Resource Limitation and Early Warning Indicators of Phytoplankton Blooms

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Introduction

- Missisquoi Bay, a shallow, warm, now eutrophic bay; is one of the five major basins composing Lake Champlain (Douglas, 2012).
- For the past years, Missisquoi Bay (MB) continued to experience increases in algal biomass as well as high nutrient loads caused by multiple factors.
- Shallow lakes can have critical thresholds where an abrupt shift from a clear to a turbid state may occur (Scheffer, 2007).
- A relative increase of turbidity caused by the increased incidence of harmful algal blooms has been noticed during the summers, when water temperatures are high.
- This alternative stable state can promote the dominance by filamentous cyanobacteria such as *Microcystis*, *Anabaena* and *Aphanizomenon*; which were founded to dominate these blooms in previous studies (Pearce et al., 2013).
- Detrended Correspondence Analysis (DCA) will be use to relate how diversity and abundance of phytoplankton groups varies with chemical variables.
- DCA, an ordination method, starts with a correspondence analysis followed by detrending and rescaling the positions of samples along an axis (Holland,2008).

Objectives

- Establish a relationship between phytoplankton community composition and resource limitation by considering alternate stable states.
- Attempt to identify factors that can be used as early warning indicators of cyanobacteria blooms.

Hypothesis

- We expected that high amounts of total nitrogen (TN), total phosphorus(TP), soluble reactive phosphorus (SRP) and increasing water temperature promote alternate stable states of phytoplankton community composition, leading to increased likelihood of harmful cyanobacteria blooms.
- We expect that nutrient amounts can be use as early warning signs of phytoplankton blooms.

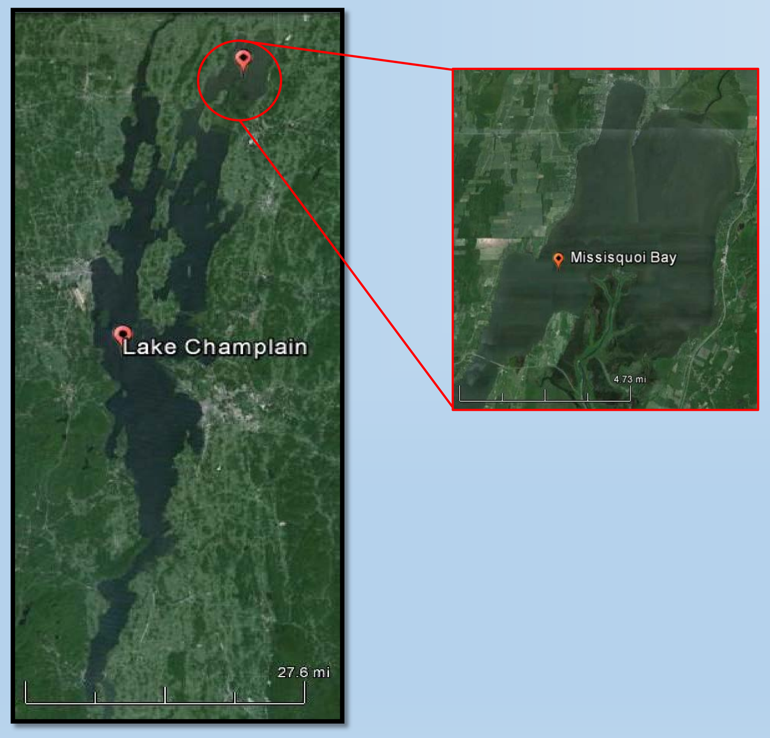
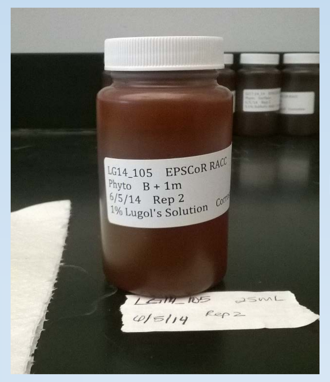


Figure 1. Study Site. Missisquoi Bay. Photo taken from Google Earth.

Methodology

Count using an inverted microscope



Add 0.75 mL of Lugol's Solution to water sample.

Prepare chambers.

Count using an Inverse Microscope.

TN/TP

Prepare and acidified water sample.

Results

- 2012

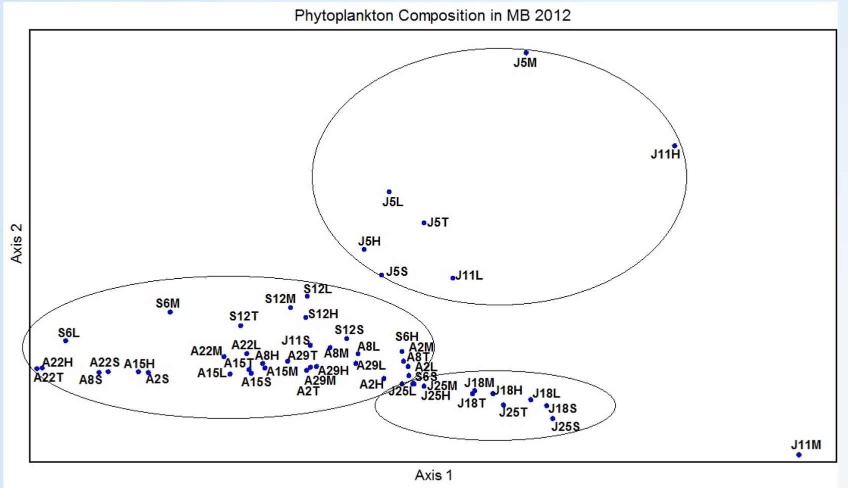


Figure 2. Phytoplankton community composition in MB during 2012 summer. The first letter on label corresponds to months (J=July, A= August and S=September). The numbers represent the day and the last letter corresponds to depths (S= surface, T= 1m, H=2m, M=2.5m, L=3m, D=3.5m and B=4m).

- 2013

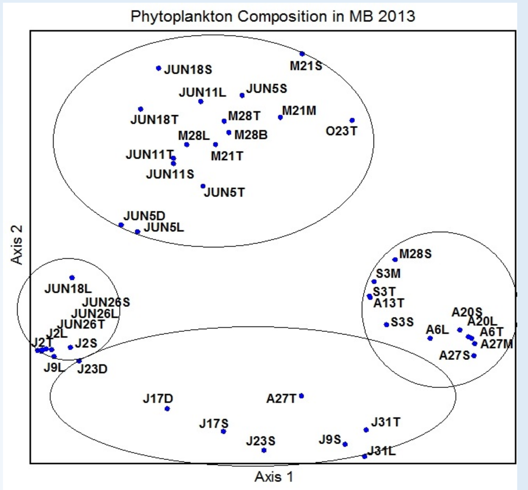


Figure 5. Phytoplankton community composition in MB during 2013 summer. The first letter on label corresponds to months (J=July, A= August and S=September). The numbers represent the day and the last letter corresponds to depths (S= surface, T= 1m, H=2m, M=2.5m, L=3m, D=3.5m and B=4m).

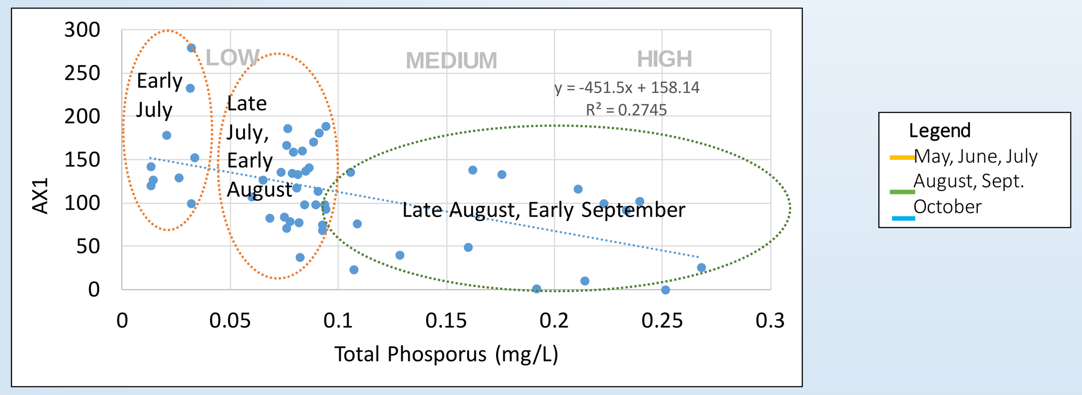


Figure 3. Changes in phytoplankton community composition due to Total Phosphorus concentration.

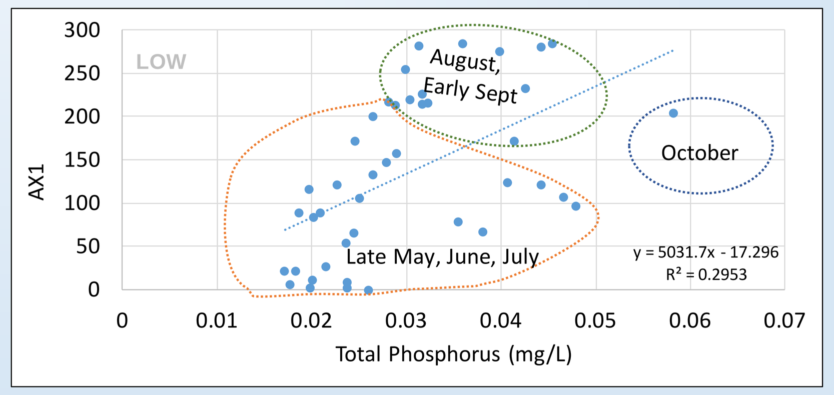


Figure 6. Changes in phytoplankton community composition due to Total Phosphorus concentration.

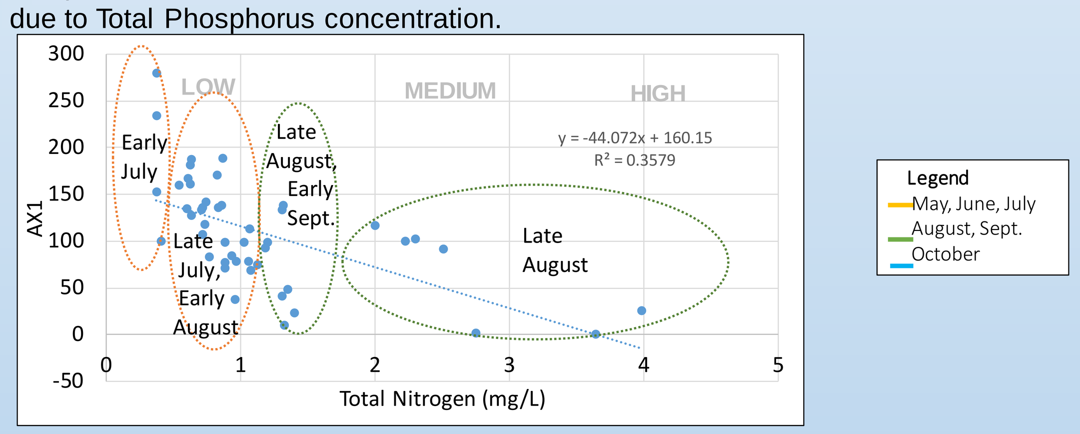


Figure 5. Changes in phytoplankton community composition due to Total Nitrogen concentration.

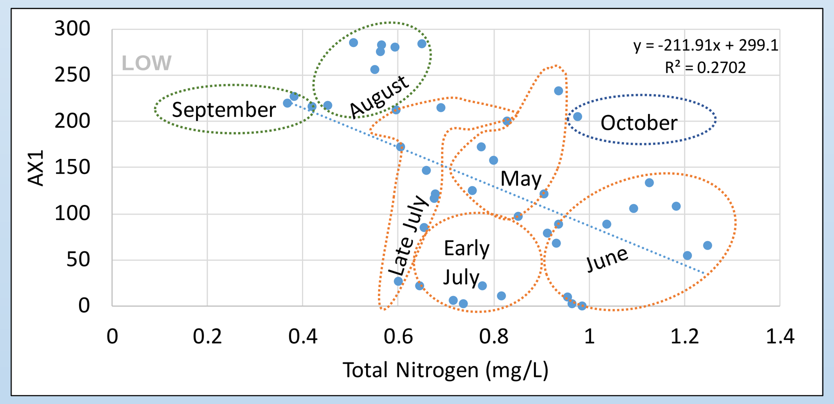


Figure 7. Changes in phytoplankton community composition due to Total Nitrogen concentration.

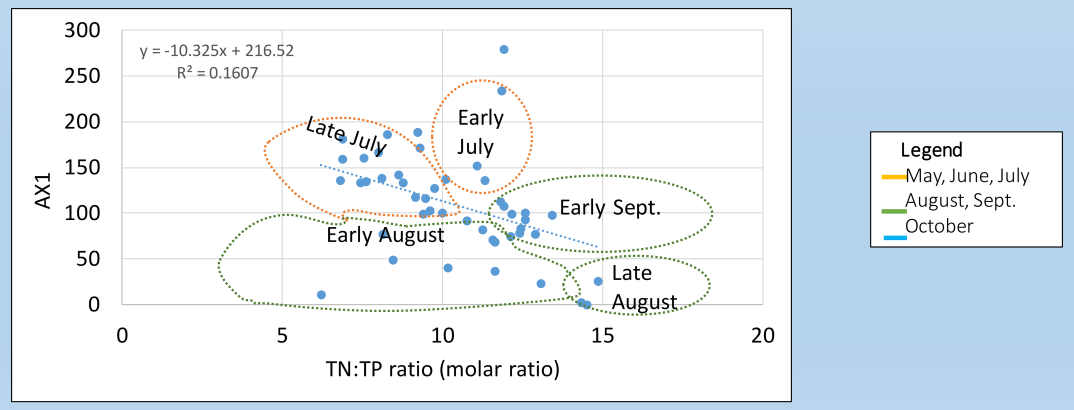


Figure 4. Changes in phytoplankton community composition due to TN:TP ratio.

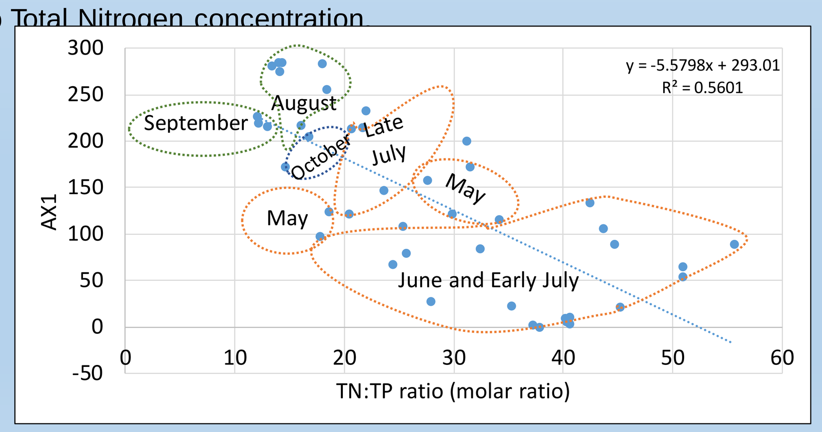


Figure 8. Changes in phytoplankton community composition due to TN:TP ratio.

Period	Dominant Species	Resource Limitation		
		TN (mg/L)	TP (mg/L)	TN:TP ratio (molar ratio)
Early July	*Microcystis* *Aulacoseira* *Anabaena* *Peridinium* *Pennate Diatom*	LOW (0.382)	LOW (0.024)	11.866
Late July	*Microcystis* *Aphanizomenon* *Anabaena* *Eudorina* *Aulacoseira*	LOW (0.704)	LOW (0.084)	8.358
August and Sept.	*Microcystis* *Anabaena* *Aulacoseira* *Aphanizomenon* *Pediastrum*	LOW (1.383)	MEDIUM (0.128)	10.817

Table 1. Dominant species through summer 2012.

Period	Dominant Species	Resource Limitation (mg/L)		
		TN (mg/L)	TP (mg/L)	TN:TP ratio (molar ratio)
Late May, Early June	*Peridinium* *Aulacoseira* *Cryptomonas* *Chroomonas* *Microcystis*	LOW (0.960)	LOW (0.032)	33.472
Late June, Early July	*Aulacoseira* *Aphanizomenon* *Microcystis* *Asterionella* *Anabaena*	LOW (0.824)	LOW (0.021)	38.681
Late July	*Aphanizomenon* *Aulacoseira* *Anabaena* *Microcystis* *Fragelaria*	LOW (0.645)	LOW (0.025)	26.009
August, Sept.	*Anabaena* *Microcystis* *Aphanizomenon* *Aulacoseira* *Cryptomonas*	LOW (0.513)	LOW (0.036)	14.526

Table 2. Dominant species through summer 2013.

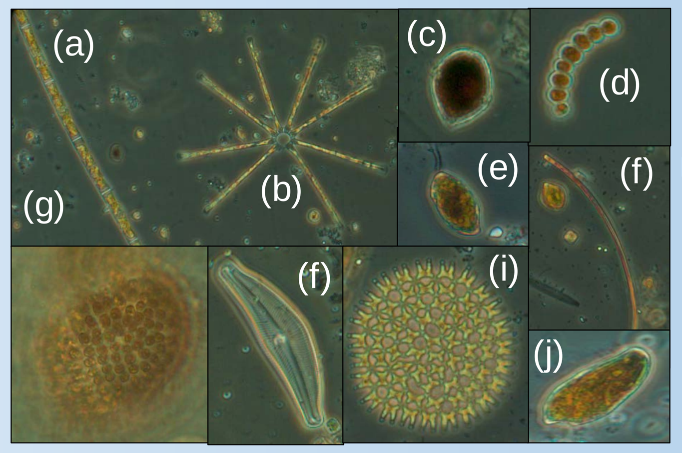


Figure 9. Dominant phytoplankton species in Missisquoi Bay pictures taken with a Spot Insight Color camera.

(a) *Aulacoseira* (b) *Asterionella*
(c) *Peridinium* (d) *Anabaena*
(e) *Chroomonas* (f) *Aphanizomenon*
(g) *Microcystis* (h) *Pennate Diatom*
(i) *Pediastrum* (j) *Cryptomonas*

Discussion

- For 2012 and 2013, **three** and **four** well separated groups of species were found along the summers (figure 2, 6); respectively, suggesting a gradient and a regime shift of species across the course of the summer.
- Figure 2 and 6 explain the **57%** and **65%** of variance in the species data with axes for 2012 and 2013, respectively.
- TN and TP concentration were **higher** in MB for 2012 compared to 2013, meanwhile TN:TP ratio was **lower** in 2012 compared to 2013 (Figure 3-5, 7-9) which may be one of the factors explaining why there was a much weaker algal bloom during 2013 .
- Blue green algae were **dominant** for both summers (Table 1, 2) with ***Microcystis***, ***Aphanizomenon*** and ***Anabaena*** as common species.
- According to the results, different phytoplankton species dominance changes when nutrient amount changes (Table 1, 2).
- Nutrient concentrations can be used as early warning signs but other parameters like meteorological controls need to be studied as important factors controlling harmful algal blooms.

References

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