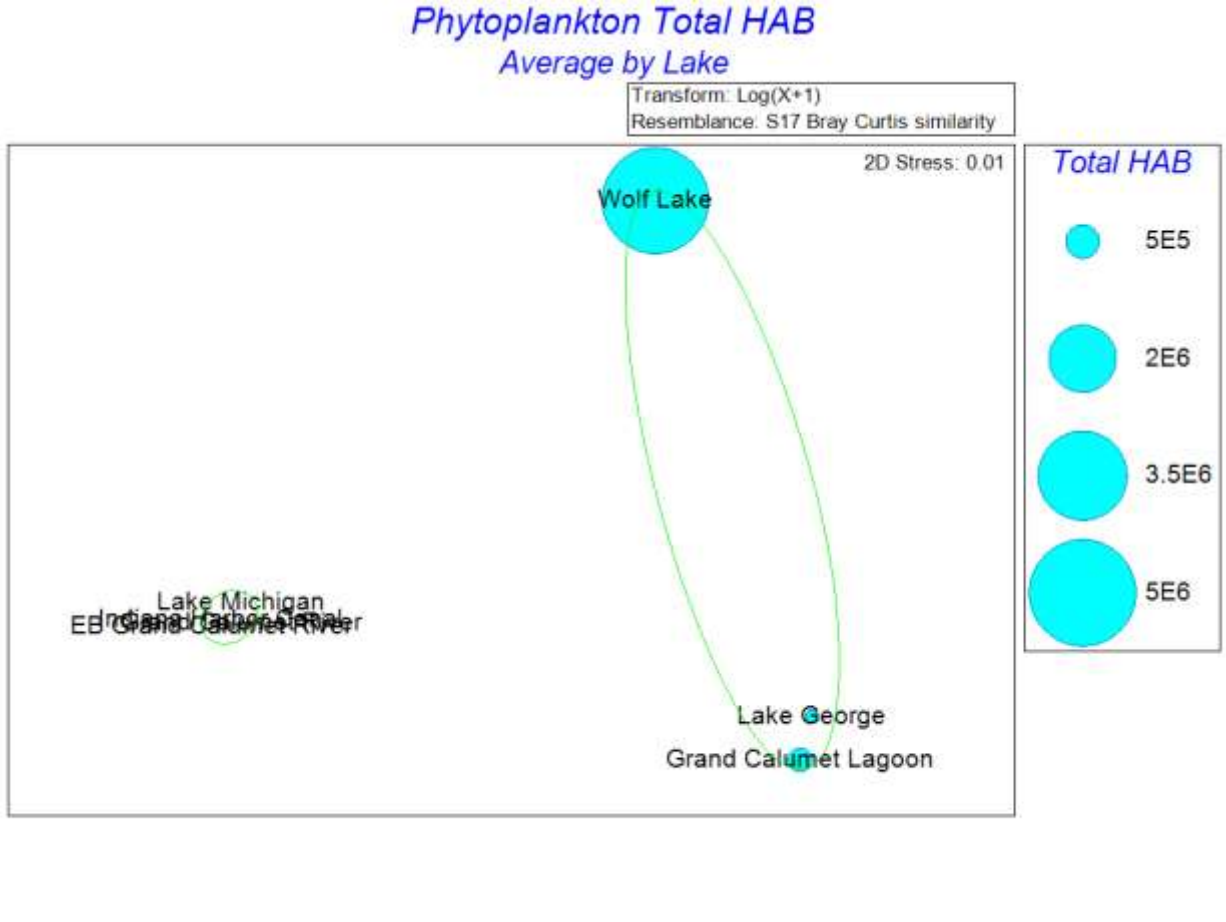
Same site/lake clusters as for the full algal assemblage.

Phytoplankton – Functional Groups



Solid lines indicate statistically significant relationships ($p<0.05$)

Phytoplankton – Total HABs



Total HAB includes both heterocystic and non-heterocystic bluegreen algae

Phytoplankton – Site/Lake Clusters

- Sites/lakes cluster consistently into at least 2 significantly different groups:
  - Lake Michigan (although somewhat unique), Grand Calmuet River, EB Grand Calmuet River and Indiana Harbor Canal.
  - Wolf Lake, Lake George (North and South), Grand Calmuet Lagoons (North and South).
  - Persistent HAB algae are one of the factors which separate the site/lake groups.

Phytoplankton Indices

Phytoplankton Richness and Diversity					
Location	Site	Date	Richness	Shannon-Weiner Index (H')	Eveness (E)
Grand Calumet Lagoon	GCL1	June	17	0.7797	0.2764
		August	25	2.0518	0.6378
	GCL4	June	24	1.1709	0.3707
		August	22	1.4871	0.4825
Grand Calumet River East Branch	EB3	June	32	2.3524	0.681
		August	28	0.834	0.2505
	EB8	June	26	2.2901	0.7075
		August	24	1.5825	0.4989
Grand Calumet River West Branch	WB1	June	36	2.2343	0.6264
		August	31	1.3607	0.3965
	WB2	June	46	3.0828	0.8081
		August	34	1.0737	0.3047
Indiana Harbor Canal	IHC2	June	38	2.8395	0.7838
		August	30	0.987	0.2904
Lake George North	LGN	June	31	1.4817	0.4319
		August	23	1.7374	0.5583
Lake George South	LGS	June	24	1.9314	0.6079
		August	35	1.7524	0.4929
Lake Michigan at Jeorse Park	JP	June	30	2.4162	0.7152
		August	35	2.658	0.7503
Lake Michigan at Whihala Beach	LMW	June	30	2.6836	0.7955
		August	26	2.7573	0.8502
Wolf Lake	WL	June	33	1.1873	0.3407
		August	44	2.3227	0.6138

Phytoplankton Indices

- Lowest Shannon Diversity (<1)
  - Grand Calmuet Lagoon
  - EB Grand Calmuet River
  - Indiana Harbor Canal
- Lowest Evenness (<0.5)
  - Grand Calmuet Lagoon
  - EB Grand Calmuet River
  - WB Grand Calmuet River
  - Indiana Harbor Canal
  - Lake George
  - Wolf Lake
- Highest Shannon Diversity
  - Lake Michigan
- Highest Evenness
  - Lake Michigan

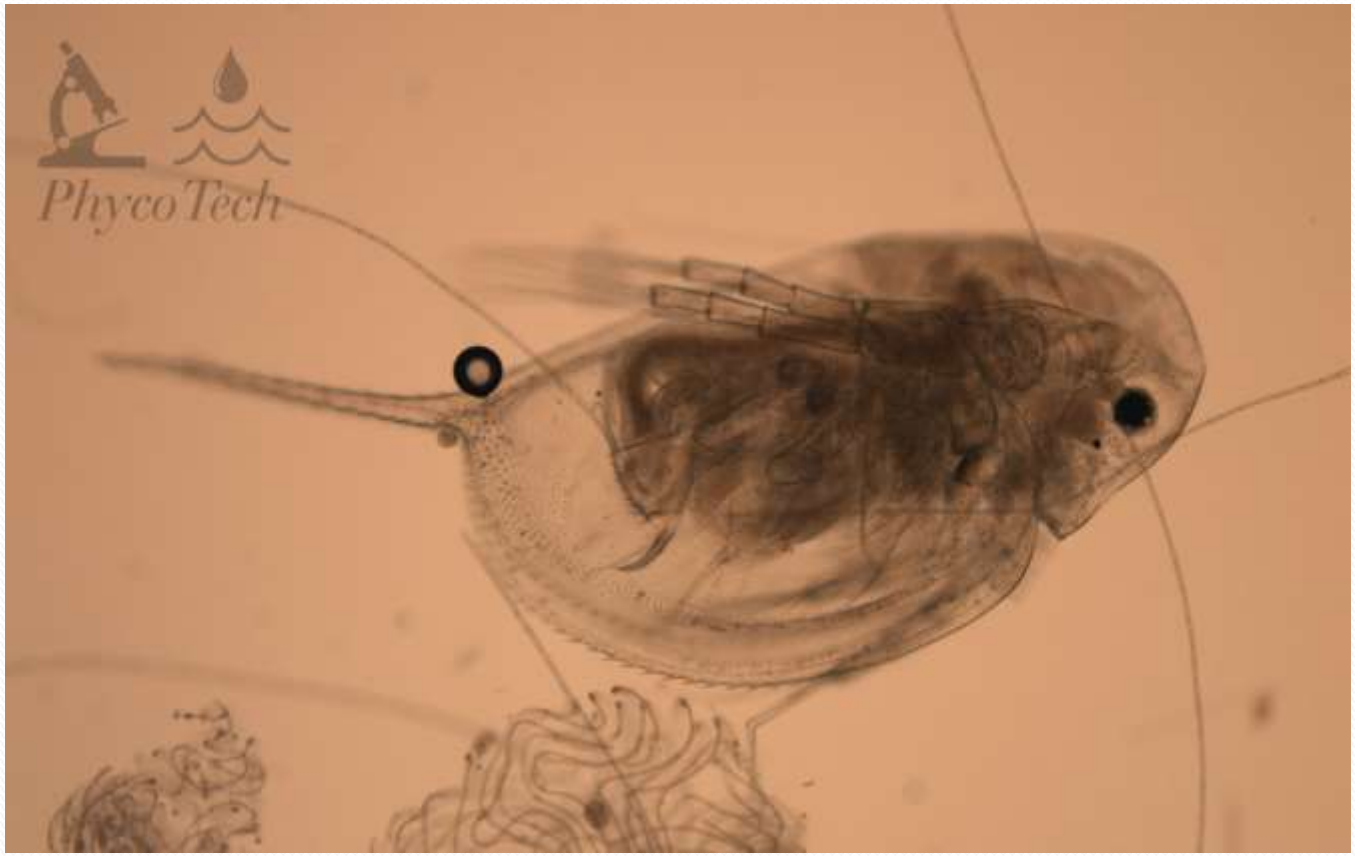
Zooplankton Results

- We analyzed zooplankton in terms of the total assemblage,functional groups and indicator taxa.

Zooplankton – Small Cladocerans

Bosmina longirostris

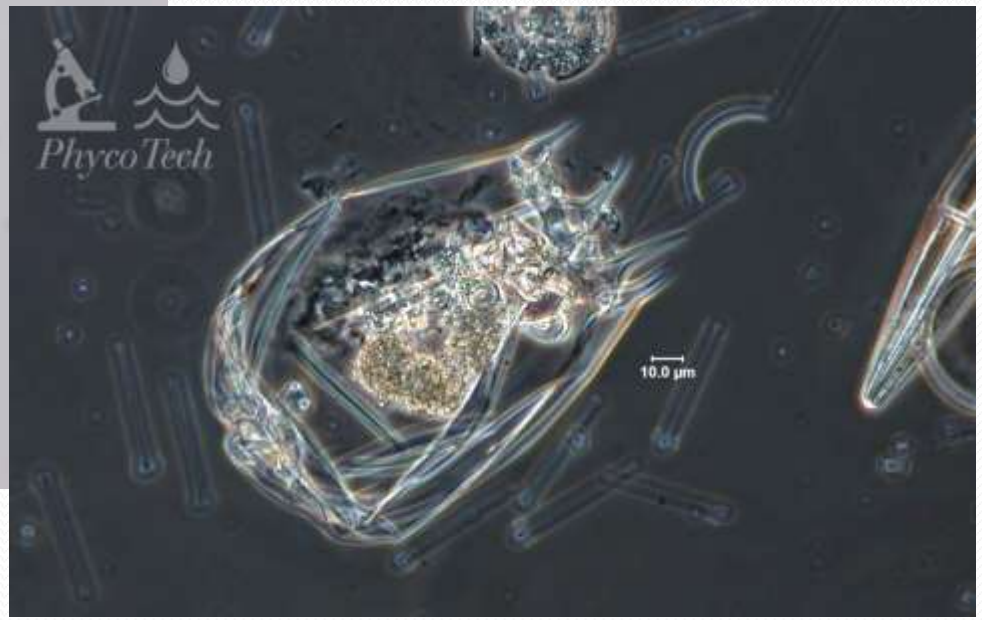
Zooplankton – Large Cladocerans



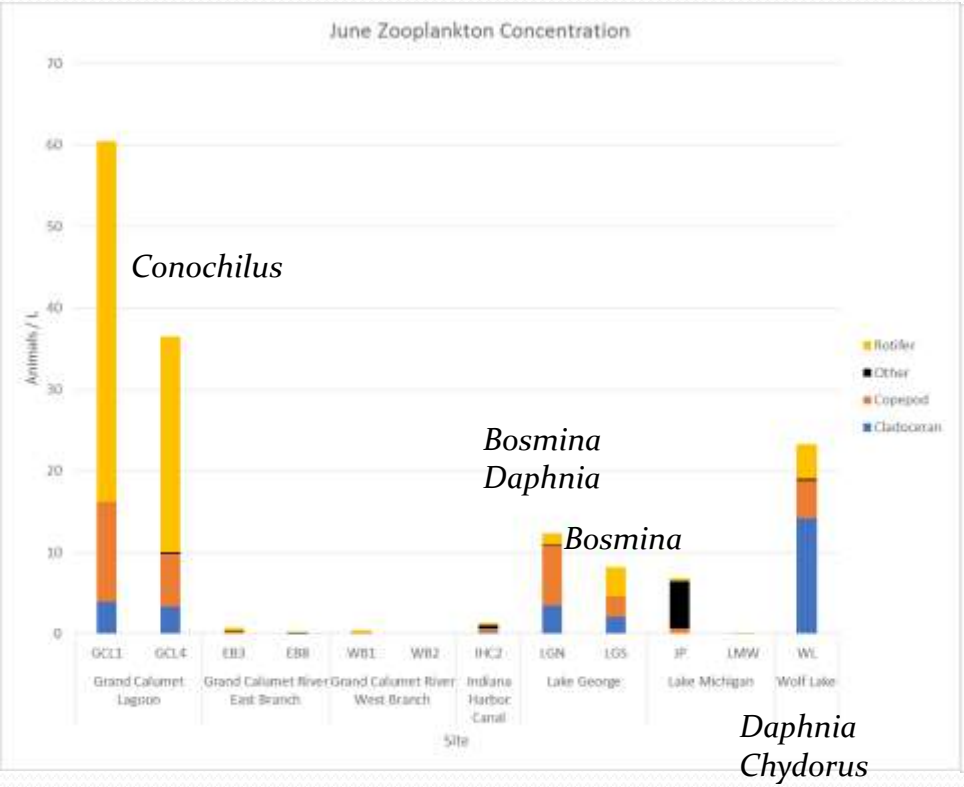
Daphnia ambigua

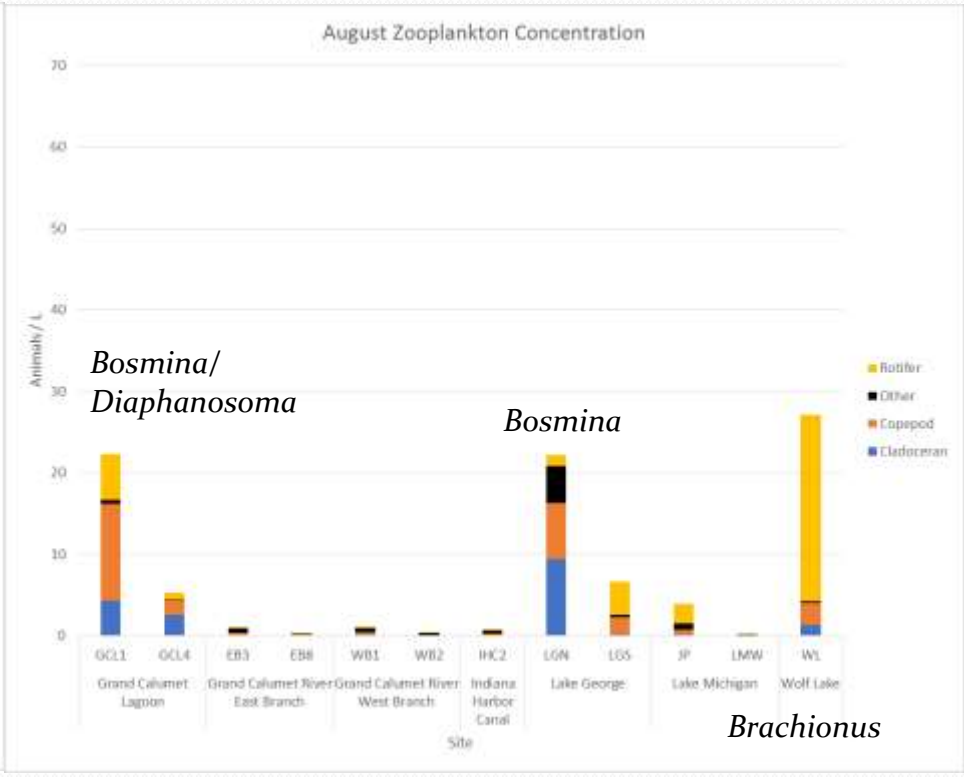
Zooplankton - Copepods

Zooplankton - Rotifers



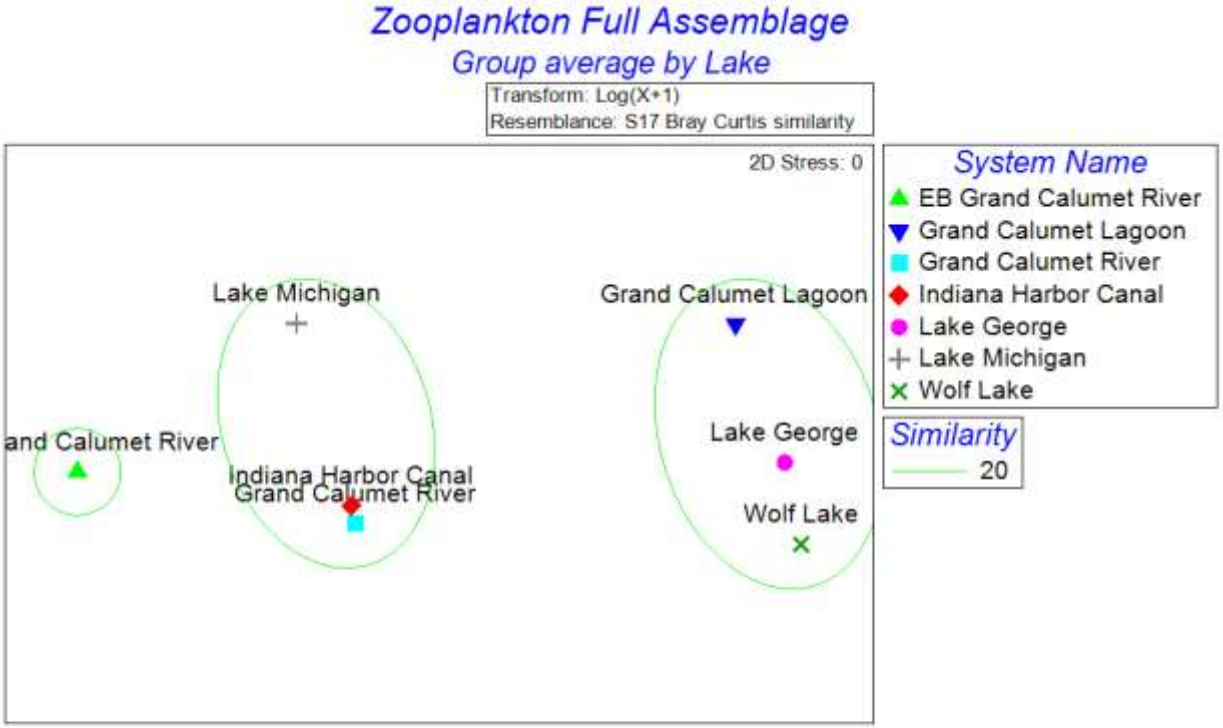
Zooplankton – Full Assemblage





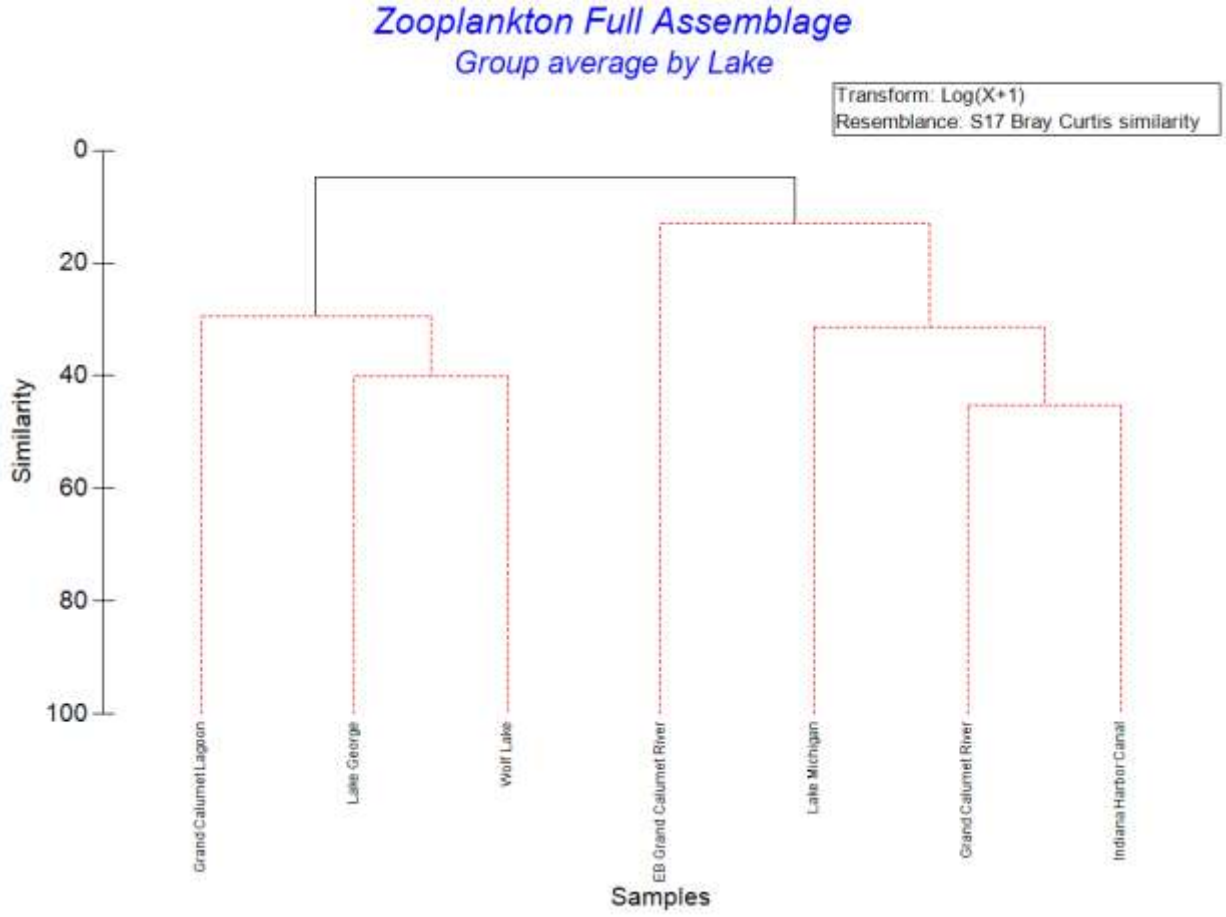
"Other" includes mussel veligers and testate amoeba

Zooplankton Full Assemblage



Groups are loosely the same as the algae, but with much lower similarity

Zooplankton Full Assemblage



Zooplankton Indices

Zooplankton Richness and Diversity					
Location	Site	Date	Richness	Shannon-Weiner Index (H')	Eveness (E)
Grand Calumet Lagoon	GCL1	June	9	1.2454	0.5668
		August	16	1.9839	0.7155
	GCL4	June	13	1.3163	0.5132
		August	14	1.9356	0.7334
Grand Calumet River East Branch	EB3	June	10	1.5585	0.6768
		August	9	1.7892	0.8143
	EB8	June	11	1.8962	0.7908
		August	9	1.9611	0.8926
Grand Calumet River West Branch	WB1	June	8	1.9794	0.9519
		August	14	2.338	0.8859
	WB2	June	2	0.4506	0.65
		August	7	1.773	0.9111
Indiana Harbor Canal	IHC2	June	9	1.838	0.8365
		August	8	1.8763	0.9023
Lake George North	LGN	June	12	1.1871	0.4777
		August	18	2.1266	0.7357
Lake George South	LGS	June	9	1.4415	0.656
		August	10	1.549	0.6727
Lake Michigan at Jeorse Park	JP	June	7	0.6457	0.3318
		August	10	1.7174	0.7458
Lake Michigan at Whihala Beach	LMW	June	6	1.6313	0.9105
		August	6	1.6414	0.9161
Wolf Lake	WL	June	9	1.6768	0.7631
		August	12	1.056	0.425

Zooplankton Indices

- Couldn't calculate the Calanoid/Cladoceran Index
- Lowest Shannon Diversity (<1)
  - WB Grand Calmuet River-WB2
  - Lake Michigan - JP
- Lowest Evenness (<0.5)
  - Lake George
  - Wolf Lake
  - Lake Michigan - JP
- Highest Shannon Diversity
  - WB Grand Calmuet River – WB1
  - EB Grand Calmuet River
  - Lake Michigan – WB
  - Indiana Harbor Canal
  - Lake George
- Highest Evenness
  - Lake Michigan -WB

Conclusions

- Phytoplankton
  - Sites/systems consistently cluster into 2 statistically significant groups
    - Lake Michigan (although somewhat unique), Grand Calmuet River, EB Grand Calmuet River and Indiana Harbor Canal.
    - Wolf Lake, Lake George (North and South), Grand Calmuet Lagoons (North and South).
  - Persistent HAB algae are one of the factors which separate the site/lake groups.
  - Shannon Diversity and Evenness indicate that several additional sites/lakes are experiencing lower water quality than Lake Michigan.
- Zooplankton
  - Same basic site/lake groups with much less similarity.
  - *Bosmina* is associated with more eutrophic conditions, and does dominate at several sites/lakes.
  - Shannon Diversity and Evenness indicate that several additional sites/lakes are experiencing lower water quality than Lake Michigan-WB, but not necessarily JP.

Conclusions

- We only have 2 sampling runs in 2019.
- Phytoplankton data indicate that there is impairment in several sites/lakes compared to Lake Michigan.
  - HABs
  - Lower Diversity/Evenness
- Zooplankton data is especially variable per sampling month and site/system because they tend to be more patchy in the environment.
  - Lot of benthic influence in the samples which made analysis challenging.
  - May be related to water quality and sediments.
  - Tend to have lower zooplankton densities in riverine and high wave action systems.
  - Zooplankton populations will be impacted by fish community structure as well.
  - Dominance of *Bosmina* does indicate a tendency towards eutrophication.


Questions?
astamand@phycotech.com
269-983-3654